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Variation of soil nutrients and particle size under different vegetation types in the Yellow River Delta

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ABSTRACT

The Yellow River Delta wetland, located at the southern coast of Bohai Gulf, provides important ecosystem services such as flood control, water purification, biodiversity conservation, nutrient removal and carbon sequestration, shoreline stabilization, tourism attraction and wetland products maintains in the Yellow River Delta. This study assessed how agricultural activities in a reclamation wetland changed soil pH, soil electric conductivity, soil nutrient and soil particle size as compared to natural vegetation by using a combination of field experiments and lab analysis. The vegetation type included adjacent alfalfa field (*Medicago sativa*), cotton field (*Gossypium* spp.), Chinese tamarisk shrub (*Tamarix chinensis*), and reed marsh (*Phragmites sage*). The results indicated that the soil pH was higher (pH > 8) in alfalfa field and cotton field, and alfalfa field and reed marsh had significant function in reducing soil salt content, soil electric conductivity of alfalfa field at 0–30 cm were 140.38 ± 14.36, 114.48 ± 14.36, 125.30 ± 11.37 µs/cm. The effect of different vegetation types on soil nutrient was significant ($P < 0.05$). Soil organic matter at 0–10 cm in Chinese tamarisk shrub and reed marsh was 21.66 ± 3.82 g/kg and 16.51 ± 4.60 g/kg, which was higher than that of alfalfa field (10.47 ± 2.36 g/kg) and cotton field (9.82 ± 1.27 g/kg), but soil total nitrogen content in alfalfa field was the highest, which is significantly higher than that of cotton field, Chinese tamarisk shrub and reed marsh($P < 0.05$), the content of soil total nitrogen at 0–10 cm and 10–20 cm was 7.67 ± 0.38 g/kg and 5.97 ± 0.51 g/kg, respectively, while the content of available *P* and available *K* was reversed. The difference of soil particle size between layers was not significant ($P > 0.05$), the sand content of Chinese tamarisk shrub soils in 0–10 cm was the highest, the next was alfalfa field and cotton field, and the content of silt and clay in reed marsh was higher than the others. The correlation and significant degree between soil particle size and soil nutrient was related with vegetation types, and soil organic matter was significantly positively correlated with soil silt and clay content on the alfalfa field. The results demonstrated that wetland cultivation was one of the most important factors influencing on the nutrient fate and reserves in soil, which could lead to rapid nutrient release and slow restoration through abandon cultivation. Consequently, compared with cotton field, alfalfa field is more favorable to sustainable management of wetland cultivation in the Yellow River Delta. It should be considered in wetland restoration projects planning.

1. Introduction

Soil and vegetation are the two important components of the terrestrial ecosystem. As the media during ecology process of ecosystem [1,2], soil is also the important content of ecology research. The relationship between soil physicochemical properties and vegetation styles is rely on and resistance each other [3,4]. Soil nutrient condition is the key index in evaluating function recover and retain of degradation ecosystem [5]. Soil particle fraction change, the indicator of soil-vegetation system feedback each other [6], affects the change of water infiltration and allocation [7]. The retention of soil nutrient and water decline during the soil sandy process, and soil structure will be destroyed with the loss of soil fine particle fraction [8,9]. Vegetation styles affect the soil formation and nutrient cycle [10,11] and change the surface soil

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characteristics [12]. Frequent human disturbance contributed to the transition of vegetation style. The research showed that the transition of natural vegetation system to artificial farmland will lead to the emission of soil organic carbon [13,14].

The saline–alkali reclamation area of the Yellow River Delta is the particular agricultural grassland style, and for a long time it has been the key zone of reclamation for agriculture and the establishment of artificial grassland. The characteristics of its habitat condition are complexity, instability and vulnerability [15,16]. The search results about land use change for 30 years of the Yellow River Delta through sense data and vector data have shown that the area of new reclamation forage land and farmland increased fast, and the area of forage land changed most frequently in newborn wetland [17,18]. In recent years, the Yellow River Delta wetland has deteriorated to various certain extents due to the natural and human factors, such as fast increasing population, land reclamation and oil exploitation, and its recover and reconstruction have become the search hot of wetland field [15,19–21]. Some research showed the ratio of soil organic carbon input/output changed significantly after the wetland vegetation was reclaimed into farmland, and previous balance of soil organic was disturbed seriously. The biomass carbon put into the soil reduced with the aerobic decomposition of soil organic matter due to agricultural tillage and harvest. Huang et al. established the Soil-C model to modify the soil organic carbon change of farmland [22,23], and estimated the soil organic carbon change after the conversion of Sanjiang Plain to farmland. It can be better to modify the effect of wetland reclamation on soil organic carbon [24]. It is different intensity that the effect of different reclamation style on soil properties. The search of Huo Lili in Sanjiang Plain showed that it was better for soil organic carbon sequestration over a long period of time following the conversion of *Calamagrostis angustifolia* wetland to soybean field than rice field [25]. Ewing' research about wetland soil and chemical properties for different tillage years showed that the tillage production for a long period of time led to the significant difference of soil chemical properties in different soil depth; the increased soil nutrient for 15 years tillage was mainly in the soil surface of 0–20 cm, and the increased soil nutrient for 30 years tillage was mainly in the soil surface of 0–100 cm [26].

