Fig. S1 The total N fertilizer input amount under different treatments. Different letters indicate significant differences at the level of *P* < 0.05. N+PK, straw return plus regular inorganic N-P-K fertilizers; 0.75N+PK, straw return plus regular inorganic P-K with 25% N fertilizer reduction; 0.5N+PK, straw return plus regular inorganic P-K with 50% N fertilizer reduction; PK, straw return plus regular inorganic P-K without N fertilizer.
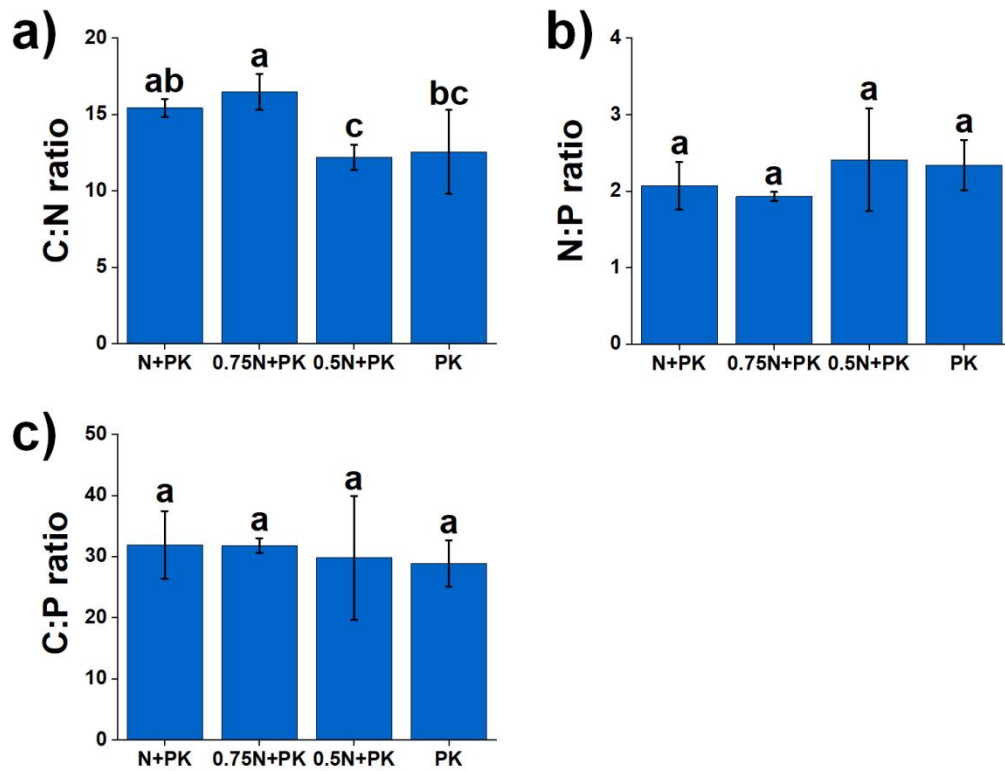
Fig. S2 The soil C:N ratio (a), N:P ratio (b) and C:P ratio (c) under different treatments. Different letters indicate significant differences at the level of $p < 0.05$. N+PK, straw return plus regular inorganic N-P-K fertilizers; 0.75N+PK, straw return plus regular inorganic P-K with 25% N fertilizer reduction; 0.5N+PK, straw return plus regular inorganic P-K with 50% N fertilizer reduction; PK, straw return plus regular inorganic P-K without N fertilizer.
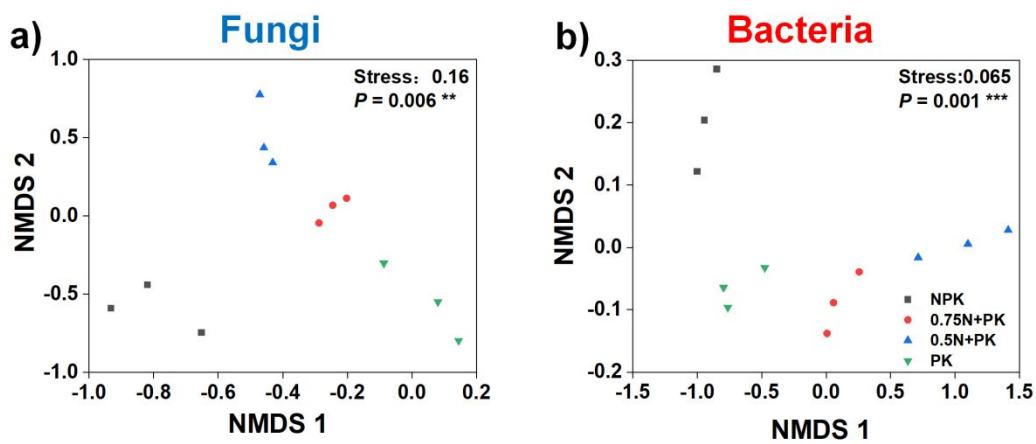
Fig. S3 Non-metric multidimensional scaling ordination showing the fungi (a) and bacteria (b) under different N input levels; significant differences in sample clustering are measured by ANOSIM. N+PK, straw return plus regular inorganic N-P-K fertilizers; 0.75N+PK, straw return plus regular inorganic P-K with 25% N fertilizer reduction; 0.5N+PK, straw return plus regular inorganic P-K with 50% N fertilizer reduction; PK, straw return plus regular inorganic P-K without N fertilizer.

