INTERANNUAL VARIATIONS AND DISTRIBUTION OF HUMUS COMPONENTS IN SALINE-ALKALI PADDY SOILS

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(Received 24th Oct 2019; accepted 2nd Jul 2020)

Abstract. This study analyzed saline-alkali paddy sois of different reclamation durations in the western Jilin Province of China to identify the distribution and variation of humus components so as to provide a scientific basis for rationally utilizing land resources. Test samples were collected from the former Guoerluosi irrigation area in western Jilin. Paddies with five different farming durations (1, 10, 20, 30 and 55 years) under which single-cropping rice was planted from May to October every year and where all other conditions were common, were selected as the test plots. The results showed that: (1) The ratio of Soil Humus content to organic carbon in paddy field with different cultivation years showed humin > humus carbon > humic acid > fulvic acid, and the content of Humus and its components decreased gradually with the deepening of soil layer; (2) Soil humus components were closely correlated with the content of organic carbon in soil as the regeneration and activation of soil humus had a direct bearing on the variations of the organic carbon pool in soil; (3) The HA/FA and PQ values of saline-alkali paddy soil were positively correlated with farming duration, with the biggest increase in the 20–30 cm soil layer.
Keywords: *cultivation, carbon variation, vertical distribution, saline-alkaline rice fields, humus composition*

Introduction

[Study significance] A large amount of CO_2 has accumulated in the Earth's atmosphere since the 19th century due to the conversion of natural forests and grasslands to farmland (Jonczak, 2014). Therefore, the ebb and flow of carbon in farmland soils will exert direct influences on the atmospheric CO_2 level (Shao et al., 2018). The former Guoerluosi (Qianguo) irrigation area, western Jilin Province, China, is one of the four largest irrigation areas in Northeast China and also one of the world's three largest areas of saline-alkali soil; therefore, the region is of importance for global carbon cycle studies (Tang et al., 2011). Included among recent efforts to improve land salinization in this area are the artificial enclosures of degraded grasslands and some dry land or the conversion of these areas to paddy fields. Changing carbon fixation capacity, soil fertility and CO_2 emissions of paddy soils is evident with changing land use (Ding et al., 2013; Zhang et al., 2015). Therefore, it is of great significance to study the factors driving the variations and regeneration patterns of humus components in saline-alkali soils under different farming durations so as to derive knowledge for improving the soil quality, fertility and carbon sequestration capacity of saline-alkali paddy fields. [Previous study progress] Soil humus is one of the main components of soil organic matter and is a key indicator of soil fertility and quality as its amount and composition can reflect certain soil-forming conditions and processes (Six et al., 2004; Dong et al., 2017; Wiao et al., 2020). As an organic substance formed by the decomposition of dead

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1804_50655077

organisms by soil microorganisms, humus is mostly derived from plant litter and decaying roots. Humus is not a single organic compound, but rather a mixture of organic compounds with commonalities and differences in composition, structure and properties, including humus carbon (HE), humic acid (HA), fulvic acid (FA) and humin (HM) (Brady, 1974; Bunting, 1987; Brady et al., 2000; Zheng, 2019). Much research, both in China and globally, has been performed in recent years on the factors influencing the composition of soil humus (Andreetta et al., 2011; Vos et al., 2015; Dong and Dou, 2017; Daryanti et al., 2019). It has generally been shown that humus is a relatively stable soil component and is notably affected by the geographical environment and biological factors (Zhu et al., 2018). [Study approach] It is known that farming practices and duration both affect the content and distribution of soil humus to some extent (Wang et al., 2015; Li et al., 2016). Therefore, the present study has analyzed the variation in the vertical distribution of humus over time in saline-alkali paddy soil. [Proposed solutions to key problems] The present study has analyzed the variations in the composition of humus for different paddy soil layers as a result of farming duration to provide a scientific basis for the rational use of land resources so as to improve both rice yield and soil carbon sequestration capacity. Saline-alkali soil is an important reserve land resource. Through this study, the response of Humus composition to reclamation years and soil layers can be determined, which is the focus of this study, the results can provide reference for the rational development and utilization of saline-alkali land.

