Effect of Soil Nitrogen for Maize Planting in Different Ratio of Compound Soil

Yangjie Lu1, 2, 3, 4, *, Juan Li1, 2, 3, 4 and Zhen Guo1, 2, 3, 4

1Institute of Land Engineering and Technology, Shaanxi Provincial Land Engineering Construction Group Co., Ltd. 710075, Xi’an, China
2Shaanxi Provincial Land Engineering Construction Group Co., Ltd. 710075, Xi’an, China
3Key Laboratory of Degraded and Unused Land Consolidation Engineering, the Ministry of Natural Resources, 710075, Xi’an, China
4Shaanxi Provincial Land Consolidation Engineering Technology Research Center. 710075, Xi’an, China

*Corresponding author e-mail: 995915203@qq.com

Abstract. The experiment was carried out by planting corn on the compound soil formed by mixing different proportions of soft sandstone and sand. The distribution and migration of nitrate nitrogen and ammonium nitrogen in the compound soil were studied. The results showed that: 1. Soil nitrate nitrogen was easily leached by water, and the greater the proportion of sand in the compound soil, the faster the soil nitrate nitrogen was leached and the depth of the leaching is deeper; 2. The content of ammonium nitrogen in the compound soil was generally low, and the higher the sediment concentration of the compound soil, the greater the change of ammonium nitrogen. Therefore, appropriate measures should be taken in the compound soil with high sediment concentration to reduce the fertility waste caused by nutrient loss.

1. Introduction

The soft sandstone is a loose Strata that has formed for a long time [1]. It is mainly composed of sandstone and sand shale[2], and is concentrated in the Ordos Plateau in the Yellow River Basin at the junction of Shanxi, Shaanxi and Inner Mongolia, with an area of 1.67×104 km2 [3-4]. The soft sandstone is an associated rock of the Mu Us Sandland [5], its rock thickness is small, the pressure bearing capacity is poor, and the characteristics of “waterless rock-solid, water-like rotten mud” [1] make it difficult to use. The high degree of erosion and the various erosion modes in the soft sandstone area [6-7] lead to serious soil erosion [8-9] and poor ecological environment [10]. The improvement and utilization is difficult. Therefore, it is called “Earth Environment Cancer”.

At present, a large number of scholars have studied the soil erosion and ecological management in the soft sandstone area. Cai Huaisen et al. [11] and Wang Lunjiang et al. [12] studied the hydraulic erosion of different color sandstones and found that the higher the iron oxide content in the sandstone, the redder the color of the sandstone, and the more serious the soil erosion. For the treatment of soft sandstone, it is possible to restore the shrub vegetation through plantation project measure [13], planting seabuckthorn plants such as buckthorn, caragana, and shadawang to establish a “flexible
And hydraulic engineering measure can be adopted, such as the construction of check dams and the key projects in harnessing the gullies [1]. A combination of various measures also can be used to reduce soil erosion and form high-yield farmland [15]. Zhang Weihua et al. [5] took the materials locally in the soft sandstone area, and mixed the soft sandstone with poor texture and poor permeability to the sand with strong permeability to form a compound soil, turning disaster into available resources.

In this experiment, the distribution and migration of soil nitrate nitrogen and ammonium nitrogen in the compound soil formed by mixing soft sandstone and sand in different proportions were studied, and the regular pattern of nitrogen in the compound soil was discussed. The result have certain guiding significance for improved utilization of soft sandstone and the application of nitrogen fertilizer for planting corn on the compound soil.

2. Materials and methods

2.1. Experimental material

The all soft sandstone and sand used in the experiment were taken from the Mu Us Sandy Land (located in the northwestern part of China, one of the four major sand areas in China) in Yuyang District, Yulin City. The basic physical properties are shown in Table 1.

| The proportion of size | texture of soil (USDA) | capillary porosity (%) |
|------------------------|------------------------|------------------------|
| sand particles         | powder particle         | clay particle           |
| (0.05-2mm)            | (0.002-0.05mm)         | (<0.002mm)             |
| soft sandstone        | 34.82a                  | 58.19a                 | 6.99a                  | Silt Loam Soil | 45.26 |
| Sand                  | 96.33b                  | 1.44b                  | 0.23b                  | Sand          | 24.97 |

