Film mulching, residue retention and N fertilization affect ammonia volatilization through soil labile N and C pools

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Introduction

Soil ammonia volatilization is one of the most important N-loss way, accounts for about 50% that mainly emitted throughout agriculture system and impact environment. The nitrogen fertilizer sources and tillage practices are main anthropogenic factors affecting the ammonia volatilization.

Soil labile nitrogen fractions is affected notably with tillage practices and urea application. The microbial biomass N (MBN), water extraction organic N (WEON), NO_3^--N, and NH_4^+-N are the main part of labile fractions N.

To investigate the tillage practice and N fertilization impact on the soil labile C, N pools and their effects on ammonia volatilization from wheat fields. A two-year consecutive field experiment was conducted at 2017 and 2018.

Methods

Field experiment → split-plot design

Wheat variety → Xiaoyan 22

Ammonia analysis → semi-open static chamber method

NO_3^--N / NH_4^+-N → KCl extractions

WEON → distilled water extractions

MBN → chloroform fumigation-extraction method

DOC → K_2SO_4 extractions

conventional tillage with residue removed, CT | film mulching with residue removed, FM | straw residue incorporated into soil, SM

Two years | Four stages

N0 对照 | N144 减氮20% | N180 当地常规

Results

Table 1 Cumulative NH_3 volatilization (kg N ha^{-1}) of different treatments

Treatment	2017-2018		2018-2019		ATA	AFR%
	Total	FR%	Total	FR%		
CT-N0	7.29±0.09^{Bc}	——	7.80±0.21^{Bc}	——	7.55	——
CT-N144	11.76±0.14^{Ab}	3.10	14.00±0.28^{Ab}	4.31	12.88	3.70
CT-N180	12.79±0.17^{Ba}	3.06	16.52±0.28^{Aa}	4.84	14.66	3.95
FM-N0	7.01±0.10^{Bc}	——	7.40±0.19^{Bc}	——	7.21	——
FM-N144	10.23±0.14^{Aa}	2.24	9.63±0.19^{Bb}	1.55	9.93	1.89
FM-N180	10.75±0.15^{Ca}	2.08	11.19±0.19^{Ba}	2.11	10.97	2.09
SM-N0	8.57±0.11^{Ac}	——	8.37±0.19^{Ac}	——	8.47	——
SM-N144	12.07±0.15^{Ab}	2.43	14.86±0.32^{Ab}	4.51	13.47	3.47
SM-N180	14.30±0.18^{Aa}	3.18	16.56±0.26^{Aa}	4.55	15.43	3.87

Note：Different capital and lowercase letters in the same stage columns indicate significant differences among same nitrogen rate and same tillage, respectively. (p<0.05) Fertilizer ammonia loss rate (FR, %) = (NH_3 loss in N144 or N180 - NH_3 loss in N0) ×100% /N144 or N180 application rate. ATA means average of total ammonia loss in two years. AFR means average FR in two years