Materials and Methods

Study Area

The study area is located in the irrigation region of the former Guoerluosi Mongolian Autonomous County of Jilin Province (E123°35' - 125°18', N44°17' - 45°28'). This region has a temperate continental monsoon climate with four distinct seasons. Highest and lowest temperatures are approximately 36 ℃ and −36 ℃, respectively. The region is dry and windy in spring, hot and humid in summer, cool in autumn with a large diurnal temperature difference and cold in winter with little snowfall and a long freezing period. The annual averages of sunny days, hours of sunshine and temperature are 110 d, 2,879 h and 4.5 ℃, respectively. The first day of frost generally falls in the middle of or late September, whereas the final frost date generally falls between late April and early May; hence, the frost-free duration is 130 – 140 d. The average annual precipitation is 400 – 500 mm. The annual average evaporation is > 1,200 mm, with evaporation from April to May accounting for 531.2 mm or 45.2% of the annual total (Tang et al., 2012; Liu et al., 2018). Single-cropping rice seedlings are generally planted in mid-May, and the mature plants are harvested in October. The rice growth stage is mainly supported by application of urea and potassium and phosphate fertilizers. *Figure 1* shows the monthly average precipitation and temperature in the study area in 2015.

Test Design

Investigation of maps of soil types and land use types combined with the paddy field farming history and field investigation was performed to facilitate the selection of representative sampling plots and universal test results (*Fig. 2*). Sampling was conducted on plots with paddy soils farmed over five different durations (1, 10, 20, 30

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and 55 years) under basically the same natural conditions. Three 20 m × 20 m sampling areas were established in each sampling plot before rice planting in 2015 (early May). Each sampling area contained five S-shaped sampling points where soils were collected from five levels (0 cm -10 cm, 10 cm -20 cm, 20 cm -30 cm, 30 cm -40 cm and 40 cm - 50 cm), soil samples were taken by a drill with a diameter of 10 cm. The collected soil samples were then processed to remove grit and plant residues, air-dried and then sequentially filtered with 0.2 mm and 0.125 mm sieves before being analyzed for soil organic carbon and humus components (*Fig. 3*). The basic information of the plots is shown in *Table 1*.

