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EFFECTS OF ADDING DIFFERENT PROPORTIONS OF SOFT ROCK ON THE DYNAMIC CHANGE OF THE QUALITY OF AEOLIAN SANDY SOIL

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Abstract

Evolution process of quality of soft rock and sand compound soil and exploration of its stability were studied. In the present study different proportions (1 : 1, 1 : 2, 1 : 5, 0 : 1) of soft rock and sand compound soil as the research object were selected. Tthe particulate organic carbon, microbial organic carbon, effective phosphorus, quick-acting potassium, nitro nitrogen and ammonium nitrogen in the compound soil were analyzed. Results showed that after 9 years of planting, the organic carbon content of particles with 0 : 1 treatment was the lowest, at 1.73 g/kg, and the treatment of 1 : 5 and 1 : 1 increased significantly by 74.74 and 94.90%, respectively. In the 20 - 30 cm soil layer, the lowest organic carbon content of particles with 1 : 2 treatment was 1.92 g/kg, and there was no significant difference between the other three treatments, with 0 : 1, 1 : 5 and 1 : 1 treatment increased by 46.20, 29.27 and 34.07%, respectively compared to 1 : 2 treatment. With developed root system, the biomass of the root system was greater than the biomass left on the ground after harvest, and the average content of organic carbon of the particles increased first and then decreased later. The microbial community in the compound soil was significantly improved, and the carbon content of microorganisms in the treatment of 1 : 1, 1 : 2 and 1 : 5 was significantly higher than that of whole sand by 85, 165 and 143%, respectively, after multi-year of cultivation. The soil root microbial community showed a benign development. With the increase of planting years, the incorporation of soft rock accelerates the process of natural succession of soil quality. Compared with sandy land, compound soil has significantly improved storage of available phosphorus and available potassium nutrients. Compound soil has been cultivated for 9 years compared with 6 years, with the ratio of 1 : 1, 1 : 2, 1 : 5 and 0 : 1, the effective phosphorus content increased significantly by 141, 181, 169 and 63% respectively, the available potassium content increased significantly by 141, 181, 169 and 63% respectively. Compound soil has been cultivated for 9 years compared with 6 years, with the ratio of 1 : 1, 1 : 2, 1 : 5, and 0 : 1, the nitrate nitrogen content increased significantly by 40, 130, 135 and 120%, respectively. Nitro nitrogen is easily soluble in water, and the higher the proportion of sand in the compound soil, the easier the loss of nitrous nitrogen content in the soil. After multiple years of cultivation, the ammonium nitrogen content in the compound soil decreased, with a significant decrease of 35 ($p < 0.05$), 34 ($p < 0.05$), 45 ($p < 0.05$) and 37% ($p < 0.05$), respectively. Due to the disruption of harvest, the exposure of the surface soil is high, which causes ammonium nitrogen to evaporate.

Introduction

Ensuring the red line of arable land and ensuring national food security are the important criteria for human survival in all countries. The improvement of unused land and degraded land is an important measure to ensure the reserve resources of arable land (Wang *et al.* 2012). The various types of desertified land in China are about 2.58 billion mu, with a large area, and it is an important area to control desertified land and supplement the reserve resources of arable land (Wang *et al.* 2020). The Mu Us Sandy Land is one of the four major sandy lands in China. The

