

STE | 田间老化生物炭对肥料氮固持和 N₂O 排放的影响（转）

Science of the Total Environment 773 (2021) 145645



Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv



Effect of field-aged biochar on fertilizer N retention and N₂O emissions: A field microplot experiment with ¹⁵N-labeled urea

Xia Liao^{a,b}, Deyan Liu^a, Yuhui Niu^a, Zengming Chen^a, Tiehu He^a, Weixin Ding^{a,*}

^a State Key Laboratory of Soil and Sustainable Agriculture, Institute of Soil Science, Chinese Academy of Sciences, Nanjing 210008, China

^b University of Chinese Academy of Sciences, Beijing 100049, China

摘要：施用生物炭被认为可以提高作物产量，减少氮素淋失和气体排放；然而，关于田间老化生物炭如何影响肥料氮固持和 N₂O 排放仍知之甚少。本文在华北平原玉米季进行了施用 ¹⁵N 标记尿素的田间微区试验，在施用（Biochar 处理）和不施用（Control 处理）老化 3 年生物炭（施用量为 12 t ha⁻¹）的砂壤土上进行了田间微区试验。总体上，**25.6–26.2% 的尿素氮被玉米地上生物量吸收，田间老化生物炭不影响产量或肥料氮回收率。**玉米收获后，对照和生物炭处理下土壤剖面（0–40 cm）中施用氮的残留率分别为 **21.6% 和 20.3%**；施用老化生物炭后，表层土壤（0–20 cm）中施用氮的残留率**增加了 10.2%**，而亚表层土壤（20–40 cm）中施用氮的残留率**减少了 37.2%**，这可能是由于**生物炭减少了 NO₃⁻ 淋失所致**。对照处理的累积 N₂O 排放量和尿素氮诱导的 N₂O 排放量分别为 **2.06 和 0.78 kg N ha⁻¹**，经生物炭处理后分别显著降低至 **1.89 和 0.74 kg N ha⁻¹**。施氮产生的 N₂O 排放量分别占对照和生物炭处理总 N₂O 排放量的 **38.0% 和 39.4%**。在对照和生物炭处理下，**施氮激发效应引起的土壤有机氮分解产生的 N₂O 排放量分别为 0.69 和 0.56 kg N ha⁻¹**，**分别占总排放量的 33.7% 和 29.7%**。总的来说，本研究结果表明，**田间老化生物炭通过减少 NO₃⁻ 淋失增加了肥料氮在表层土壤中的固持，同时有效地减少了砂壤土中肥料氮和有机氮矿化引发的 N₂O 排放。**

关键词：生物炭(Biochar); ¹⁵N 标记尿素(¹⁵N-urea); 氮素回收率(N recovery efficiency); 氮素固持(N retention); N₂O(Nitrous oxide)

Graphical abstract:

Field-aged biochar reduced movement of fertilizer N into the subsoil and mitigated N₂O emissions from fertilizer and priming effect of applied N

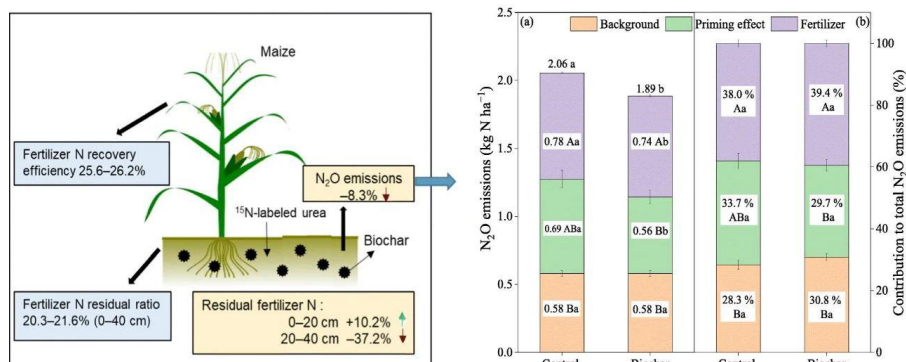


Table 1. Surface (0–20 cm) soil properties before fertilization and maize cropping.

