

Table S1. Changes of soil organic carbon contents (g kg⁻¹) under different tillage and straw return practices from (2012-2014).

Crop season	Soil layers	CTNS	CTSR	NTNS	NTSR	T	SR	T×SR
2012 rice season	0-5 cm	16.71±0.31 a	17.40±0.70 a	16.63±0.50 a	18.15±0.52 a	ns	*	ns
	5-10 cm	16.18±0.11 a	16.87±0.45 a	16.29±0.30 a	17.03±0.45 a	ns	ns	ns
	10-20 cm	15.16±0.61 a	16.27±0.97 a	14.61±0.17 a	14.47±0.71 a	ns	ns	ns
2013 wheat season	0-5 cm	17.58±0.57 b	18.76±0.38 b	18.32±0.19 b	20.10±0.18 a	*	*	ns
	5-10 cm	16.99±0.55 a	16.27±0.41 a	15.85±0.44 a	17.62±0.67 a	ns	ns	ns
	10-20 cm	15.52±0.32 a	16.17±0.57 a	14.99±0.22 a	15.92±0.26 a	ns	ns	ns
2013 rice season	0-5 cm	17.17±0.55 c	18.78±0.37 b	19.85±0.22 b	21.61±0.44 a	*	*	ns
	5-10 cm	15.99±0.45 a	17.35±0.32 a	15.51±1.78 a	15.52±1.01 a	ns	ns	ns
	10-20 cm	15.72±0.45 a	16.50±0.35 a	14.55±0.72 a	15.38±0.81 a	*	ns	ns
2014 wheat season	0-5 cm	18.64±0.14 c	19.99±0.13 a	19.19±0.27 b	20.32±0.03 a	ns	*	ns
	5-10 cm	17.19±0.55 a	17.45±0.29 a	16.74±0.94 a	17.95±0.82 a	ns	ns	ns
	10-20 cm	15.92±0.65 a	16.34±0.59 a	16.14±0.47 a	15.98±0.47 a	ns	ns	ns
2014 rice season	0-5 cm	18.35±0.26 c	19.86± 0.33 b	19.16± 0.26 bc	20.75±0.19 a	*	*	ns
	5-10 cm	17.16± 0.47 a	17.47± 0.33 a	16.80± 0.76 a	17.79± 0.68 a	ns	ns	ns
	10-20 cm	15.63± 0.26 a	15.86± 0.33 a	16.07± 0.32 a	15.41± 0.44 a	ns	ns	ns

Different letters in the columns denote statistical differences in the means of the variables between treatments by the least significant difference test ($P < 0.05$). *, $P < 0.05$; ns, not significant. CTNS, conventional intensive tillage with straw removal; CTSR, conventional intensive tillage with straw return; NTNS, no tillage with straw removal; NTSR, no-tillage with straw return. T, tillage; SR, straw return practices. T×SR, the interactions between tillage and straw return. Values are mean ± standard deviation (n = 3).

Table S2. Changes in aggregate composition (%) under different tillage and straw return practices in 0-5 cm soil layer (2012–2014).