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area has serious desertification and fragile ecology. It is a key management area for China "two screens and three belts" ecological security pattern (Kong *et al.* 2006, Cheng *et al.* 2020, Fei *et al.* 2020). The area is also widely distributed with arsenic sandstone, a set of fluvial clastic rock deposits developed in the Jurassic, Triassic, and Cretaceous periods. It is mainly brown, red, white, gray, and purple sandstone. There are argillaceous sandstone, sandy mudstone, and mudstone. It is the main source of coarse sediment in the Yellow River, and soil erosion caused by arsenic is also one of the local ecological problems (Zhang *et al.* 2019). Known as the "Ecological Cancer of the Earth", sand and arsenic sandstone, as the two hazards that threaten the ecological security of the region, have always been treated as targets, and have not been exploited as resources. At present, the remediation of sandy land is mainly based on planting trees, planting grass, and spraying sand-fixing agents, and there is a lack of new materials in large-scale sand remediation (Yang *et al.* 2019). Studies have shown that: arsenic sandstone and sand structure have complementary characteristics, and the combination of the two can promote the formation of sandy soil (Zhang 2010). In addition, these two kinds of resources overlap in geographical distribution and can be used on the spot, turning "two evils" into "one treasure." Therefore, this research aimed at the remediation of the Mu Us sandy land, selects the ubiquitous arsenic sandstone as the remediation material to improve the sandy land. In addition the evolution of the soil quality after the arsenic sandstone and sand are mixed in different proportions to form the soil are analyzed. The arsenic sandstone and sand compound stability of soil carbon and nutrients in the compound soil in order to provide basic data for the aftereffect stability study of arsenic sandstone and sand composite soil were also explored.

Materials and Methods

The aeolian sandy soil area in Yuyang District, Yulin City, China is an ecologically fragile area, and has been suffering from sandstorms for many years. The present investigators team used colloidal arsenic sandstone mixed into the sand and mixed with sand in different proportions. The technical means of soil promote the agglomeration of sand and soil, improve the physical properties of the arable layer, improve the water and fertilizer retention, and meet the basic needs of crop growth. The project was completed in 2010, and the soil texture is classified as tight sand. The main crops are potatoes and corn, and the improved areas have achieved good economic and ecological benefits.

In the test field, four different proportions of samples were selected: 1 : 1, 1 : 2, 1 : 5, 0 : 1 and the particle organic carbon, microbial carbon content, effective phosphorus, quick-acting potassium, nitro nitrogen and ammonium nitrogen were tested and analyzed. According to the characteristics of different indicators, the differential sampling method is used. According to indicators index, 5 points were randomly selected along the diagonal line in each plot, and soil profile in 2013 and 2019, respectively samples were collected layer by layer according to 0 - 10, 10 - 20, 20 - 30 with a soil drill (Wang *et al.* 2006). Five samples of the same soil layer were mixed and sieved for testing. In view of the carbon content index, 5 points were randomly selected along the diagonal in each plot, and 0 ~ 30 cm soil was selected for collection. The 5 samples of the same soil layer were mixed to form and used for testing after screening, in which nitrate nitrogen and ammonium nitrogen were used for detection in fresh soil, and available phosphorus and available potassium were screened for detection.

Results and Discussion

After 3 years of crop planting, the arsenic sandstone and sand composite soil were used to study the soil particle organic carbon. Results showed (Fig. 1A) that the soil particle organic carbon content decreased as the soil layer deepened, and the specific content was 0-10cm (1.86 g/kg) > 20-30 cm (1.14 g/kg) > 10-20 cm (1.38 g/kg). There was no significant difference in soil particle organic carbon content in all soil layers ($p > 0.05$). After 9 years of crop planting, the arsenic sandstone and sand composite soil were studied for soil particulate organic carbon. Results showed (Fig. 1B) that as the soil layer deepened, the soil particulate organic carbon content first increased and then decreased: 10-20 cm (2.70 g/kg) > 0-10 cm (2.72 g/kg) > 20-30 cm (2.45 g/kg). There was no significant difference in the organic carbon content of soil particles in the 10-20 cm soil layer ($p > 0.05$). In the 0-10 cm soil layer, the organic carbon content of particles treated with 0 : 1 was the lowest, which was 1.73 g/kg. Compared with the treatments of 1 : 5 and 1 : 1, significant increases were of 74.74 and 94.90% ($p < 0.05$). There was no significant difference between 1 : 5 and 1 : 1 treatments ($p > 0.05$). In the 20-30 cm soil layer, the particle organic carbon content of the 1 : 2 treatment was the lowest, which was 1.92 g/kg. There was no significant difference among the other three treatments. The 0 : 1, 1 : 5 and 1 : 1 treatments were more than 1 : 2. Treatment increased by 46.20 ($p < 0.05$), 29.27 ($p > 0.05$) and 34.07% ($p < 0.05$).