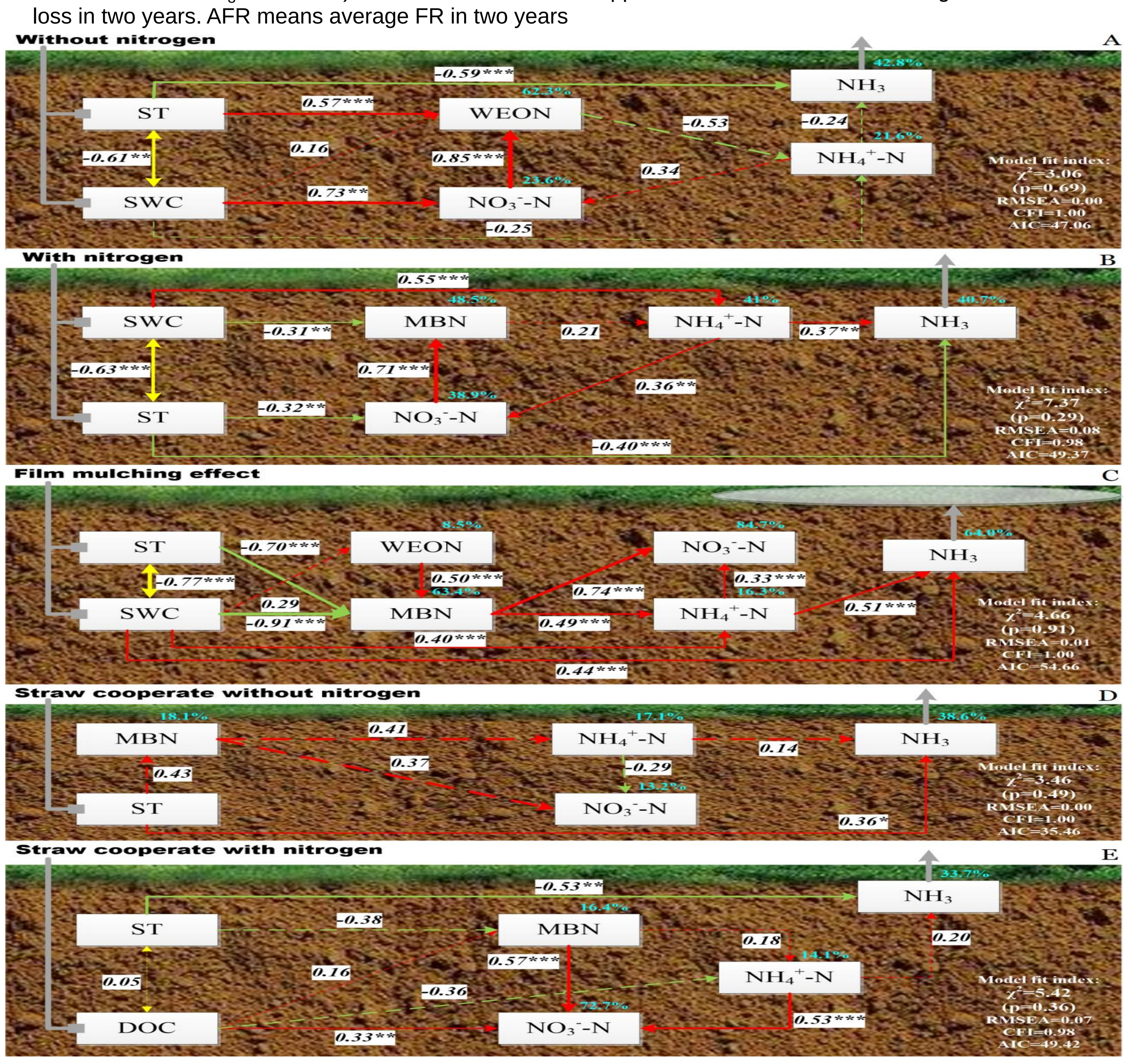

Fig.1 The structural equation modeling (SEM) of the changes in soil labile nitrogen due to without nitrogen fertilizer and straw (A) , with nitrogen fertilizer but without straw (B), film mulching (C), with straw but without nitrogen fertilizer (D) and with nitrogen fertilizer and straw (E).

N fertilizer rate and tillage almost significantly affected cumulative NH_3 volatilization. The total ammonia loss was 7.29-12.79, 7.01-10.75 and 8.57-14.30 kg N ha^{-1}, 7.80-16.52, 7.40-11.19 and 8.37-16.56 kg N ha^{-1} of CT, FM and SM in 2017-2018 and 2018-2019, respectively. Compared with CT and SM systems, ammonia emission under FM system was the lowest during the two seasons (Table 1).

The structural equation modeling (SEM) of no nitrogen and no straw retention represented the natural agro-ecosystem. The key factors, which affected the ammonia emission, were ST and SWC (Fig. 1A).

The SEM of fertilizer nitrogen represented the N fertilization conditions (Fig. 1B). The ammonia volatilization and the soil NH_4^+ content were significantly affected by N fertilization, and ST had negative effects on it (p<0.01).

In the film mulching conditions, soil NH_4^+ content and SWC directly positive effected on NH_3 potential (p<0.01), which explained 64.0% in accumulation NH_3 potential (Fig. 1C).

Only C input conditions, NH_3 volatilization was related with NH_4^+, and it was significantly affected by the ST (p<0.1) (Fig. 1D).

Both N and C input, NH_3 volatilization directly related the soil NH_4^+ content, and ST had significantly negatively impacts on it (p<0.05) (Fig. 1E).

Conclusion

1、The tillage and nitrogen fertilization had significant influences on the soil labile nitrogen and NH_3 volatilization.

2、N fertilization promoted the ammonia volatilization.

3、FM could mitigate ammonia volatilization through physical barrier or blocking while the crop residue incorporated into soil had no pronounced impact on the soil ammonia volatilization.

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