Treatment	pH (H ₂ O)	BD (g cm ⁻³)	SOC (g C kg ⁻¹)	TN (g N kg ⁻¹)	C/N	NH ₄ ⁺ -N (mg N kg ⁻¹)	NO ₃ ⁻ -N (mg N kg ⁻¹)	DOC (mg C kg ⁻¹)
Control	8.09 ± 0.02a	1.47 ± 0.03a	7.75 ± 0.29b	0.78 ± 0.04a	9.92 ± 0.87a	1.70 ± 0.44b	10.55 ± 0.23a	40.09 ± 2.25a
Biochar	8.17 ± 0.05a	1.41 ± 0.02b	9.36 ± 0.39a	0.83 ± 0.06a	11.34 ± 0.72a	2.66 ± 0.54a	9.40 ± 0.14b	39.19 ± 2.19a

BD: bulk density, SOC: soil organic carbon, TN: total nitrogen, DOC: dissolved organic carbon. Values followed by different letters within the same column indicate significant differences at $P < 0.05$.

Table 2. Distribution of fertilizer N in the cropped maize under control (Control) and biochar (Biochar) treatment.

	Treatment	Grain	Straw	Aboveground	Belowground	Total
Yield (kg ha ⁻¹)	Control	10,479 ± 118a	9740 ± 408a	20,219 ± 433a	1537 ± 89a	21,756 ± 462a
	Biochar	10,583 ± 64a	9508 ± 242a	20,091 ± 306a	1499 ± 82a	21,590 ± 224a
N uptake (kg N ha ⁻¹)	Control	154.59 ± 4.76a	89.56 ± 2.18a	244.14 ± 6.93a	14.07 ± 1.40a	258.21 ± 7.41a
	Biochar	153.34 ± 2.41a	74.30 ± 3.82b	227.64 ± 1.43a	14.81 ± 0.65a	242.44 ± 1.99a
Fertilizer N uptake (kg N ha ⁻¹)	Control	34.54 ± 2.01a	17.88 ± 0.59a	52.42 ± 2.43a	2.99 ± 0.31a	55.41 ± 2.39a
	Biochar	36.14 ± 1.09a	15.12 ± 0.87b	51.26 ± 0.49a	3.02 ± 0.16a	54.28 ± 0.54a
Fertilizer N recovery efficiency (%)	Control	17.27 ± 1.00a	8.94 ± 0.29a	26.21 ± 1.21a	1.50 ± 0.16a	27.70 ± 1.19a
	Biochar	18.07 ± 0.54a	7.56 ± 0.44b	25.63 ± 0.25a	1.51 ± 0.08a	27.14 ± 0.27a

Values followed by different letters within the same column indicate significant differences at $P < 0.05$.

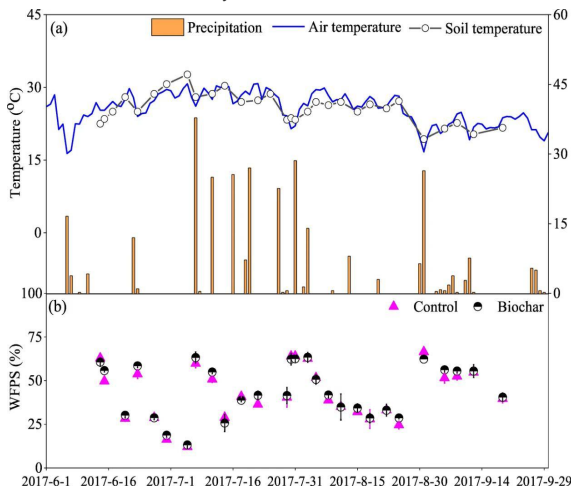


Fig. 1. Variations in (a) air temperature, soil temperature and precipitation, and (b) soil water-filled pore space (WFPS) values during the maize growing season.