There are two reclamation models of perennial alfalfa and annual cotton crop in the Yellow River Delta reclamation zone. The tillage intensity is lower in perennial alfalfa than in annual cotton crop. There were few searches about the particle fraction, soil nutrient and its relationship under the two reclamation models. In this study, we investigated the effect of two reclamation models on soil physicochemical properties in the Yellow River Delta reclamation zone, and try to understand the change and relationship between soil nutrient and particle fraction of different vegetation styles in the Yellow River Delta through compare the soil physicochemical properties of two kinds of artificial and natural vegetation. The aim of our study was to provide the scientific evidence for optimizing the land use structure in wetland reclamation zone.

2. Materials and methods

2.1. General characteristics of study sites

The present study field was located at the Yellow River Delta which was in the north of Shandong Peninsula, on the northern east coast of China (latitude 37°47′49.4″–37°84′57.2″N, longitude 118°39′47.4″–119°08′36.1″E, elevation 3–12 m). The study was conducted in March, 2010. The climate of the site was classified as warm and semi-humid monsoon with a long-term annual mean air temperature of 12.1 °C; the frost-free period was 193 d; mean annual precipitation was 585 mm; annual evaporation was 1900–2000 mm. The soil was mainly silt particle type, and the soil surface texture was light loam with good arable land suitable sowing for alfalfa. But granular structure was not formed in soil, and the soil had a poor fertilizer conservation due to short development time. The salinization of most soil in research region was potentially serious, and was typical heavy chloride saline.

2.2. Experiment design and soil measurement

There are four types of vegetation in the experimental region, including alfalfa (*Medicago sativa*) grassland (AG), cotton (*Gossypium* spp.) field (CF), *Tamarix chinensis* shrub land (TL) and *Phragmites sage* grassland (RG). The AG site was artificial grassland reclaimed from natural saline–alkaline land in 2001. The CF site was mainly crop field in the local region converted from natural saline–alkaline land in 2001. The TL site was shrub land without ever reclaimed where the main vegetation was *T. chinensis*. The RG site was native saline–alkaline grass land that never reclaimed where the representative plant was *Phragmites sage*. The alfalfa and cotton were ever rotational planted due to the constant salinization in the surface and waterlogging. The alfalfa was subject to mowing three to four times in late May, early July, late August or early October, respectively. There was no other disturbing factor except for mowing with no fertilizers, no weeding and no irritation. The cotton field was conventional tillage type with a basal fertilizer and after fertilizer ($CO(NH_2)_2$:$(NH_4)_2HPO_4$ = 3:1; 600 kg/h m^2 every time).

The natural RG site and TL shrub site with 30–45 m width were located beside the two sides of reclamation crop land. The natural site was isolation belt beside the reclamation crop field. There was no other disturbance except for the small animals such as wild rabbits and mice.

Four relative flat surface and representative sample sites were selected as replicates from the vegetation types discussed above. The plant position and its condition of four sample sites for each vegetation type can be seen in Table 1. In August 2010, soils were collected randomly of 20 points in according to "S" route in each replicate plot field with a 4-cm diameter soil auger, and were separated into 10 cm layers down to 100 cm depth. Then 20 replicate

Table 1
The site condition of different vegetation types.

Vegetation types	Latitude and longitude	Elevation	Cultivation and reclamation history
AG	N37°56′56.6"–N37°56′57.5″ E118°41′45.1″–E118°41′55.8″	9\11\11\8 m	Reclaimed from natural land in 2001. Then planted cotton for 2 years (2005–2006) after alfalfa for 4 years (2001–2004). Then changed for alfalfa until 2011 (2007–2011)
CF	N37°52′49.4″–N37°55′26.5″ E118°42′51.0″–E118°43′36.1″	12\9\10\10 m	Reclaimed from natural land in 2001. Then planted cotton for 5 years (2005–2011) after alfalfa for 4 years (2001–2004)
RG	N37°54′19.0″–N37°57′46.9″ E118°40′52.2″–E118°43′02.7″	11\10\9\12 m	No reclaimed site (native vegetation) of *Phragmites sage*
TL	N37°53′55.5″–N37°57′36.5″ E118°40′47.4″–E118°43′34.7″	12\9\6\6 m	No reclaimed site (native vegetation) of *Tamarix chinensis*

Note: AG: alfalfa grassland; CF: cotton field; RG: reed grassland; TL: Tamarix land, the same as below.