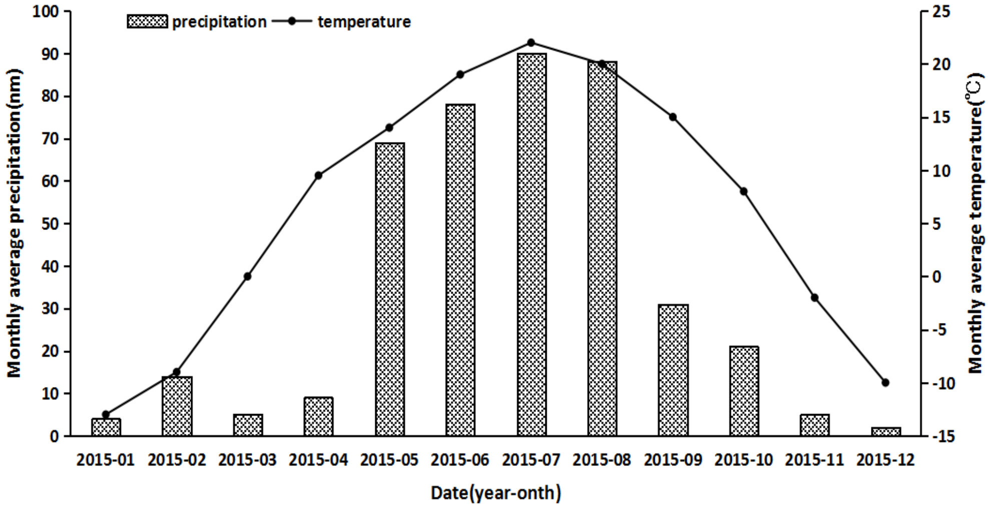

Figure 1. *Mean precipitati on and temperature in the study area in 2015*

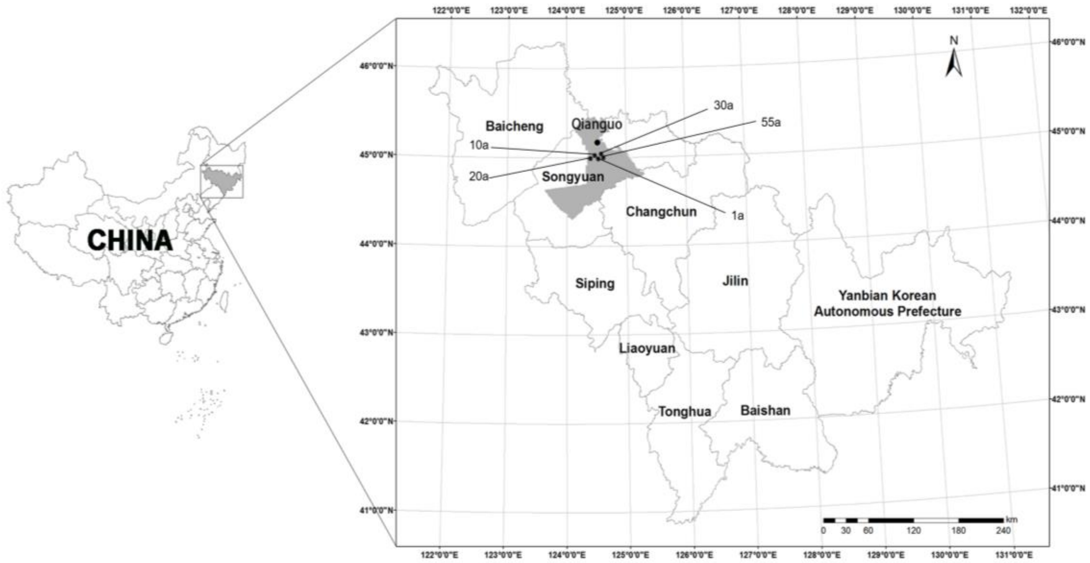

Figure 2. *The location of the study area and the distribution of the sampling points*

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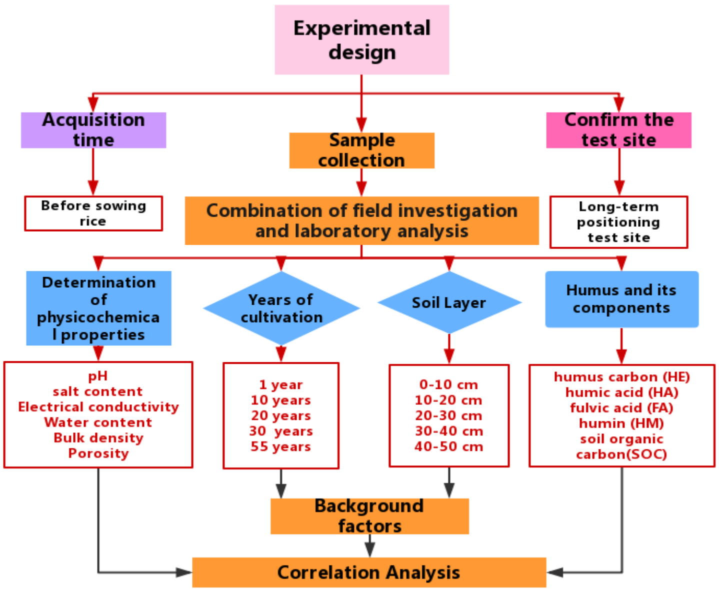

Figure 3. *Test Design and procedure*

Table 1. *Overview of study area*

Sample number	Cultivation history	Geographical location	Soil type	pH	Salt content /%	Electrical conductivity /ms·cm^{-1}	Water content /%	Bulk density /g·cm^{-3}	Porosity /%
R1	1 a	E124°42′27″, N45°00′05″	rice soil	8.7	2.088	0.306	0.54	1.01	0.63
R10	10 a	E124°41′40″, N45°00′23″	rice soil	8.53	1.923	0.218	0.48	0.87	0.67
R20	20 a	E124°40′41″, N45°00′25″	rice soil	8.56	1.961	0.211	0.50	0.83	0.70
R30	30 a	E124°42′45″, N45°01′24″	rice soil	8.12	1.784	0.132	0.47	0.90	0.66
R55	55 a	E124°43′03″, N45°00′19″	rice soil	8.07	1.736	0.104	0.48	0.92	0.64

Test Indicators and Methods

Soil organic carbon and humus components were determined using the potassium dichromate volumetry-thermodilution method (Cha, 2017). The humus components were extracted by weighing 2.5 gair-dried soil sample in 100 mL centrifuge tube, adding 0.1 mol·L^{-1} $Na_4P_2O_7 \cdot 10H_2O$, 0.1 mol·L^{-1} NaOH mixture 50 mL, shaking 145 r·min^{-1} at 70 °C in a constant temperature water bath oscillator, extracting for 1 h, then centrifuging and filtering, the humic acid (HE) can be extracted in a 50 mL volumetric flask. The residue in the centrifuge tube is called crude humin (HM). The Alkali extract was extracted with 30 mL in 50 mL flask, and 1 mol·L^{-1} H2SO4 was added to adjust the pH value to 1.0-1.5. Place the solution in a 60-70 °C water bath for 1-2 h, then leave overnight. On the next day, the solution was quantitatively filtered

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DOI: http://dx.doi.org/10.15666/aeer/1804_50655077

with medium speed filter paper, and the precipitate was HA, and the solution was FA (Zhang et al., 2004).