Crop season	Soil aggregate	CTNS	CTSR	NTNS	NTSR	T	SR	T×SR
	fraction							
2012 rice season	1-2 mm	27.77±0.94 a	28.55±1.52 a	25.66±1.68 a	25.19±1.20 a	ns	ns	ns
	0.25-1 mm	52.10±0.83 a	49.40±1.25 a	56.02±1.42 a	51.39±2.43 a	ns	ns	ns
	0.053-0.25 mm	16.60±1.41 a	18.72±1.92 a	15.38±0.35 a	19.67±3.12 a	ns	ns	ns
	<0.053 mm	3.53±0.15 a	3.33±0.07 a	2.94±0.10 a	3.76±0.43 a	ns	ns	ns
2013 wheat season	1-2 mm	30.98±0.21 b	32.49±0.84 ab	31.53±0.37 b	33.41±0.37 a	ns	*	ns
	0.25-1 mm	48.39±0.27 a	49.01±0.69 a	48.60±0.71 a	47.85±0.47 a	ns	ns	ns
	0.053-0.25 mm	16.48±0.26 a	14.57±1.33 a	15.61±1.03 a	14.25±0.28 a	ns	ns	ns
	<0.053 mm	4.15±0.24 a	3.93±0.17 a	4.26±0.32 a	4.49±0.33 a	ns	ns	ns
2013 rice season	1-2 mm	28.60±0.06 b	29.25±0.06 b	28.77±0.15 b	30.63±0.40 a	*	*	ns
	0.25-1 mm	48.49±0.69 a	48.43±0.66 a	48.71±0.33 a	49.14±0.16 a	ns	ns	ns
	0.053-0.25 mm	18.62±0.26 a	17.91±0.72 a	18.56±0.51 a	17.14±0.56 a	ns	ns	ns
	<0.053 mm	4.29±0.38 a	4.41±0.37 a	3.96±0.32 ab	3.09±0.09 b	*	ns	ns
2014 wheat season	1-2 mm	28.52±0.46 c	30.75±0.11 ab	30.31±0.30 b	31.40±0.28 a	*	*	ns
	0.25-1 mm	49.22±0.52 a	47.90±0.46 a	48.54±0.65 a	48.53±0.20 a	ns	ns	ns
	0.053-0.25 mm	16.78±0.66 a	17.22±0.19 a	16.77±0.60 a	16.43±0.56 a	ns	ns	ns
	<0.053 mm	5.48±0.33 a	4.13±0.40 b	4.37±0.31 b	3.64±0.11 b	ns	*	ns

Different letters in the columns denote statistical differences in the means of the variables between treatments by the least significant difference test ($P < 0.05$). *, $P < 0.05$; ns, not significant. CTNS, conventional intensive tillage with straw removal; CTSR, conventional intensive tillage with straw return; NTNS, no tillage with straw removal; NTSR, no-tillage with straw return. T, tillage; SR, straw return practices. T×SR, the interactions between tillage and straw return. Values are mean \pm standard deviation ($n = 3$).

Table S3. Changes of dissolved organic carbon (g kg⁻¹) contents in 0-5 cm soil layer under different tillage and straw return practices during 2012-2014.

Treatment	2012	2013		2014	
	Rice season	Wheat season	Rice season	Wheat season	Rice season
CTNS	1.05±0.03 a	0.77±0.02 c	0.99±0.03 c	0.87±0.03 c	1.03±0.01 c
CTSR	1.11±0.05 a	0.89±0.03 b	1.17±0.03 c	1.04±0.04 b	1.18±0.01 b
NTNS	1.13±0.01 a	0.79±0.01 c	1.03±0.02 b	0.99±0.02 b	1.13±0.01 b
NTSR	1.13±0.05 a	1.04±0.03 a	1.33±0.01 a	1.16±0.03 a	1.26±0.02 a
T	ns	ns	ns	*	*
SR	ns	*	*	*	*
T×SR	ns	*	*	ns	ns

Different letters in the columns denote statistical differences in the means of the variables between treatments by the least significant difference test ($P < 0.05$). *, $P < 0.05$; ns, not significant. CTNS, conventional intensive tillage with straw removal; CTSR, conventional intensive tillage with straw return; NTNS, no tillage with straw removal; NTSR, no-tillage with straw return. T, tillage; SR, straw return practices. T×SR, the interactions between tillage and straw return. Values are mean \pm standard deviation ($n = 3$).

Table S4. Changes of soil microbial biomass carbon (mg kg⁻¹) contents in 0-5 cm soil layer under different tillage and straw return practices during 2012-2014.

Treatment	2012	2013		2014	
	Rice season	Wheat season	Rice season	Wheat season	Rice season
CTNS	903±36.59 a	770±88.83 c	1191±5.18 c	1593±7.37 c	1131±56.66 c
CTSR	879±92.80 a	1018±53.57 ab	1316±38.35 b	1759±20.96 b	1290±43.78 c
NTNS	773±77.77 a	918±47.42 bc	1273±16.04 bc	1684±9.70 b	1507±49.49 b
NTSR	982±101.47 a	1140±42.71 a	1593±48.67 a	2389±22.11 a	1877±77.80 a
T	ns	*	*	*	*
SR	ns	*	*	*	*
T×SR	ns	ns	*	*	*

Different letters in the columns denote statistical differences in the means of the variables between treatments by the least significant difference test ($P < 0.05$). *, $P < 0.05$; ns, not significant. CTNS, conventional intensive tillage with straw removal; CTSR, conventional intensive tillage with straw return; NTNS, no tillage with straw removal; NTSR, no-tillage with straw return. T, tillage; SR, straw return practices. T×SR, the interactions between tillage and straw return. Values are mean ± standard deviation (n = 3).

