

Appropriate Application of Organic Fertilizer Can Effectively Improve Soil Environment and Increase Maize Yield in Loess Plateau

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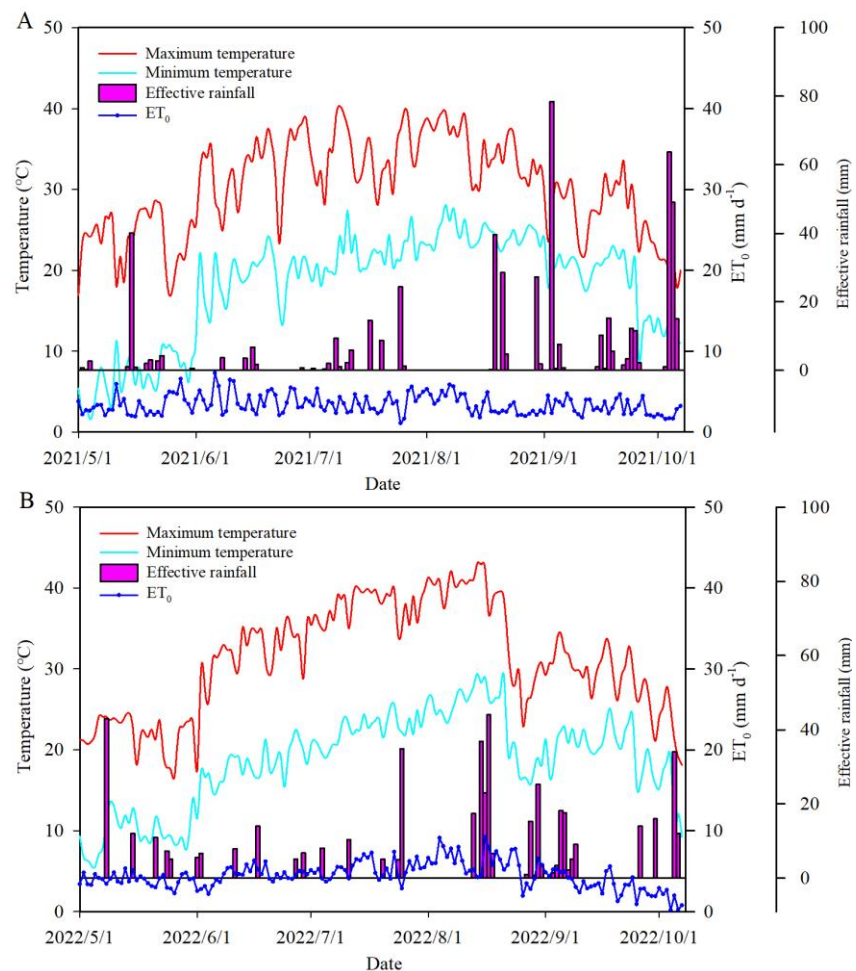
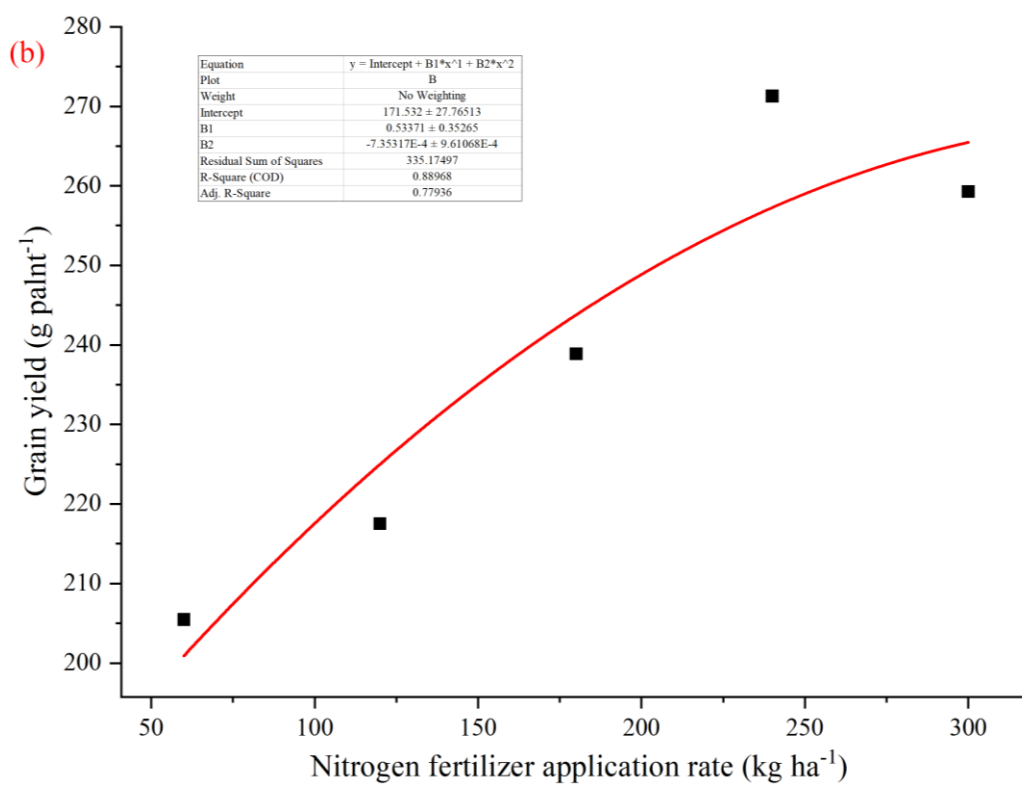
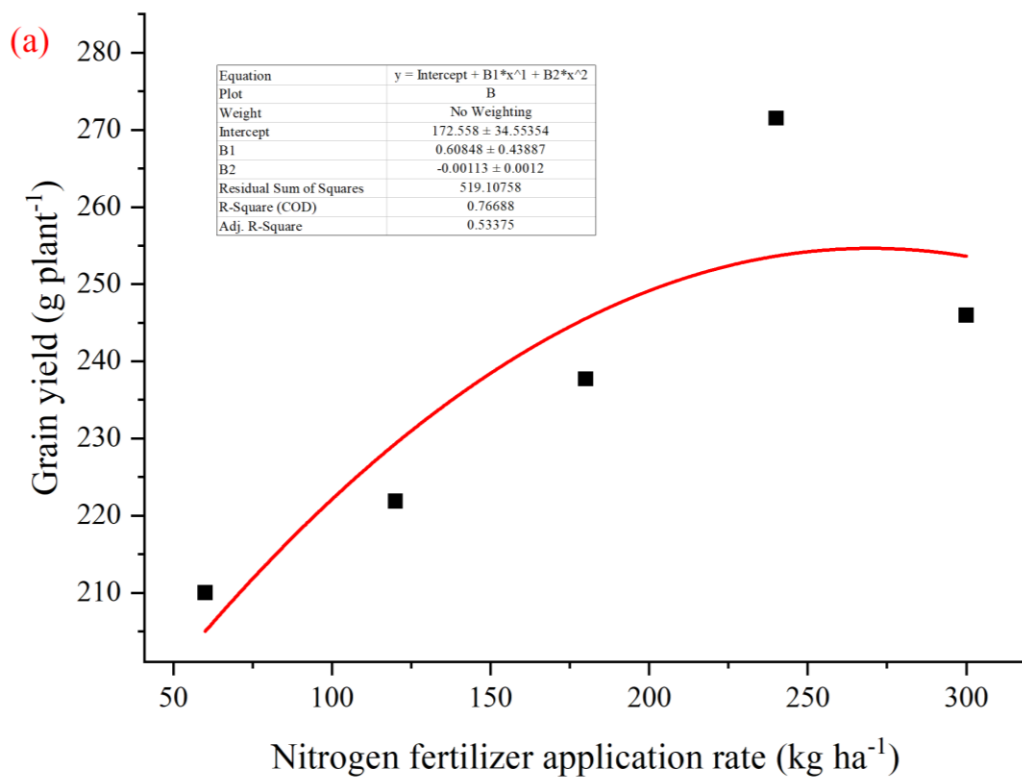