Data Processing

Statistical analysis was performed using SPSS 19.0 statistical software (SPSS Inc., Chicago, IL, USA). Statistical significance of soil organic carbon and humus components in different reclamation years and in different soil layers was determined by one-way analysis of variance (ANOVA) and Fisher's least significant difference (LSD) test. Multivariate analysis of variance was used to examine the differences of soil carbon and Statistical significance of soil organic carbon and humus in different reclamation years and soil layers. Pearson correlation analysis was used to estimate the relationship between organic carbon and humus components.

Results

Interannual Variation in Saline-alkali Paddy Soil Humus Components

Variations in Humus Carbon Content

The content of extractable humus carbon (HE) in reclaimed soil increased significantly, and showed an increasing trend with the extension of reclamation years. He in reclaimed soil was about 5.64 - 8.22 $g{\cdot}kg^{-1}$ in 55 years, which was about 10 times higher than that in unreclaimed soil. He was significantly higher in 0-10cm than in 40-50 cm *($P < 0.05$*) in different soil layers, and there was no significant difference in HE between 30-40cm and 40-50cm soil layers (*Fig. 4*).

Variations in Humic Acid Content

Humic acid (HA) is a brown to deep-brown extractable humus that is soluble in dilute alkali soil but dilute acid soil. HA has colloidal properties and is one of the relatively active parts of soil humus, playing an important role in soil structure composition (Gong et al., 2009; Chu et al., 2013). As illustrated by *Figure 5*, the HA content of each soil layer generally increased with increasing farming duration, with the lowest and highest HA contents were found in R1 and R55 soils, respectively. The HA content of the R0 0 cm–10 cm soil layer was significantly higher than those of the R1, R10, R20 and R30 soils by 48.25%, 29.01%, 17.35% and 11.19%, respectively ($P < 0.05$). For the 10 cm–20 cm soil layer, no significant difference in HA content were evident between R1, R10 and R20 soils as well as between R30 and R55 soils; however R55 HA content increased by 50% compared with R1. For the 20 cm–30 cm soil layer, no significant difference in HA content was evident between R10, R20 and R30 soils; however, R55 HA content was significantly higher than those of other farming durations, and increased by 68.87% compared with R1. For the 30 cm–40 cm soil layer, R20 soil HA content was significantly higher than those of R1, R10 and R30 soils; the R55 soil HA content was in particular higher than those of other farming years. For the 40 cm–50 cm soil layer, no significant differences in HA content were evident between R1 and R10 as well as between R20 and R30; however, that of R55 was significantly higher than those of other farming durations. A decrease in HA content with increasing depth was evident for soils of all farming durations. The soil HA contents between the 0 cm–10 cm and 40 cm–50 cm soil layers were significantly different ($P < 0.05$). The 0 cm–10 cm soil HA contents for R1, R10, R20, R30 and R55

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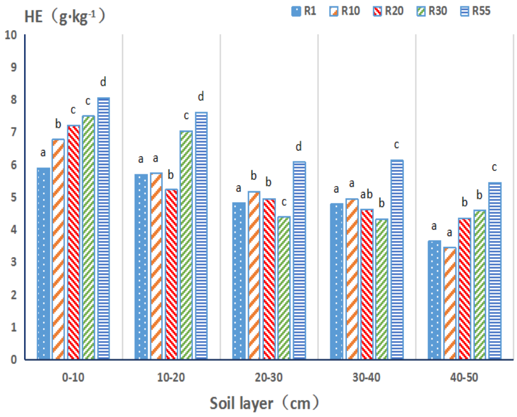
soils were higher than their respective 40 cm–50 cm layers by 1.07 g·kg^{-1}, 1.64 g·kg^{-1}, 1.4 g·kg^{-1}, 1.4 g·kg^{-1} and 1.23 g·kg^{-1}, respectively. These results indicates a buildup of soil HA with increasing farming duration. In addition, HA content decreased with increasing depth, suggesting that the surface layer gains the most HA with increasing farming duration.