2.2. Experimental methods

2.2.1. Experimental site. The field experiments were carried out during 2012 in Daji Khan Village, Xiaoji Khan Township, Yuyang District, and Yulin City. It is located in the transition zone between Mu Us Desert and Loess Plateau (107°15′~111°15′ E and 36°57′~39°34′ N). The annual average temperature is 7.9 °C ~11.3 °C, and the annual average precipitation is 316~513 mm, mostly concentrated in 7, 8 and 9 months. And the weather is temperate arid and semi-arid continental monsoon climate in this place. The climate is characterized by sufficient sunshine, large temperature difference, dry climate, rain and heat in the same season, and obvious four seasons.

2.2.2. Experimental design. The ratio of soft sandstone to sand was set to 1:1, 1:2, 1:5 three treatments [5]. Each treatment is set up three times, with a total of 9 plots. Each plot is 12m×5 m with plant spacing of 35cm and line spacing of 50cm. The corn was planted on April 22, 2012. 0.90 kg of urea and 2.25 kg of diammonium phosphate were added into every plots, and 0.90 kg of urea was applied on July 10. Each plot was filled with 50 mm water before corn planting, jointing, heading, filling and maturity.

2.3. Statistical analysis

The soil was taken in the corns jointing stage, heading stage and maturity stage of the experiment, and the contents of ammonium nitrogen and nitrate nitrogen in the soil were measured. The ammonium nitrogen in the soil was measured by KCl extraction-indophenol blue colorimetric method; the soil nitrate nitrogen was measured by dual-wavelength spectrophotometry.
The treatments were run as a single-factor analysis of variance (ANOVA) by SPSS Version 16.0. The ANOVA was performed at $\alpha=0.05$ level of significance to determine if significant differences existed among treatment means.

3. Results and discussion

3.1. Distribution of nitrate nitrogen in compound soil of corn in different periods

The difference of nitrate nitrogen in different ratios of soft sandstone and sand compound soil was obvious. The soil nitrate nitrogen content of 1:1 volume ratio mixed sand in soft sandstone and sand was lower than that of the other two ratios. The trend was that the soil nitrate nitrogen content of 0-10 cm soil layer was the highest. And with the increase of soil depth, the soil nitrate nitrogen content decreased obviously. The soil nitrate nitrogen content of 10-15 cm soil layer was 3.25 mg/kg, which is 32.0% lower than that of 0-10 cm soil layer. And then the soil nitrate nitrogen content fluctuated around 3.50 mg/kg with little change. The soil nitrate nitrogen content of sandstone and sand in a 1:2 volume ratio mixed compound soil was higher, all above 4.00 mg/kg. Among them, the content of soil nitrate nitrogen had a significant upward trend in 10-20 cm soil layer, and the 15 cm soil layer and the 20 cm soil layer were 28.5% and 34.0% higher than the top soil, respectively. The soil nitrate nitrogen content in other soil layers was about 4.30 mg/kg. The soil nitrate nitrogen content of compound soil in 1:5 volume ratio was between the other two ratios of compound soil, but the fluctuation range was larger, which generally showed that the trend of soil nitrate nitrogen content declines with the increase of soil depth. The soil nitrate nitrogen content of the three compound soils was 1:5 compound soil > 1:2 compound soil > 1:1 compound soil in the surface layer, and 1:2 compound soil > 1:5 Compound soil > 1:1 compound soil in the other soil layer.
Figure 2. Distribution of soil nitrate nitrogen in corns heading stage