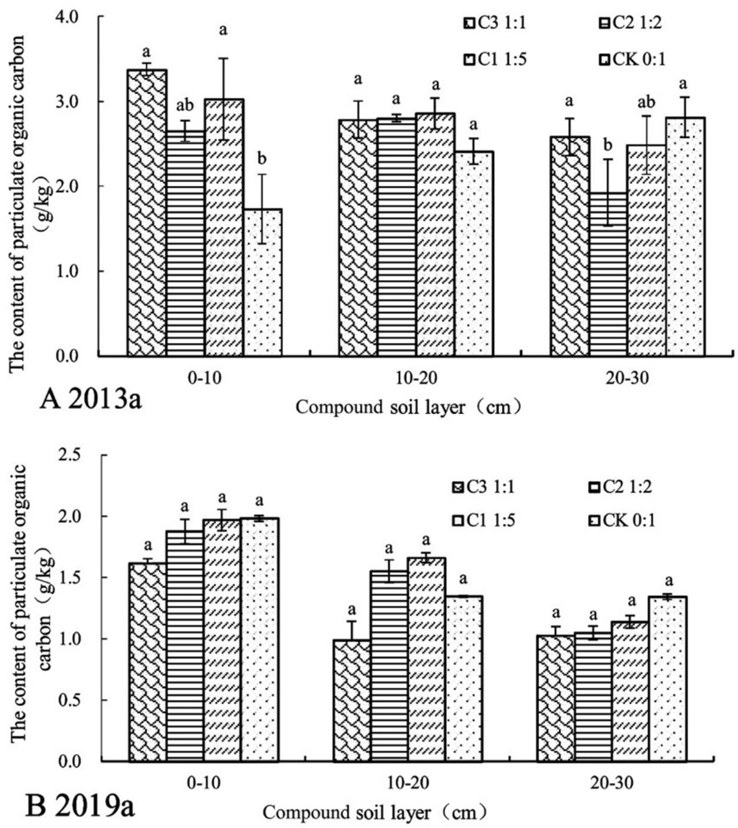

Fig. 1. The content of particulate organic carbon in different proportions of soil layers in 2013 and 2019 after the combination of arsenic and sand.

After 9 years of planting, the root system of the crop developed, and the biomass of the root residue was more than the biomass left on the ground after the crop was harvested, so the average particulate organic carbon content first increased and then decreased.

After 3 and 9 years of crop planting, the soil microbial biomass carbon of the arsenic sandstone and sand composite soil was studied, and the results showed that after crop planting and cultivation, the microbial biomass carbon content in the composite soil of various proportions was higher (Fig. 2). The whole sand has been significantly improved. After 3 years of planting, the microbial biomass carbon content in the 1 : 1, 1 : 2 and 1 : 5 treatments was significantly higher than that of the whole sand by 39 ($p < 0.05$), 117 ($p < 0.05$) and 85% ($p < 0.05$), respectively. After 9 years later, the microbial biomass carbon content in the 1:1, 1:2, and 1:5 treatments was significantly higher than that of the whole sand by 85 ($p < 0.05$), 165 ($p < 0.05$) and 143% ($p < 0.05$), respectively. After crop cultivation from 2013 to 2016, the microbial biomass carbon content in the 1 : 1, 1 : 2, 1 : 5 and 0 : 1 treatments increased significantly by 99 ($p < 0.05$), 81 ($p < 0.05$), 95 ($p < 0.05$) and 49% ($p < 0.05$), respectively. In 2013 and 2019, the microbial biomass carbon content under each treatment showed a trend of 1 : 2 > 1 : 5 > 1 : 1 > 0 : 1 and both reached the maximum value under the 1:2 treatment, which was significantly higher than other treatments .

After crop planting and cultivation, the microbial biomass carbon content in the mixed soils of all proportions has been significantly increased compared with the whole sand, and with the increase of planting years, the microbial biomass carbon content in the soil in 2019 was significantly higher than that in 2013. After the improvement of sandy soil, the microbial community in the composite soil significantly improved, and with years of planting and cultivation, the soil root microbial community has developed benign.