Table S1 The yields and soil chemical properties under different treatments of bulk soil during the experimental process

Year	Treatment	Yield (t ha^{-1})	pH	SOC (g kg^{-1})	Total N (g kg^{-1})	Total P (g kg^{-1})
2019	N+PK	11.17±0.73 a	7.29±0.14 a	17.60±2.10 a	0.93±0.02 a	0.65±0.08 a
	0.75N+PK	10.91±0.29 a	7.31±0.20 a	15.87±3.12 ab	0.94±0.08 a	0.61±0.12 a
	0.5N+PK	9.81±0.32 b	7.39±0.18 a	14.01±1.42 b	0.89±0.10 a	0.64±0.03 a
	PK	9.93±0.39 b	7.51±0.20 a	13.58±0.15 b	0.86±0.05 a	0.55±0.27 a
2020	N+PK	11.39±0.33 a	7.27±0.10 a	17.11±1.95 a	0.93±0.07 a	0.69±0.07 a
	0.75N+PK	12.00±1.19 a	7.28±0.14 a	17.01±1.77 a	0.88±0.21 a	0.63±0.10 a
	0.5N+PK	9.88±0.84 b	7.27±0.11 a	12.45±0.16 b	0.86±0.01 ab	0.67±0.07 a
	PK	9.84±0.44 b	7.48±0.16 a	11.76±0.82 b	0.81±0.03 b	0.59±0.05 a
2021	N+PK	11.41±0.05 ab	7.25±0.21 a	21.08±1.82 a	1.37±0.11 a	0.67±0.05 a
	0.75N+PK	11.65±0.06 a	7.28±0.14 a	20.95±1.27 a	1.27±0.02 a	0.66±0.19 a
	0.5N+PK	10.08±0.08 bc	7.25±0.02 a	14.01±2.01 b	1.15±0.10 a	0.49±0.10 b
	PK	8.89±0.13 c	7.39±0.10 a	13.33±1.18 b	1.10±0.28 a	0.47±0.08 b

The results show means ± standard deviations (n = 3). Different lowercase letters after values indicate significant differences between each treatment in the same year, P < 0.05. SOC, soil organic carbon; N+PK, straw return plus regular inorganic N-P-K fertilizers; 0.75N+PK, straw return plus regular inorganic P-K with 25% N fertilizer reduction; 0.5N+PK, straw return plus regular inorganic P-K with 50% N fertilizer reduction; PK, straw return plus regular inorganic P-K without N fertilizer.