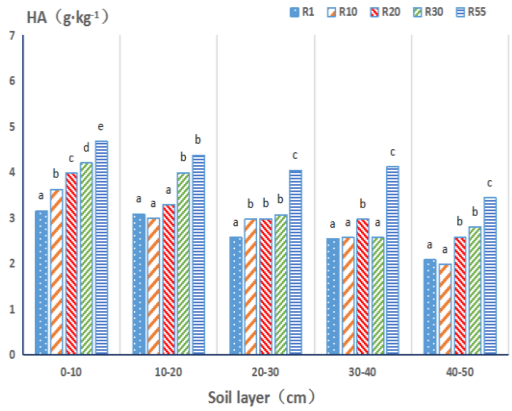


Figure 4. *Vertical distribution of humus carbon in saline-alkaline soil over different farming durations*

Figure 5. *Vertical distribution of humic acid in saline-alkaline soil over different farming durations*

Note: lowercase letters indicate a significant difference at P< 0.05

Variations in Fulvic Acid Content

Fulvic acid (FA) is low in molecular weight, with a brown or black surface appearance and is soluble in acid, alkali and ethanol solutions and water. FA is beneficial to soils in that it assists in the adsorption of heavy metals and in releasing nutrients (Sądej and Żołnowski, 2015; Borowska et al., 2015). *Figure 6* illustrates that the 0 cm-10 cm R1 soil layer FA content was dramatically higher than those of other farming durations *(P < 0.05*) and those of R10, R20, R30 and R55 soils remained relatively stable across all farming durations at 3.15 g·kg^{-1}, 3.23 g·kg^{-1}, 3.29 g·kg^{-1} and 3.39 g·kg^{-1}, respectively. For the 10 cm–20 cm soil layer, no significant difference in FA was evident between Rl and R30 as well as between R30 and R55, whereas that of R30 (3.05 g kg^{-1}) was significantly lower than those of other farming durations. For the 20 cm–30 cm soil layer, no significant differences were evident between R1 and R10 as well as between R20 and R55, whereas that of R20 (1.98 g·kg^{-1}) was notably lower than those of other farming durations. For the 30 cm–50 cm soil layer, no significant difference was evident between R1 and R10 as well as between R20 and R30. No consistent pattern was evident in soil FA content for different farming durations and between soil layers. The soil FA content appeared to accumulate with increasing farming duration in the 0 cm–10 cm and 40 cm–50 cm soil layers, whereas it decreased before increasing in the 10 cm–40 cm soil layer, and was relatively low in R20 and R30 soils.

Variations of Humin Content

Humin (HM) is a humus component which combines most closely with soil minerals, and cannot be extracted by any acid, alkali or organic solvents. Therefore, as

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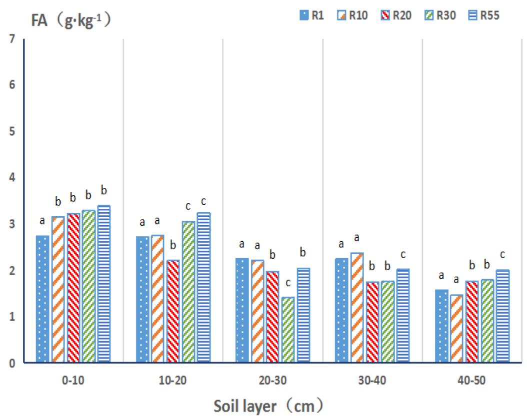
an inert humus component, it is the most resistant to decomposition and can exist in soil for over a thousand years (Newcomb, 2015). In recent years, studies have shown that HM is composed of carbonized microbial protoplasmic and plant residues, and that due to its ubiquitous presence in the natural environment, can be used as an electron mediator to promote bioremediation of organic pollutants. As a result, there is a growing interest in this substance (Kramer et al., 2004). *Figure 7* illustrates that the 0 cm–10 cm HM soil content tended to increase first and then decrease with increasing farming duration. In addition, R1 and R30 soils had the lowest and highest HM contents at 6.89 $g \cdot kg^{-1}$ and 8.06 $g \cdot kg^{-1}$, respectively, with no significant difference evident between R1 and R10 as well as between R30 and R55. HM in the 10 cm–20 cm soil layer appeared to increase with increasing farming duration. However, HM contents for this layer in the R1, R10 and R20 soils remained stable at between 6.08 $g \cdot kg^{-1}$–6.64 $g \cdot kg^{-1}$ and between 7.73 $g \cdot kg^{-1}$–7.81 $g \cdot kg^{-1}$ for R30 and R55 soils. The HM content of the 20 cm–50 cm soil layer increased, then decreased and then increased again with increasing farming duration, and was highest in the R10 and R55 soils with no significant difference between R1 and R20 soils. R55 presented the highest HM content, with values of 6.57 $g \cdot kg^{-1}$, 6.82 $g \cdot kg^{-1}$ and 5.64 $g \cdot kg^{-1}$ for the 20 cm–30 cm, 30 cm–40 cm and 40 –50 cm soil layers, respectively. All soils showed decreasing HM content with increasing soil depth, indicating that that uppermost soil layer is subject to heavier HM accumulation.