Table S5. Soil bacterial and fungal PLFA under different tillage practices and residue returning methods in 0-5 cm soil layer (2013–2014).

Treatment	2013 wheat season		2013 rice season		2014 wheat season		2014 rice season	
	Bacterial PLFA	Fungal PLFA	Bacterial PLFA	Fungal PLFA	Bacterial PLFA	Fungal PLFA	Bacterial PLFA	Fungal PLFA
CTNS	6.56±2.03 b	0.08±0.03 ab	9.64±0.25 c	/	11.95±0.80 c	0.16±0.04 a	14.48±0.06 b	/
CTSR	10.85±1.02 b	0.12±0.05 ab	14.69±1.19 b	/	18.68±1.16 b	0.15±0.01 a	17.66±0.78 b	/
NTNS	10.04±1.22 b	0.06±0.03 b	12.84±0.22 b	/	16.52±0.34 b	0.14±0.03 a	15.94±1.01 b	/
NTSR	18.45±1.41a	0.15±0.03 a	20.15±0.28 a	/	31.33±1.65 a	0.24±0.05 a	30.91±3.72 a	/
T	ns	ns	*	/	*	ns	ns	/
SR	*	ns	*	/	*	ns	*	/
T*SR	ns	ns	ns	/	*	ns	ns	/

Different letters in the columns denote statistical differences in the means of the variables between treatments by the least significant difference test ($P < 0.05$). *, $P < 0.05$; ns, not significant. CTNS, conventional intensive tillage with straw removal; CTSR, conventional intensive tillage with straw return; NTNS, no tillage with straw removal; NTSR, no-tillage with straw return. T, tillage; SR, straw return practices. T×SR, the interactions between tillage and straw return. Values are mean \pm standard deviation ($n = 3$).

Table S6. The change in bacterial community at order level (relative abundance >0.5%) under different tillage and straw return practice in 2013 rice season.