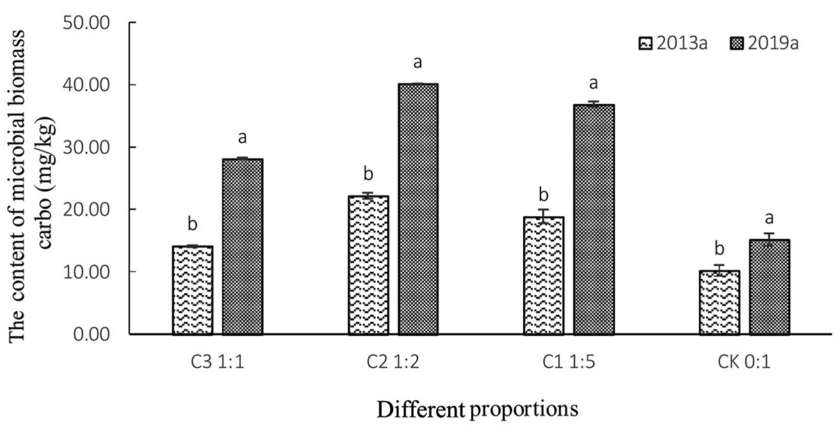

Fig. 2. The content of microbial biomass carbon in different proportions of soil after the combination.

Through the compounding of different proportions of arsenic sandstone and sand, after years of cultivation, long-term location monitoring of the available phosphorus in each proportion of compounded soil from 2016 to 2019 showed that with the extension of the ratio, the content of available phosphorus in the composite soils of all proportions has increased (Fig. 3). Under the 1:1 treatment, the content of available phosphorus increased by 46 ($p < 0.05$) and 4% ($p > 0.05$) from 2016 to 2019 year by year, 59% ($p < 0.05$), under the 1 : 2 treatment, the content of available phosphorus increased by 31 ($p < 0.05$), 10 ($p > 0.05$) and 96% ($p < 0.05$) year by year from 2016 to 2019. Under the 1:5 treatment, the content of available phosphorus from 2016 to 2019 increased by 31 ($p < 0.05$), -4 ($p > 0.05$) and 115% ($p < 0.05$) year by year, and under the 0:1 treatment, 2016. In 2019, the content of available phosphorus increased by 11 ($p > 0.05$), 31 ($p < 0.05$) and 13% ($p > 0.05$) year by year. In different years, the available phosphorus content in each ratio showed a trend of 1 : 2 > 1 : 5 > 1 : 1 > 0 : 1. After 9 years of cultivation compared with 6 years of cultivation, the ratios of compound soil were cultivated for 9 years. The effective phosphorus content in the compound ratios of 1 : 1, 1 : 2, 1 : 5, 0 : 1 were significantly increased by 141 ($p < 0.05$), 181 ($p < 0.05$), 169 ($p < 0.05$) and 63% ($p < 0.05$).

With the extension of planting years, the content of available phosphorus in the mixed soils of various proportions has increased, and in different years, the content of available phosphorus in each proportion reflected 1 : 2 > 1 : 5 > 1 : 1 > 0 : 1 trend. After adding arsenic colloidal substance, the phenomenon of water leakage and fertilizer leakage on sandy land has been significantly improved, and the ratio of soil sand to clay under the 1 : 2 compound ratio was moderate, which can better store the content of available phosphorus in the soil. .