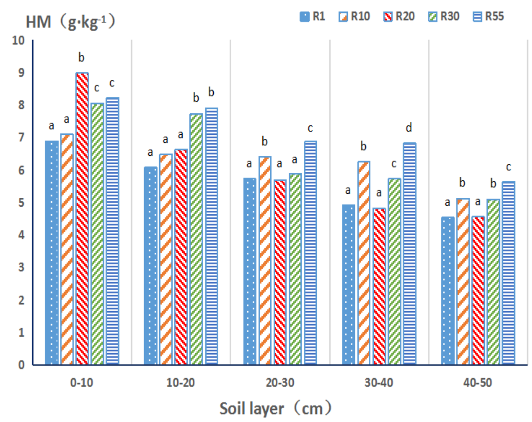


Figure 6. *Vertical distribution of fulvic acid in saline-alkaline soil over different farming durations*

Figure 7. *Vertical distribution of humin in saline-alkaline soil over different farming durations*

Note: lowercase letters indicate a significant difference at P< 0.05

Analysis of the Variations in Humus Components in Saline-alkali Paddy Soil

Variations in the composition and content of soil humus reflect the mechanisms behind soil formation and evolution (Liu et al., 2019). *Table 2* shows the proportions of humic components (HE, HA, FA and HM) in organic carbon. It can be seen that HM accounted for the largest proportion at > 50% of soil organic carbon. Generally, the proportions of soil components in soil organic carbon was in the order of HM > HE > HA > FA, indicating that stable HM made up the majority of soil humus. In the 0 cm–10 cm, 10 cm–20 cm, 20 cm–30 cm and 30 cm–50 cm soil layers, the value of

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[(HM)/(SOC)]% and [(HE)/(SOC)]% decreased and increased with increasing farming duration, respectively. *Table 3* shows a consistently significant positive correlation between soil HE, HA, FA, HM and SOC across all farming durations. This indicates a close internal correlation between soil humus components. A strong correlation between soil humus components and soil organic carbon was also evident, indicating that the stability of soil organic carbon was related to humus content.

Table 2. *Soil humus composition as a proportion of organic carbon*

Sample number	Proportion of organic carbon in soil	Soil layer/(cm)				
		0–10	10–20	20–30	30–40	40–50
R1	[(HM)/(SOC)]%	53.91	51.61	54.31	50.67	55.43
	[(HE)/(SOC)]%	46.09	48.39	45.69	49.33	44.57
	[(HA)/(SOC)]%	24.65	25.30	24.36	26.16	25.40
	[(FA)/(SOC)]%	21.44	23.09	21.33	23.17	19.17
R10	[(HM)/(SOC)]%	51.19	52.21	55.31	54.02	59.74
	[(HE)/(SOC)]%	48.81	47.79	44.69	45.98	40.26
	[(HA)/(SOC)]%	26.10	25.29	25.63	24.73	23.10
	[(FA)/(SOC)]%	22.71	22.50	19.07	21.25	17.15
R20	[(HM)/(SOC)]%	55.47	55.94	53.52	50.05	51.18
	[(HE)/(SOC)]%	44.53	44.06	46.48	49.95	48.82
	[(HA)/(SOC)]%	24.58	25.44	27.89	31.43	28.96
	[(FA)/(SOC)]%	19.95	18.62	18.59	18.52	19.87
R30	[(HM)/(SOC)]%	51.83	52.34	57.25	51.99	52.63
	[(HE)/(SOC)]%	48.17	47.66	42.75	48.01	47.37
	[(HA)/(SOC)]%	27.01	27.01	29.02	30.52	28.90
	[(FA)/(SOC)]%	21.16	20.65	13.73	17.50	18.47
R55	[(HM)/(SOC)]%	50.49	50.32	50.69	52.62	50.86
	[(HE)/(SOC)]%	49.51	49.68	49.31	47.38	49.14
	[(HA)/(SOC)]%	28.69	28.80	33.49	31.79	31.02
	[(FA)/(SOC)]%	20.82	20.88	15.82	15.59	18.12

Abbreviations: humus carbon (HE), Humic acid (HA), fulvic acid (FA), Humin (HM), soil organic carbon (SOC)