Bacterial community			CTNS	CTSR	NTNS	NTSR	T	SR	T×SR
Phylum	Class	Order							
Acidobacteria	<i>Acidobacteria_Gp1</i>	<i>Gp1</i>	19.60±0.97 a	22.21±1.17 a	19.30±2.68 ab	15.11±0.97 b	*	ns	*
	<i>Acidobacteria_Gp18</i>	<i>Gp18</i>	5.81±0.21 a	4.52±0.27 b	4.34±0.30 b	3.98±0.13 b	*	*	*
	<i>Acidobacteria_Gp3</i>	<i>Gp3</i>	3.55±0.46 a	3.38±0.26 a	3.90±0.62 a	3.37±0.22 a	ns	ns	ns
	<i>Acidobacteria_Gp6</i>	<i>Gp6</i>	1.96±0.55 a	1.98±0.10 a	2.20±0.86 a	2.76±0.12 a	ns	ns	ns
	<i>Acidobacteria_Gp7</i>	<i>Gp7</i>	1.93±0.08 a	1.80±0.27 a	1.77±0.21 a	1.68±0.09 a	ns	ns	ns
	<i>Acidobacteria_Gp2</i>	<i>Gp2</i>	1.16±0.79 a	1.48±0.16 a	1.78±0.62 a	0.95±0.12 a	ns	ns	ns
	<i>Acidobacteria_Gp13</i>	<i>Gp13</i>	0.81±0.03 a	0.91±0.12 a	0.72±0.30 a	0.92±0.07 a	ns	ns	ns
	<i>Acidobacteria_Gp4</i>	<i>Gp4</i>	0.65±0.02 b	0.34±0.02 c	0.40±0.05 c	1.23±0.05 a	*	*	*
	<i>Acidobacteria_Gp17</i>	<i>Gp17</i>	0.57±0.12 b	0.46±0.06 b	0.50±0.04 b	0.79±0.09 a	ns	*	*
	<i>Acidobacteria_Gp16</i>	<i>Gp16</i>	0.56±0.13 a	0.43±0.10 a	0.66±0.16 a	0.54±0.16 a	*	ns	ns
Actinobacteri a	<i>Holophagae</i>	<i>Holophagales</i>	0.61±0.06 ab	0.42±0.04 b	0.60±0.18 ab	0.79±0.06 a	ns	ns	*
	<i>Actinobacteria</i>	<i>Actinomycetales</i>	1.03±0.17 a	1.41±0.12 a	1.80±0.97 a	1.68±0.16 a	ns	ns	ns
Bacteroidetes	<i>Sphingobacteria</i>	<i>Sphingobacteriales</i>	1.87±0.82 a	1.94±0.26 a	1.82±0.81 a	2.56±0.12 a	ns	ns	ns
Chloroflexi	<i>Anaerolineae</i>	<i>Anaerolineales</i>	5.38±1.75 a	3.48±0.28 a	6.54±1.73 a	3.60±1.08 a	ns	ns	ns
	<i>Dehalococcoidetes</i>	<i>Dehalogenimonas</i>	0.78±0.08 b	0.48±0.07 c	0.64±0.09 bc	0.98±0.03 a	*	ns	*
Chamydiae	<i>Chamydiae</i>	<i>Chlamydiales</i>	1.56±0.09 b	1.71±0.13 b	1.62±0.20 b	2.29±0.17 a	ns	*	*
Proteobacteria	<i>Alphaproteobacteria</i>	<i>Rhodospirillales</i>	3.92±0.35 a	3.95±0.34 a	4.19±0.08 a	3.92±0.14 a	ns	ns	ns
		<i>Caulobacteriales</i>	0.61±0.05 b	0.60±0.10 b	0.64±0.03 b	0.90±0.06 a	*	*	*

		<i>Rhizobiales</i>	1.21±0.17 b	1.35±0.24 ab	2.26±0.58 a	1.12±0.30 b	ns	ns	ns
	<i>Betaproteobacteria</i>								
		<i>Burkholderiales</i>	2.35±0.68 a	1.20±0.10 b	2.03±0.15 ab	1.53±0.40 ab	ns	*	ns
		<i>Syntrophobacteriales</i>	1.43±0.30 b	1.34±0.19 b	1.38±0.38 b	2.32±0.06 a	ns	ns	*
	<i>Deltaproteobacteria</i>	<i>Desulfuromonadales</i>	1.65±0.55 a	1.05±0.23 a	2.09±0.62 a	1.49±0.32 a	*	ns	ns
		<i>Myxococcales</i>	1.33±0.38 a	1.04±0.08 a	1.99±0.62 a	1.41±0.48 a	*	ns	ns
	<i>Gammaproteobacteria</i>	<i>Xanthomonadales</i>	1.40±0.19 b	1.55±0.06 ab	1.33±0.18 b	1.83±0.18 a	ns	ns	ns
		<i>Legionellales</i>	1.34±0.09 a	1.27±0.14 ab	1.34±0.09 a	1.01±0.13 b	*	ns	ns
Planctomycetes	<i>Planctomycetacia</i>	<i>Planctomycetales</i>	0.97±0.34 a	1.44±0.34 a	1.45±0.28 a	1.29±0.17 a	ns	ns	ns
		<i>Subdivision3_genera_incertae_sedibus</i>	23.95±2.95 a	24.16±0.68 a	17.57±6.02 a	25.50±1.96 a			
	<i>Subdivision3</i>	<i>s</i>					ns	ns	ns
Verrucomicrobia	<i>Opitutae</i>	<i>Opitiales</i>	4.67±0.56 a	4.70±0.44 a	5.58±1.33 a	5.09±0.17 a	ns	ns	ns
		<i>Spartobacteria_genera_incertae_sedibus</i>	2.68±0.31 b	4.45±0.68 a	3.91±0.97 ab	3.09±0.32 ab			
	<i>Spartobacteria</i>	<i>edis</i>					ns	ns	*

Different letters in the columns denote statistical differences in the means of the variables between treatments by the least significant difference test ($P < 0.05$). *, $P < 0.05$; ns, not significant. CTNS, conventional intensive tillage with straw removal; CTSR, conventional intensive tillage with straw return; NTNS, no tillage with straw removal; NTSR, no-tillage with straw return. T, tillage; SR, straw return practices. T×SR, the interactions between tillage and straw return. Values are mean \pm standard deviation (n = 3).