Table S2 The basic chemical properties of initial and treated straw under different N input levels after straw return

Treatment	Straw C (g kg^{-1})	Total N (g kg^{-1})	Total P (g kg^{-1})	Total K (g kg^{-1})
Initial	485.77±25.21 a	6.72±0.36 c	2.01±0.12 a	21.00±0.13 a
N+PK	428.86±17.82 b	17.20±0.51 ab	1.36±0.11 b	1.48±0.16 bc
0.75N+PK	429.00±30.21 b	16.72±0.45 b	1.45±0.10 b	1.18±0.14 c
0.5N+PK	427.72±29.96 b	18.15±1.03 a	1.81±0.17 a	1.86±0.10 b
PK	446.36±2.42 b	18.33±0.53 a	1.88±0.35 a	1.77±0.46 b

The results show means ± standard deviations (n = 3). Different lowercase letters after values indicate significant differences between each treatment, $P <$ 0.05. SOC, soil organic carbon; N, nitrogen;P, phosphorus; K, potassium; N+PK, straw return plus regular inorganic N-P-K fertilizers; 0.75N+PK, straw return plus regular inorganic P-K with 25% N fertilizer reduction; 0.5N+PK, straw return plus regular inorganic P-K with 50% N fertilizer reduction; PK, straw return plus regular inorganic P-K without N fertilizer.

Table S3 The abundances of fungal and bacterial abundances across different N fertilizer level treatments after straw return

Treatment	Fungi abundance ($\times 10^7$ copies g^{-1} soil)	Bacteria abundance ($\times 10^7$ copies g^{-1} soil)	Fungi: Bacteria ratio
N+PK	0.63±0.16 bc	3.15±0.30 a	0.20±0.04 b
0.75N+PK	0.85±0.09 a	2.88±0.24 ab	0.30±0.05 a
0.5N+PK	0.57±0.04 c	2.87±0.42 ab	0.20±0.03 b
PK	0.39±0.05 d	2.17±0.43 b	0.18±0.02 c

The results show means ± standard deviations (n = 3). Different lowercase letters after values indicate significant differences between each treatment, $P < 0.05$. N+PK, straw return plus regular inorganic N-P-K fertilizers; 0.75N+PK, straw return plus regular inorganic P-K with 25% N fertilizer reduction; 0.5N+PK, straw return plus regular inorganic P-K with 50% N fertilizer reduction; PK, straw return plus regular inorganic P-K without N fertilizer.

Table S4 The fungal and bacterial alpha diversity under different N input levels after straw return

	Treatment	Chao1	Richness
Fungi	N+PK	1118.60±71.84 a	883.00±38.57 a
	0.75N+PK	1117.82±67.17 a	796.33±28.45 ab
	0.5N+PK	1063.37±84.82 a	781.00±33.87 ab
	PK	1054.50±22.29 a	772.33±27.54 b
Bacteria	N+PK	5917.52±149.48 a	4475.00±87.11 a
	0.75N+PK	5920.19±197.47 a	4396.67±27.43 a
	0.5N+PK	5881.07±152.30 a	4398.33±32.35 a
	PK	5672.76±82.25 a	4241.00±64.55 b

The results show means ± standard deviations (n = 3). Different lowercase letters after values indicate significant differences between each treatment, $P < 0.05$. N+PK, straw return plus regular inorganic N-P-K fertilizers; 0.75N+PK, straw return plus regular inorganic P-K with 25% N fertilizer reduction; 0.5N+PK, straw return plus regular inorganic P-K with 50% N fertilizer reduction; PK, straw return plus regular inorganic P-K without N fertilizer.

Table S5 The relative abundances of keystone taxa across different N fertilizer level treatments after straw return

Treatment	FOTU22 (Module 3)	BOTU21 (Module 1)	BOTU6346 (Module 3)	BOTU240 (Module 2)
N+PK	388.33	453.67	63.67	44.33
0.75N+PK	536.67	638	147	79
0.50N+PK	367	303.33	150	82.66
PK	109.33	421	18.33	63

The results show means (n = 3). Different lowercase letters after values indicate significant differences between each treatment, $P < 0.05$. N+PK, straw return plus regular inorganic N-P-K fertilizers; 0.75N+PK, straw return plus regular inorganic P-K with 25% N fertilizer reduction; 0.5N+PK, straw return plus regular inorganic P-K with 50% N fertilizer reduction; PK, straw return plus regular inorganic P-K without N fertilizer. FOTU, the OTU in fungi; BOTU, the OTU in Bacteria.