Variations in Humus Composition of Saline-alkali Paddy Soil

The degree of soil humification and quality of humus are generally measured by values of HA/FA and PQ (the ratio of HA to HE), with higher values indicating better soil quality (Shu et al., 2015). The results of *Figure 8* and *Figure 9* showed that the HA/FA and PQ values of soil humus in different tillage years had the same trend, which was R55 > R30 > R20 > R10 > R1. However, the changes of HA/FA and PQ of humus in different soil layers were not completely consistent, and the changes of HA/FA and PQ of R1 and R10 showed a “W”-type trend with the depth of soil layers, the values of HA/FA and PQ of R20, R30 and R55 in the soil layers of 10-20 cm and 30-40 cm, respectively showed a trend of increasing first and then decreasing with the depth of soil layers, and the peak value was 20-30 cm. The HA/FA and PQ of Soil in different tillage years were higher than 1 and 0.5, respectively, because the humus in soil was renewed and activated every year. The values of HA/FA and PQ in 20-30 cm soil layer increased the most, and the values of HA/FA and PQ in R55 were 85.96% and 28.3% higher than those in R1 soil

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layer, which indicated that the tillage years could significantly increase the values of HA/FA and PQ, the proportion of humic acid increased gradually, and the soil humus quality improved gradually. In addition, we also know that soil layer and reclamation years are the two factors that control the contents of HE, HA and FA (*Table 4*).

Table 3. *Analysis of the correlation between soil humus composition and soil organic carbon*

Sample number	Index	SOC	HM	HE	HA	FA
	SOC	1	.979**	.977**	.988**	.959*
	HM		1	.913*	.939*	.882*
R1	HE			1	.995**	.996**
	HA				1	.982**
	FA					1
	SOC	1	.990**	.997**	.999**	.978**
	HM		1	.976**	.996**	.940*
R10	HE			1	.991**	.992**
	HA				1	.966**
	FA					1
	SOC	1	.996**	.990**	.963**	.993**
	HM		1	.974**	.938*	.984**
R20	HE			1	.987**	.990**
	HA				1	.955*
	FA					1
	SOC	1	.988**	.989**	.994**	.971**
	HM		1	.955*	.977**	.925*
R30	HE			1	.989**	.994**
	HA				1	.966**
	FA					1
	SOC	1	.994**	.995**	.910*	.936*
	HM		1	.978**	.916*	.905*
R55	HE			1	.894*	.954*
	HA				1	0.719
	FA					1

Note: Correlation coefficients labeled by * and ** indicate significant difference at P = 0.05 and P = 0.01, respectively. Abbreviations: humus carbon (HE), Humic acid (HA), fulvic acid (FA), Humin (HM), soil organic carbon (SOC)

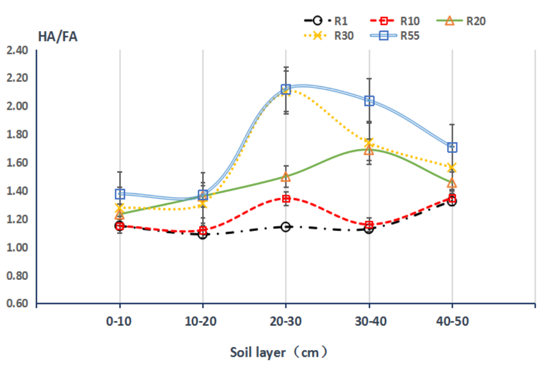

Figure 8. *Trends in the relative proportions of saline-alkaline soil (C_{HA}/C_{FA}) over different farming durations*

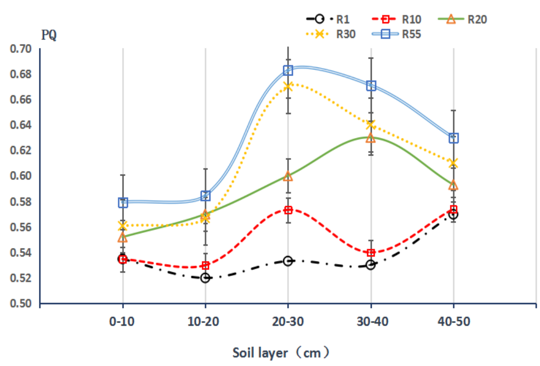

Figure 9. *Trends in PQ values of saline-alkaline soil over different farming durations*

Note: The error line in figure shows the positive and negative deviation of the value

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DOI: http://dx.doi.org/10.15666/aeer/1804_50655077

Table 4. *Multifactor Variance Analysis of Soil HE, HA and FA in Saline-alkali Rice Paddy Soil during Soil Layer, Reclamation years*