Table S7 The change in bacterial community at order level (relative abundance >0.5%) under different tillage and straw return practice in 2014 wheat season

Bacterial community			CTNS	CTS	NTNS	NTS	T	SR	T×S R
Phylum	Class	Order							
	<i>Acidobacteria_Gp1</i>	<i>Gp1</i>	5.78±1.50 a	4.62±0.81 a	3.70±0.69 a	5.33±1.32 a	ns	ns	ns
	<i>Acidobacteria_Gp3</i>	<i>Gp3</i>	5.01±4.00 a	4.55±2.17 a	2.86±1.32 a	6.13±1.58 a	ns	ns	ns
	<i>Acidobacteria_Gp16</i>	<i>Gp16</i>	2.75±0.16 a	2.82±0.46 a	4.55±1.87 a	2.17±0.51 a	ns	ns	ns
	<i>Acidobacteria_Gp6</i>	<i>Gp6</i>	0.26±0.30 a	1.88±3.03 a	1.88±2.96 a	4.87±1.29 a	ns	ns	ns
<i>Acidobacteria</i>	<i>Acidobacteria_Gp4</i>	<i>Gp4</i>	0.22±0.20 b	0.90±0.86 ab	0.27±0.14 b	2.35±0.80 a	ns	*	ns
	<i>Acidobacteria_Gp10</i>	<i>Gp10</i>	0.18±0.25 b	0.48±0.68 b	0.32±0.51 b	2.55±1.19 a	ns	*	ns
	<i>Acidobacteria_Gp18</i>	<i>Gp18</i>	0.47±0.37 b	0.62±0.36 ab	0.50±0.14 b	1.29±0.14 a	ns	*	*
	<i>Acidobacteria_Gp17</i>	<i>Gp17</i>	0.15±0.15 a	0.48±0.53 a	0.70±0.83 a	1.33±0.87 a	ns	ns	ns
	<i>Acidobacteria_Gp7</i>	<i>Gp7</i>	0.18±0.09 b	0.55±0.43 b	0.29±0.17 b	1.34±0.09 a	ns	*	ns
<i>Actinobacteria</i>	<i>Actinobacteria</i>	<i>Actinomycetales</i>	2.42±0.92 a	1.49±0.50 a	2.42±1.76 a	2.45±1.84 a	ns	ns	ns
	<i>Sphingobacteria</i>	<i>Sphingobacteriales</i>	1.34±0.69 a	2.68±1.96 a	1.08±0.83 a	3.72±0.57 a	ns	*	ns
<i>Bacteroidetes</i>	<i>Flavobacteria</i>	<i>Flavobacteriales</i>	0.64±0.34 a	0.92±0.52 a	0.68±0.73 a	1.57±0.68 a	ns	*	*
<i>Chloroflexi</i>	<i>Anaerolineae</i>	<i>Anaerolineales</i>	26.13±4.13 a	27.94±3.47 a	27.78±1.90 a	20.71±4.48 a	ns	ns	ns
<i>Gemmatimonadetes</i>	<i>Gemmatimonadetes</i>	<i>Gemmatimonadales</i>	13.45±6.95 a	8.85±6.74 a	10.08±1.46 a	3.44±0.68 a	ns	*	ns
<i>Nitrospira</i>	<i>Nitrospira</i>	<i>Nitrospirales</i>	3.25±0.89 a	2.63±1.32 a	3.42±1.59 a	1.22±0.40 a	ns	ns	ns
<i>Planctomycetes</i>	<i>Planctomycetacia</i>	<i>Planctomycetales</i>	9.84±3.06 a	8.16±3.45 a	7.28±3.79 a	4.69±1.26 a	ns	ns	ns
		<i>Rhizobiales</i>	11.96±1.88 a	11.44±5.33 a	12.51±2.73 a	5.50±0.63 a	ns	ns	ns
<i>Proteobacteria</i>	<i>Alphaproteobacteria</i>	<i>Rhodospirillales</i>	5.58±2.10 a	3.60±2.11 a	3.49±0.74 a	1.66±0.14 a	ns	*	ns
		<i>Caulobacteriales</i>	0.57±0.06 a	0.97±0.32 a	1.05±0.18 a	0.91±0.63 a	ns	ns	ns