The higher content of soil nitrate nitrogen at corns heading stage was due to the application of urea to ensure the growth of corn. The soil nitrate nitrogen content in different proportions of compound soil showed the same trend as the soil depth. The content of nitrate nitrogen in the compound soil of 1:1 volume ratio was lower than that of the other two ratios. The soil nitrate nitrogen content peaked at 15cm soil layer, which was 61.5% higher than the surface layer, followed by 15- The nitrate content of the 20 cm soil layer decreased, but the change was not significant. Subsequently, the nitrate nitrogen content in the 15-20 cm soil layer decreased, and the change was not significant in other soil layers. The peak nitrate nitrogen content of 1:2 volume ratio compound soil was found in the 20cm soil layer, which was 79.4% higher than the surface layer, and decreased to 33.58mg/kg in the 40cm soil layer. The change was not significant after the 40cm soil layer. The soil nitrate content of 1:5 volume ratio compound soil increased with depth in the 0-40cm soil layer, reaching a maximum value of 59.79mg/kg in the 40cm soil layer, which was 110.7% higher than the surface layer. Then the value decreased to 35.61 mg/kg at 60 cm soil layer, and the soil nitrate nitrogen content did not change much with the increase of soil depth.

Figure 3. Distribution of soil nitrate nitrogen in corns maturity stage
The nitrate nitrogen content of 1:1 and 1:2 volume ratio compound soil was stable. With the increase of soil depth, the content of nitrate nitrogen changed little, while the volume ratio of compound soil 1:5 was quite different from the other two. The soil nitrate nitrogen peak of 3.13mg/kg in the 1:1 compound soil appeared in the 40cm soil layer, which was 11.6% higher than the surface layer, and the difference was not obvious. With the increase of soil depth, the soil nitrate nitrogen content fluctuated around 3.50mg/kg and changed small. The peak value of soil nitrate nitrogen in the 1:2 compound soil appeared at 40cm soil layer, which was 29.9% higher than the surface layer. The difference was larger than that of the 1:1 compound soil. The overall change of soil nitrate nitrogen content was small, also in 3.50mg/kg fluctuates up and down. The soil nitrate nitrogen content of 1:5 compound soil was similar to the other two compound soils in the 0-15cm soil layer, but it decreased rapidly with the increase of soil depth. The nitrate nitrogen content dropped to 0 in 60-80cm soil layer, and then the soil nitrate nitrogen content increased rapidly, reaching a peak at 140cm soil layer, which was 215.5% higher than the surface soil layer, and the difference was obvious.

3.2. Distribution of ammonium nitrogen in compound soil of corn in different periods

The overall trend was that the soil ammonium nitrogen of 1:1 compound soil decreased with the increase of soil depth. The soil ammonium nitrogen peak value of 0.77mg/kg appeared in the soil surface layer. The ammonium nitrogen content of 0-20cm soil layer decreased rapidly. And it did not change much in the 40-100cm soil layer, and then fell rapidly. The soil ammonium nitrogen of 1:2 compound soil is that as the depth of the soil increases, it rised first, then decreased and rised slowly. The ammonium nitrogen peak of 0.77 mg/kg appeared in the 15 cm soil layer, which was 4.2% higher than the surface soil layer. The change trend of soil ammonium nitrogen content in 1:5 compound soil was similar to that of 1:2 compound soil, and the peak value 0.71 mg/kg of ammonium nitrogen appeared in 40 cm soil layer. The ammonium nitrogen content of 0-10 cm soil layer is 1:1 compound soil>1:2 compound soil>1:5 compound soil.

![Ammonium nitrogen distribution](image.png)

**Figure 4.** Distribution of soil ammonium nitrogen in corns jointing stage
Figure 5. Distribution of soil ammonium nitrogen in corns heading stage

The soil ammonium nitrogen content in 1:1 compound soil showed a decreasing trend in the 0-20cm soil layer, and it increased with the increase of soil depth, reaching a maximum value of 0.90mg/kg in the 120cm soil layer, then it decreased again. The trend of ammonium nitrogen of the 1:2 compound soil is closed to that of the 1:1 compound soil. The soil ammonium nitrogen content decreased first and then increased and then decreased with the increase of soil depth. The peak value of soil ammonium nitrogen was 0.89mg/kg, and it appeared in the 60cm soil layer. The soil ammonium nitrogen in the 1:5 compound soil showed an upward trend in the 0-20cm soil layer, and the peak value at the 20cm soil layer was 0.94mg/kg, which then decreased with the increase of the soil depth, and the decrease was greater than 1:1 and 1:2 compound soil. The soil ammonium nitrogen content in the 0-40cm soil layer was 1:5 compound soil > 1:1 compound soil > 1:2 compound soil, and 1:1 compound soil > 1:2 compound soil > 1:5 compound soil below the 60cm soil layer.