Index	Source of variation	Sum of squares	Degree of freedom	Mean square	F	P
HE	Soil layer	608.312	4	152.078	1221.48	*
	Reclamation years	1755.474	4	438.868	3524.965	*
	Soil layer * Reclamation years	62.121	16	3.883	31.184	*
HA	Soil layer	157.722	4	39.431	1163.278	*
	Reclamation years	448.556	4	112.139	3308.319	*
	Soil layer * Reclamation years	14.206	16	0.888	26.194	*
FA	Soil layer	126.172	4	31.543	1298.59	*
	Reclamation years	318.766	4	79.692	3280.811	*
	Soil layer * Reclamation years	12.144	16	0.759	31.246	*

Note: $P<0.001$

Discussion

Humus generally undergoes synthesis and decomposition during its formation. Soil humus composition is partly derived from the decomposition of plant residues and partly from the synthesis of microorganisms (Cu, 2015); therefore, its content is related to the process of soil mineralization and humification. In the present study, the proportions of soil humus components (HA, FA and HM) gradually increased with increasing farming duration, consistent with the results of Clark et al. (1998), Pimente et al. (2005) and Melerol et al. (2006), who showed consistent increases in soil organic carbon and humus carbon with increasing soil cultivation time. This can be explained by considering that soil microorganisms directly participate in the degradation and humification of organic residues; farming provides more suitable temperature and humidity conditions for microorganisms, thereby increasing microbial activity in soil. In this way, the decomposition of soil organic carbon is increased along with soil mineralization and humification, resulting in a rise in the soil organic carbon and humus contents (Yu et al., 2004; Watanabe et al., 2007; Wissing et al., 2013).

The variances of soil carbon content and humus components across different farming durations and soil layers has also resulted in some regular variations in the proportion of organic carbon in each component. HM was found to make up the largest proportion in soil, accounting for approximately half of organic carbon. In general, the rank proportion of each component in soil was HM > HE > HA > FA, with a significant correlation between soil humus components and organic carbon evident. This indicates that the majority of humus exists as stable HM, and that saline-alkaline paddy soils have certain potentials for carbon sequestration.

The relative variations in soil humus components can also be analyzed by comparing the values of specific indicators, namely HA/FA or PQ. The total amount of humus and the degree of soil humification increased with increasing soil maturity, with HA/FA values of 1.4, 0.5 and 0.2–0.3 for highly mature, moderately mature and relatively immature paddy soils, respectively (Liu et al., 2017). In the present study, increasing farming duration resulted in an improvement in HA content across all soil layers. Moreover, both HA, HA/FA and PQ values increased with increased duration of rice farming. This indicates that an increase in the amount of soil HA resulted in an increase

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DOI: http://dx.doi.org/10.15666/aeer/1804_50655077

in soil humification, thereby also improving soil maturity, humus quality and fertility (Liu et al., 2018). The variations in and regeneration of soil humus can not only be used to evaluate soil quality and vegetation restoration, but also bears vital significance for soil carbon sequestration. Paustian pointed out that the chemical combination of soil humus and soil minerals serves as an important mechanism for the stabilization of organic carbon and prevention of microbial degradation (Paustian et al., 1992). Therefore, further studies on the molecular structure of humus and the mechanism of regulation of molecular *in-situ* polymerization for saline-alkali paddy soils would play an important role in limiting soil microbial mineralization and improving soil organic carbon sequestration.

Conclusion

(1) Variations in soil humus were found across different farming durations and soil layers. Soil humic acid content increased significantly with increasing farming duration. In general, the soil humus components were found to decrease in value with increasing soil depth. Farming maintained soil fulvic acid content at a relatively stable level across all farming durations. Humin made up the largest proportion of humus in saline-alkaline paddy soil and increased remarkably with increased farming duration, with the largest accumulation in the top soil. (2) Soil humus components (humic acid, fulvic acid and humin) were significantly correlated with organic carbon content, and the regeneration and activation of soil humus exerted direct impacts on the variations of the soil organic carbon pool. (3) Farming duration significantly increased the values of HA/FA and PQ of saline-alkali paddy soils with the largest increase shown in the 20-30 cm soil layer.

As a stable carbon component in soil, soil humus carbon increased with the extension of cultivation years. The content of soil humus carbon after cultivation was significantly higher than that of uncultivated saline-alkali wasteland, the results showed that saline-alkali soil was improved and reclaimed as a back-up soil of farmland, and it was also beneficial to improve the function of soil carbon sink. This suggests that we should make better and reasonable use of the reserve land resources, increase production, and at the same time, improve the climate change also has a certain role in promoting.

Funding. This research was funded by National Natural Science Foundation of China (No.51179073, 41471152) and Changchun University Scientific Research and cultivation Fund (2019JBC27L40).

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DOI: http://dx.doi.org/10.15666/aeer/1804_50655077