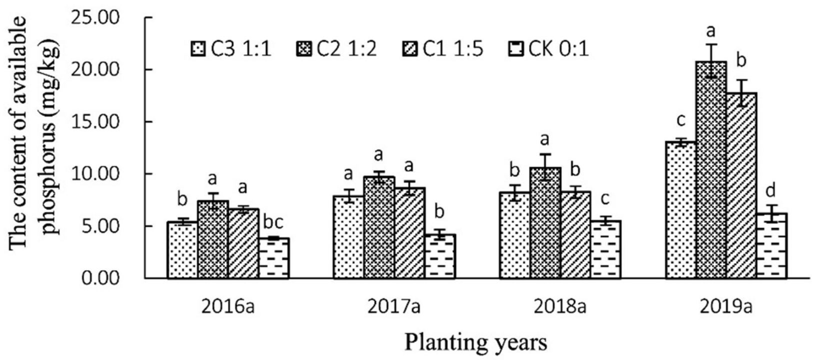

Fig. 3. The content of available phosphorus in surface soil at different proportions from 2016 to 2019 after the combination of arsenic and sand.

Through the compounding of different proportions of arsenic sandstone and sand, after years of cultivation, the available potassium in each proportion of compounded soil from 2016 to 2019 was monitored for long-term positioning. The results showed that the content of available potassium in each proportion of the compound soil expressed an overall upward trend (Fig. 4). Among them, under the 1 : 1 treatment, the content of available potassium increased by -10 ($p > 0.05$) 36 ($p < 0.05$) and 21% ($p < 0.05$), under the 1:2 treatment, the content of available potassium increased by 24 ($p < 0.05$), 7 ($p > 0.05$) and 18% ($p < 0.05$) (from 2016 to 2019). Under the 1 : 5 treatment, the content of available potassium increased year by year by 7 ($p > 0.05$), -7 ($p > 0.05$) and 28% ($p < 0.05$) (from 2016 to 2019). Under the 0 :1 treatment, the content of available potassium increased by 21 ($p < 0.05$), 6 ($p > 0.05$) and 20% ($p < 0.05$) year by year (from 2016 to 2019). In different years, the content of available potassium showed a trend of 1 : 2 > 1 : 5 > 1 : 1 > 0 : 1 in each ratio. After 9 years of cultivation compared with 6 years of cultivation, the proportions of compound soil were cultivated for 9 years. The content of available potassium in the compound ratio of 1 : 1, 1 : 2, 1 : 5, 0 : 1 was significantly increased by 48 ($p < 0.05$), 56 ($p < 0.05$) 27 ($p < 0.05$) and 55% ($p < 0.05$).

With the extension of planting years, the content of available potassium in each proportion of compound soil showed an overall upward trend. After 9 years of cultivation compared with 6 years of cultivation, the ratio of compound soil was cultivated. The content of available potassium in the compound ratios of 1 : 1, 1 : 2, 1 : 5 and 0 : 1 significantly increased. With the increase of planting years, the incorporation of arsenic sandstone accelerates the natural succession process of soil quality (Wang *et al.* 2017, Cao *et al.* 2018).

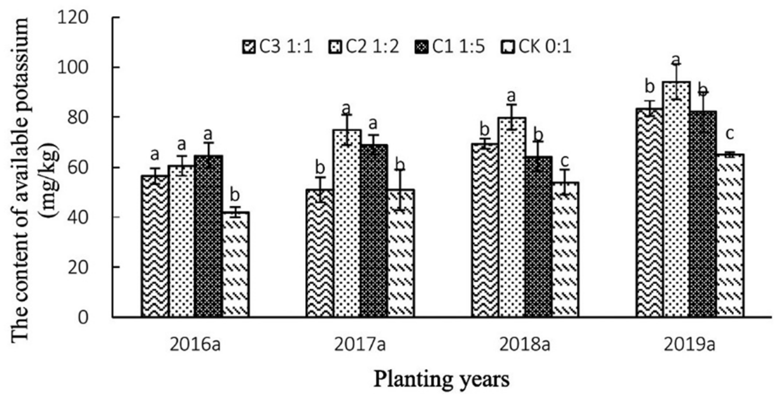

Fig. 4. The content of available potassium in surface soil at different proportions from 2016 to 2019 after the combination of arsenic and sand.

