

Measurement methods

N₂O and CH₄

The N₂O emission rate from the soil surface was determined using a static chamber method. After fertilization, the N₂O and CH₄ emission rate was measured continuously for 10 days until the emission peak appeared, then measuring the rate every 2 or 3 days. As the N₂O and CH₄ emission rate decreased, the time interval for gas sampling was changed to once a week or once every 10 days, and then once every 20 days or each month in the later maize growth stage until the maize was harvested. A set of static boxes was placed in each maize population, where each static box comprised an iron base (50 cm × 50 cm × 15 cm) with a stainless steel top box (50 cm × 50 cm × 50 cm). The base was flush with the ground and fixed in the maize planting row and between the rows after fertilization. The static box base remained fixed throughout the whole experiment. Reflective films were attached around and at the top of the top box to reduce changes in the box's temperature during sampling. Small holes were present in the top and side of the top box. A mercury thermometer was installed in the hole on the top to measure the change in temperature in the box during sampling, and a gas collecting pipe with a length of 20 cm was passed through the hole in the side to collect gas from the box.

During the gas collection process, a small fan with a voltage of 5 V was positioned in the base to mix the gas inside the box, before injecting a specific amount of clean water into the groove in the base to ensure that no gas exchange occurred between the inside and outside of the box, and the top box was then placed on the groove. The gas in the top box was collected with a 50-mL syringe at 0, 10, 20, and 30 min after placing the top box in the groove, and the volume of gas collected was about 40 mL. Before each gas sample was collected, the injector was pushed

uniformly 10 times to mix the gas in the gas collection pipe while the small fan operated in the box. The N₂O and CH₄ concentration was measured by gas chromatography (GC-2010 plus, Shimadzu, Japan) and calculated as:

$$F = \rho \cdot h \cdot \frac{\Delta c}{\Delta t} \cdot \frac{273}{273 + T} \quad (S1)$$

where F is the N₂O and CH₄ emission flux (mg m⁻² h⁻¹), ρ is the gas density under standard conditions ($\rho_{CO_2} = 1.964 \text{ kg} \cdot \text{m}^{-3}$, $\rho_{CH_4} = 0.714 \text{ kg} \cdot \text{m}^{-3}$), h is the height of the static box (m), $\Delta c/\Delta t$ is the change in the N₂O and CH₄ concentration per unit time, and T is the temperature (°C) in the box during sampling. The cumulative N₂O and CH₄ emissions were calculated by the interpolation method according to the N₂O and CH₄ emission rate on the sampling date.

NH₃

In each maize plot, a PVC tube was placed between two maize plants in the same row (fertilization band, about 15 cm wide) and between two maize rows (non-fertilized band, about 45 cm wide), and ammonia volatilization was determined using the ventilation method. Ammonia volatilization samples were collected every day from 0–20 days after fertilization, every 5 days from 20–40 days, and every 10 days from 40 days until the harvest. The NH₄⁺-N concentration in each sample was determined using an auto-analyzer (AutoAnalyzer3-AA3, SEAL, Germany). Finally, the total NH₃ emissions from the whole population were calculated using the area method:

$$F = \frac{\left[\frac{M}{A \times D} \right]}{100} \quad (S2)$$

where F is the NH₃ volatilization rate (kg m⁻² h⁻¹), M is the concentration of NH₄⁺-N, A is the

cross-sectional area of the PVC pipe ($A = \pi \times 7.5 \times 7.5 = 176.71 \text{ cm}^2$), and D is the time (days) of continuous ammonia volatilization determination. The cumulative NH_3 emissions from different soil bands were calculated by interpolation based on the NH_3 concentration on the sampling date. The total NH_3 emissions from the experimental site were calculated according to the area method.