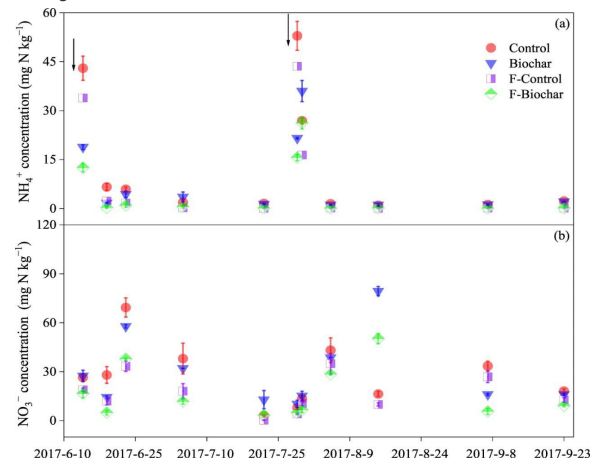


Fig. 2. Dynamic variations in the concentration of total soil $\text{NH}_4^+\text{-N}$ and $\text{NO}_3^-\text{-N}$ (Control and Biochar) and $\text{NH}_4^+\text{-N}$ and $\text{NO}_3^-\text{-N}$ derived from applied ^{15}N -urea (F-Control and F-Biochar) during the maize growing season. Vertical bars denote the standard errors of the mean ($n = 3$).

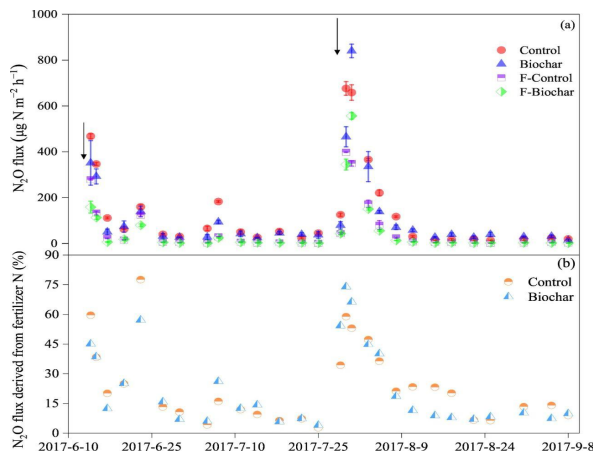


Fig. 3. Dynamic variations in the fluxes of total N_2O (Control and Biochar) and N_2O derived from applied ^{15}N -urea (F-Control and F-Biochar) during

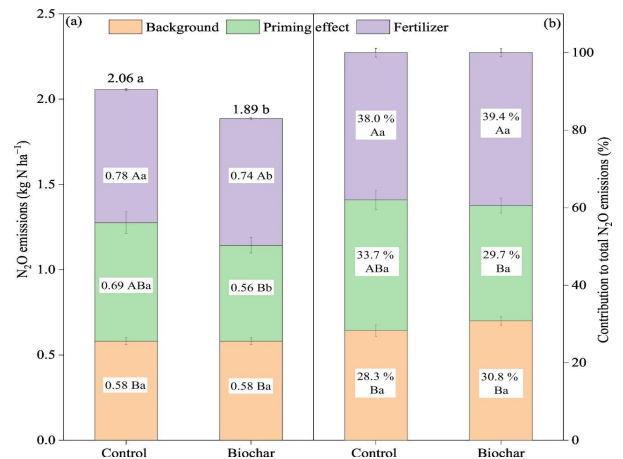


Fig. 4. Cumulative N_2O emissions and the contribution of soil background N_2O emissions, N_2O emissions derived from applied fertilizer N, and N_2O emissions resulting from the decomposition of organic N induced by the priming effect of applied fertilizer to total N_2O emissions under Control and Biochar treatment.