Figure 6. Distribution of soil ammonium nitrogen in corn’s maturity stage

The content of ammonium nitrogen in the 1:1 compound soil did not change much with the increase of soil depth, and the whole fluctuated around 0.43mg/kg, and the trend was gentle. The change trend of ammonium nitrogen in the 1:2 compound soil is similar to that of the 1:1 compound soil. But the ammonium nitrogen content fluctuated around 0.44mg/kg, and the fluctuation range was...
larger than that of the 1:1 compound soil. The change trend of soil ammonium nitrogen in 1:5 compound soil was different from the other two. In the 0-15cm soil layer, the soil ammonium nitrogen content showed a downward trend, but it increased obviously in the 20cm soil layer, with a peak value of 0.54mg/kg. Then soil ammonium nitrogen showed a downward trend in the 20-40 cm soil layer, and then changed little with the increase of soil depth.

4. Conclusion

It can be seen from the distribution of soil nitrate nitrogen in three proportions of soil of the three periods:

1) Soil nitrate nitrogen is easily leached by water. This is reflected in the soil nitrate nitrogen profile, which was the peak value always found below the soil surface. The reason is soil nitrate nitrogen ions are negatively charged and difficult to be adsorbed by the same negatively charged soil colloid, and nitrate nitrogen is easily soluble in water and easily migrates with water to the soil \[16\], which may cause nutrient loss.

2) The greater the proportion of sand in the compound soil, the faster the soil nitrate nitrogen is leached and the depth of the leaching is deeper. Comparing the depth of soil nitrate nitrogen in each period, the higher the sediment concentration in the compound soil, the deeper the peak value of nitrate nitrogen in the soil. Especially in the harvest period, after a full growth period, there was a part of nitrate distribution in the 1:5 compound soil 0-20cm soil layer, but the soil nitrate nitrogen content in the 20-80cm soil layer was close to 0. And the peak appeared at the 140cm soil layer. The reason is that the sand has poor water retention, and the water is easily lost downwards \[17\]. Therefore, the soil water carried the nitrate nitrogen which is easily soluble in water and migrated to the deep, resulting in higher sediment concentration in the soil, the deeper the nitrate nitrogen distribution in the soil.

It also can be seen from the distribution of soil ammonium nitrogen in three proportions of soil of the three periods:

1) The content of ammonium nitrogen in the compound soil in each period is generally low. In the jointing stage, heading stage and maturity stage of corn, the content of ammonium nitrogen in the different proportions of compounded soil was concentrated between 0.40-1.00 mg/kg. The reasons for the low ammonium nitrogen content in the soil may be: 1. High temperature and drought in summer made the oxidation process of ammonium nitrogen to nitrate nitrogen quickly; 2. higher temperature accelerates the conversion of ammonium nitrogen into ammonia gas. Ammonia gas volatilizes, causing nutrient loss \[18\].

2) The distribution of ammonium nitrogen in each proportion of compound soil is small, and the change of ammonium nitrogen with the increase of soil depth is also small. The reason is that the ammonium nitrogen has a positive charge and is easily adsorbed by the negatively charged soil colloid in the soil, which is difficult to transport and less with water loss. During the tillage period, the distribution of ammonium nitrogen in the three compound soils was not much different. At the end of a tillage period, the higher the sediment concentration, the greater the change of ammonium nitrogen in the compound soil. This is because the compound soil with a larger sediment concentration has less clay in the soil, and it is not easy to form a soil colloid, and the adsorption of ammonium nitrogen is weakened.

The nitrate nitrogen in the compound soil is easily leached by water, resulting in the loss of nutrients, and the higher the sediment concentration, the more serious the nitrate leaching phenomenon. Therefore, appropriate measures should be taken in the compound soil with a high sediment concentration to reduce the fertility waste caused by nutrient loss. The accumulation of ammonium nitrogen does not occur in the compound soil, which may be related to the nature of the compound soil and the local climatic conditions. Later, the adsorption effect of the compound soil on ammonium nitrogen and the conversion of nitrate nitrogen to ammonium nitrogen should be carried out in consecutive study.
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