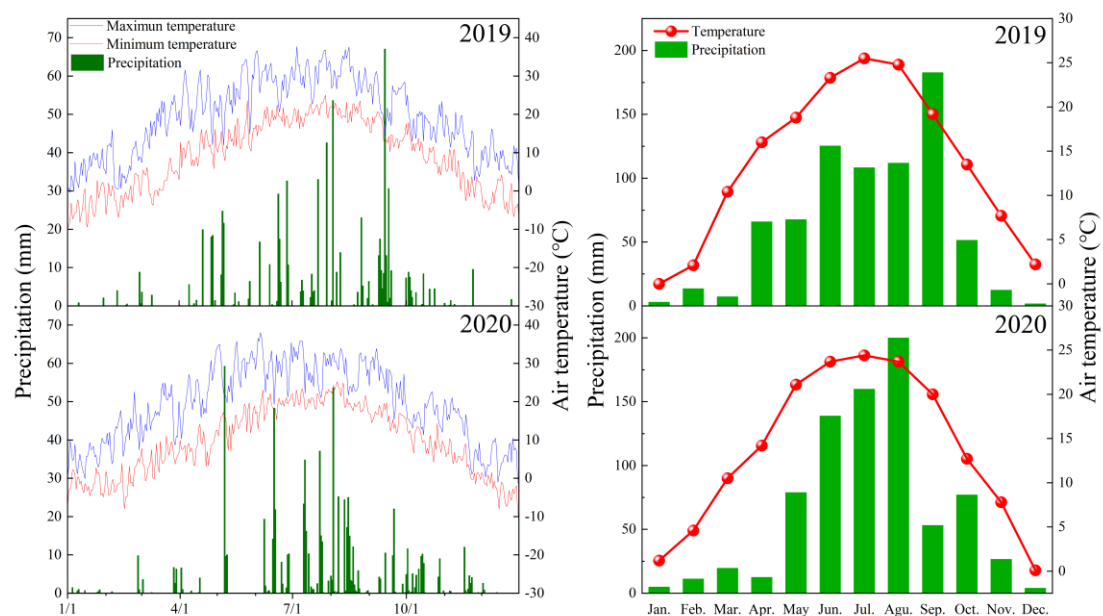


Fig. S1 Daily precipitation and temperature during maize growth and fallow seasons in 2019 and 2020 at the experimental site.

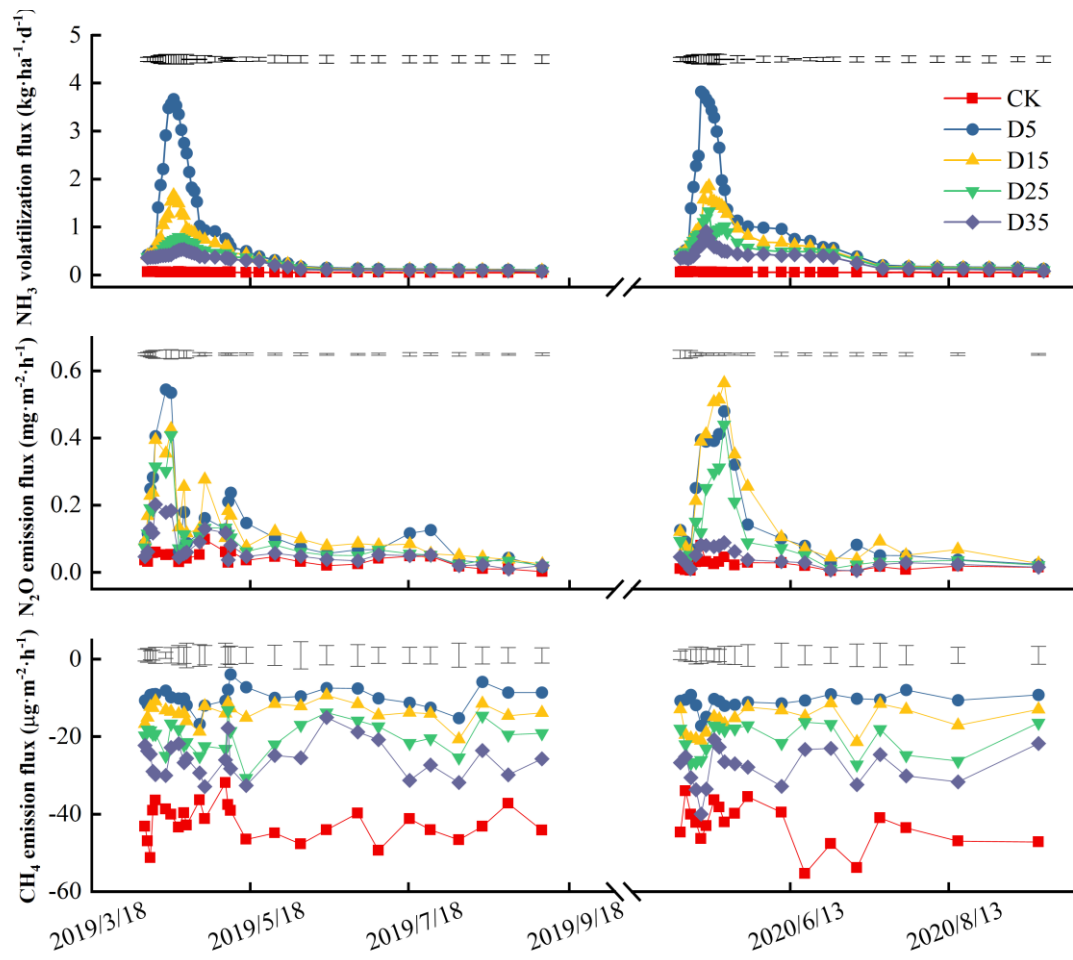


Fig. S2 Surface N₂O flux (mg m⁻² h⁻¹), NH₃ volatilization (kg ha⁻¹ d⁻¹), and cumulative N₂O emission (kg ha⁻¹), NH₃ volatilization (kg ha⁻¹) during maize growth stages under different deep fertilization depth treatments in 2019 and 2020. CK: No N-P placement in the soil; and D5, D15, D25, and D35 indicate N-P deep-band placement at depths of 5, 15, 25, and 35 cm below the soil surface, respectively. Vertical bars represent the least significant test values at $P = 0.05$. and standard errors ($n = 3$).