The arsenic sandstone and sand were mixed in different proportions. After years of cultivation, the nitrate nitrogen in the mixed soil in each proportion from 2016 to 2019 was monitored for long-term positioning. The results showed that with the extension of the years, the overall nitrate nitrogen in each proportion of the composite soil expressed an overall upward trend (Fig. 5). Under the 1 : 1 treatment, the nitrate nitrogen content increased by 8 ($p > 0.05$) and 11 ($p > 0.05$) and 18% ($p < 0.05$), (from 2016 to 2019) under the 1 : 2 treatment, the content of nitrate nitrogen increased by 72 ($p < 0.05$), 29 ($p < 0.05$) and 4% ($p > 0.05$) from 2016 to 2019 under the 1 : 5 treatment, the nitrate nitrogen content increased by 98 ($p < 0.05$), 8 ($p > 0.05$) and 10% ($p > 0.05$) year by year from 2016 to 2019, and under the 0:1 treatment, the content of nitrate nitrogen increased by 90 ($p < 0.05$), -8 ($p > 0.05$), and 26% ($p < 0.05$) year by year (from 2016 to 2019). From 2017 to 2019, the nitrate nitrogen content was the highest under the 1:2 treatment, and the nitrate nitrogen content in the mixed soils of all proportions in different years was significantly higher than that of the sandy land. After 9 years of cultivation compared with 6 years of cultivation, the nitrate nitrogen content in the ratios of 1 : 1, 1 : 2, 1 : 5 and 0 : 1 of the compound soil increased significantly by 40 ($p < 0.05$), 130%, ($p < 0.05$), 135 ($p < 0.05$) and 120% ($p < 0.05$), respectively.

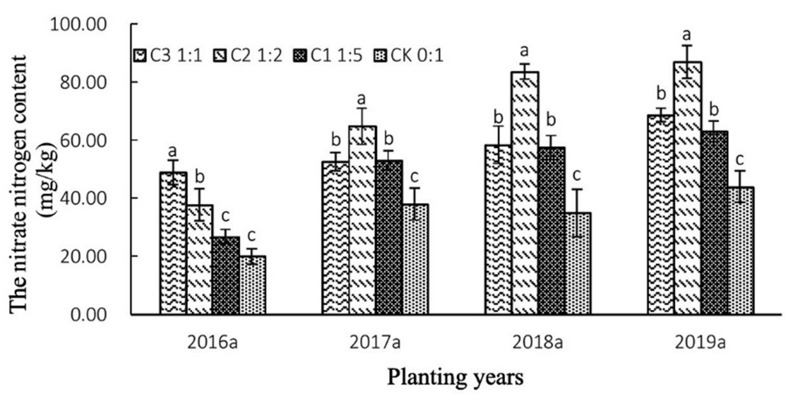

Fig. 5. The nitrate nitrogen content of surface soil at different proportions from 2016 to 2019 after the combination of arsenic and sand.

With the extension of planting years, the overall nitrate nitrogen in each proportion of compound soil showed an upward trend. Compared with 6 years of cultivation in each proportion of compound soil, the nitrate nitrogen content in the compound ratio of 1 : 1, 1 : 2, 1 : 5, and 0 : 1 were significantly increased. From 2017 to 2019, the content of nitrate nitrogen was the highest in 1 : 2 compound soil. Nitrate nitrogen is easily soluble in water, and the higher the proportion of sand in the composite soil, the easier the nitrate nitrogen content in the soil will be lost (Sun *et al.* 2018, Cao *et al.* 2019).