	<i>Burkholderiales</i>	1.84±1.12 a	3.99±3.53 a	3.76±2.92 a	6.73±1.14 a	ns	ns	ns
<i>Betaproteobacteria</i>	<i>Rhodocyclales</i>	1.16±0.12 a	1.19±0.45 a	0.92±0.20 a	1.56±0.48 a	ns	ns	ns
	<i>Hydrogenophilales</i>	0.51±0.15 a	0.78±0.22 a	0.66±0.17 a	0.62±0.15 a	ns	ns	ns
<i>Gammaproteobacteria</i>	<i>Xanthomonadales</i>	1.70±0.54 b	2.35±0.33 ab	2.65±0.41 ab	3.30±0.89 a	ns	ns	ns
<i>Deltaproteobacteria</i>	<i>Myxococcales</i>	0.44±0.39 b	1.09±1.14 ab	1.23±1.57 ab	3.47±0.36 a *	ns	ns	ns

Different letters in the columns denote statistical differences in the means of the variables between treatments by the least significant difference test ($P < 0.05$). *, $P < 0.05$; ns, not significant. CTNS, conventional intensive tillage with straw removal; CTSR, conventional intensive tillage with straw return; NTNS, no tillage with straw removal; NTSR, no-tillage with straw return. T, tillage; SR, straw return practices. T×SR, the interactions between tillage and straw return. Values are mean \pm standard deviation (n = 3).

Table S8. Crop yield (kg ha⁻¹ y⁻¹) under different tillage practices and residue returning methods (2012–2014).

Treatment	2012	2013		2014	
	Rice season	Wheat season	Rice season	Wheat season	Rice season
CTNS	7325±200 a	4652±336 a	7615±287 a	5114±213 ab	7767±220 a
CTSR	7022±534 a	4585±150 a	7901±279 a	5564±291 b	7848±171 a
NTNS	7230±120 a	4868±137 a	7413±260 a	5142±105 ab	7840±59 a
NTSR	7636±315 a	4776±207 a	7894±263 a	4668±218 a	7878±175 a
T	ns	ns	ns	*	ns
SR	ns	ns	ns	ns	ns
T×SR	ns	ns	ns	**	ns

Different letters in the columns denote statistical differences in the means of the variables between treatments by the least significant difference test ($P < 0.05$). *, $P < 0.05$; ns, not significant. CTNS, conventional intensive tillage with straw removal; CTSR, conventional intensive tillage with straw return; NTNS, no tillage with straw removal; NTSR, no-tillage with straw return. T, tillage; SR, straw return practices. T×SR, the interactions between tillage and straw return. Values are mean \pm standard deviation (n = 3).

Table S9 The relationship between crop yield and soil properties

	Crop yield	SOC in 0-5 cm soil layer	SOC in 5-10 cm soil layer	SOC in 10-20 cm soil layer	DOC	MBC
Crop yield	1	-0.18	-0.27	-0.22	0.62**	-0.22
SOC in 0-5 cm soil layer	-0.18	1	0.09	0.18	0.32*	0.62**
SOC in 5-10 cm soil layer	-0.27	0.09	1	0.23	-0.01	0.22
SOC in 10-20 cm soil layer	-0.22	0.18	0.23	1	-0.02	0.24
DOC	0.62**	0.32*	-0.01	-0.02	1	0.29*
MBC	-0.22	0.62**	0.22	0.24	0.29*	1

Note: SOC, soil organic C; MBC, microbial biomass C; DOC, dissolved organic carbon. *, $P < 0.05$; **, $P < 0.01$.