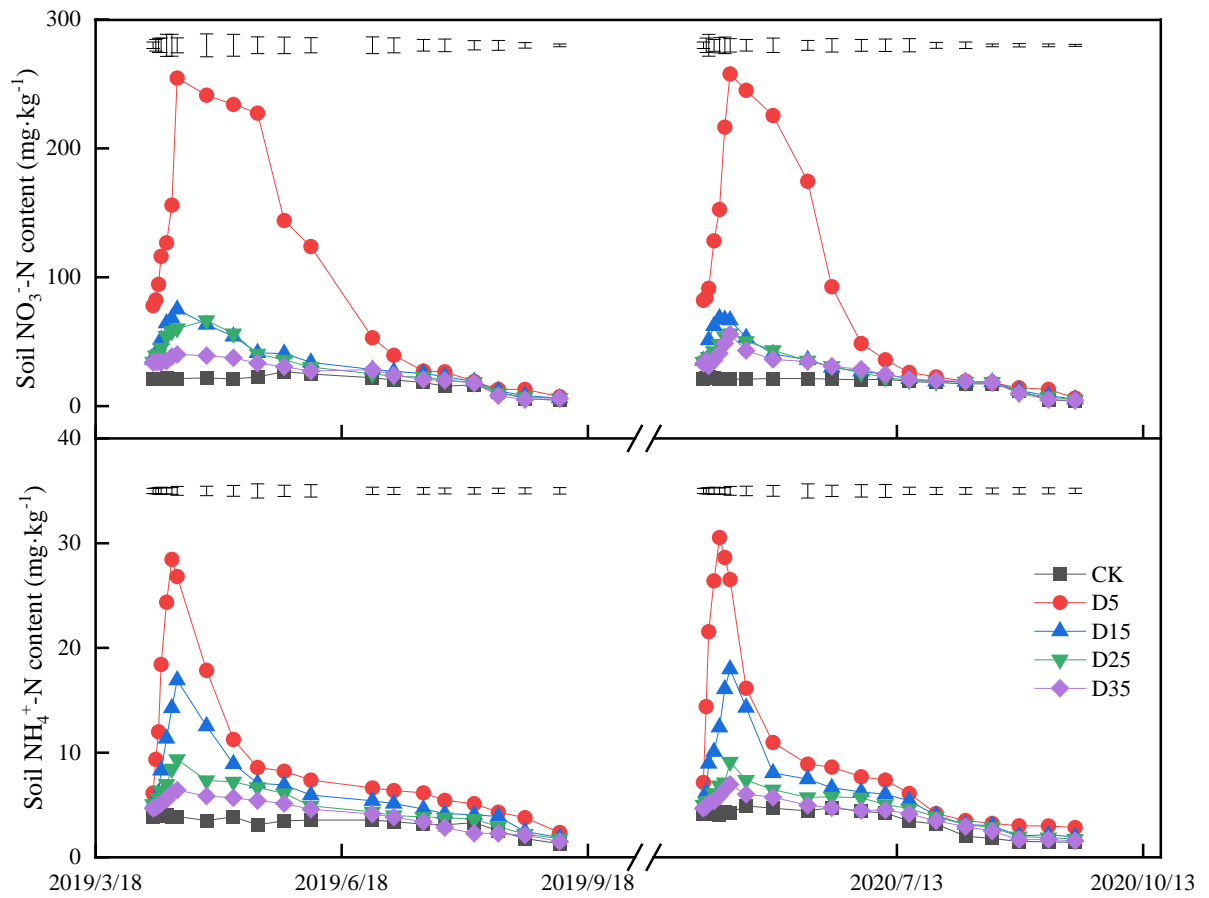


Fig. S3 Soil NO₃⁻-N and NH₄⁺-N content at 0-10 cm soil depth under different deep fertilization depth treatments during 2019 and 2020.

Note: CK: No N-P placement in the soil; and D5, D15, D25, and D35 indicate N-P deep-band placement at depths of 5, 15, 25, and 35 cm below the soil surface, respectively. Vertical bars represent the least significant test values at $P = 0.05$.

Table S1 Physical and chemical properties of the soil before the experiment.

Soil depth (cm)	SOM g·kg ⁻¹	Olsen-P mg·kg ⁻¹	Available K mg·kg ⁻¹	Total N g·kg ⁻¹	Total P g·kg ⁻¹
0-10	14.96	12.98	143.85	1.05	1.01
10-20	14.37	9.65	125.97	1.03	1.00
20-30	14.34	3.72	103.29	0.98	0.89
30-40	12.24	2.88	95.76	0.80	0.87