The arsenic sandstone and sand were compounded in different proportions. After years of cultivation, long-term positioning monitoring of ammonium nitrogen in the compound soils in various proportions from 2016 to 2019 showed that with the extension of the age, the overall ammonium nitrogen in each proportion of the composite soil increased first and then declined (Fig. 6). Under the 1 : 1 treatment, the content of ammonium nitrogen increased by 30% from 2016 to 2019 ($p < 0.05$), -27 ($p < 0.05$) and -32% ($p < 0.05$), under the 1 : 2 treatment, the content of ammonium nitrogen increased by 17 ($p < 0.05$) and -50% ($p < 0.05$) from 2016 to 2019 year by year, 12% ($p < 0.05$), under 1:5 treatment, the content of ammonium nitrogen increased by 23% ($p < 0.05$), -39 ($p < 0.05$) and -27% ($p < 0.05$), under 0:1 treatment, the content of ammonium nitrogen increased by 29 ($p < 0.05$) and -24% ($p < 0.05$), and -37% ($p < 0.05$) year by year from 2016 to 2019. In 2016, 2017 and 2019, the content of ammonium nitrogen was the highest under the 1:2 treatment, and the content of ammonium nitrogen in the mixed soils of various proportions in different years was significantly higher than that of the sandy land. After 9 years of cultivation compared with 6 years of cultivation, the various proportions of compound soil have significantly reduced the ammonium nitrogen content of 1 : 1, 1 : 2, 1 : 5, and 0 : 1 by 35 ($p < 0.05$) and 34 ($p < 0.05$), 45 ($p < 0.05$) and 37% ($p < 0.05$), respectively.

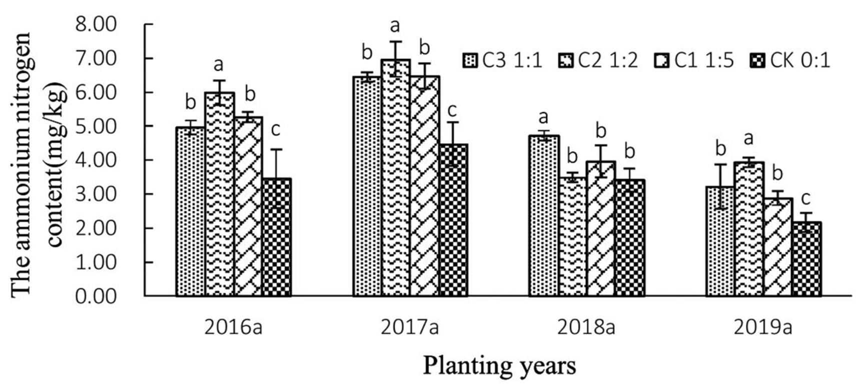

Fig. 6. The ammonium nitrogen content of surface soil at different proportions from 2016 to 2019 after the combination of arsenic and sand.

With the extension of planting years, the overall ammonium nitrogen in each proportion of compound soil increased first and then decreased. The proportion of compound soil was cultivated for 9 years compared with 6 years cultivation, 1 : 1, 1 : 2, 1 : 5, 0 : 1 The ammonium nitrogen content in the compound ratio was significantly reduced. Ammonium volatilization is an important part of the loss of nitrogen fertilizer in farmland. At the surface of the soil, due to harvest disturbance and high soil exposure, the content of ammonium nitrogen has decreased significantly. With the erosion of precipitation, the ammonium salt will be washed downward, and the ammonium nitrogen accumulated in the surface layer caused by continuous downward scouring (Zhang *et al.* 2015).

The project was completed in 2010.After 9 years of planting, the root system of the crop was developed, and the biomass of the root residue was more than that left on the ground after the crop was harvested. The average particle organic carbon content increased first and then decreased. After sandy soil was improved, the microbial community in the compound soil has been significantly improved, and with years of planting and cultivation, the soil root microbial community has developed benign. With the increase of planting years, the incorporation of arsenic sandstone accelerated the process of natural succession of soil quality, and better improved the phenomenon of water leakage and fertilizer leakage in sandy land. Compared with sandy land, the compound soil is less effective for available phosphorus and available potassium. Storage was significantly improved. The proportions of compound soil were cultivated for 9 years compared with 6 years. The nitrate nitrogen content in the compound ratios of 1 : 1, 1 : 2, 1 : 5 and 0 : 1, respectively increased significantly, and the nitrate nitrogen was easily soluble in water. The higher the proportion of sand in the mixed soil, the easier the nitrate nitrogen content in the soil will be lost. After years of cultivation, the ammonium nitrogen content in the compound soil has a downward trend. The soil surface is disturbed by harvesting and the soil is exposed to a high degree. The volatilization of ammonium nitrogen is the main factor for the decline of the ammonium nitrogen content.

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