Figure S1. Main meteorological data of maize during the two-year growing period.



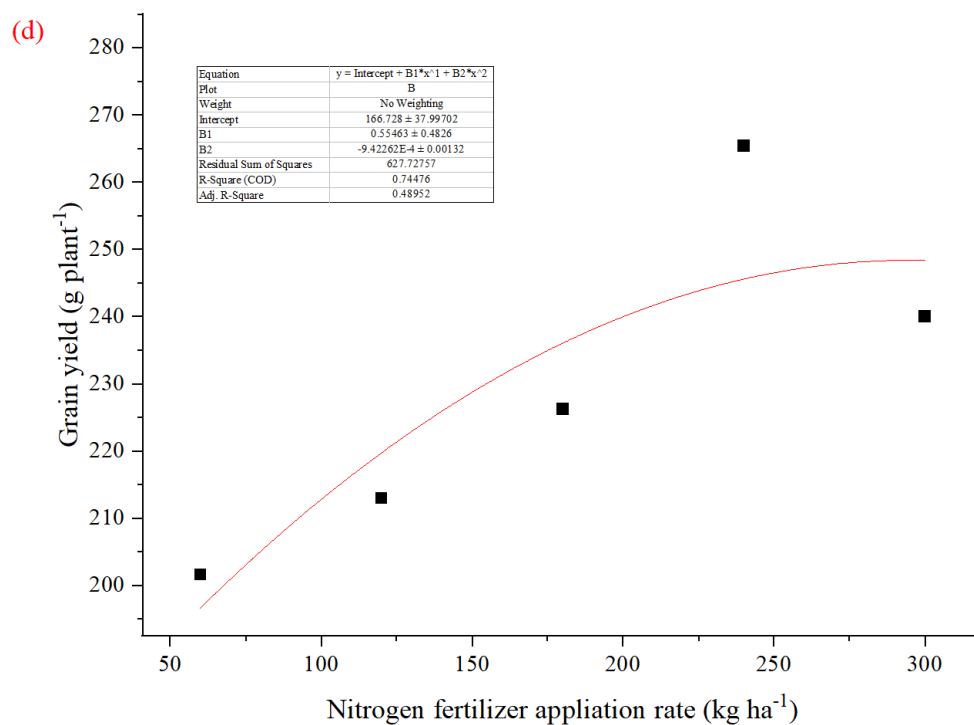
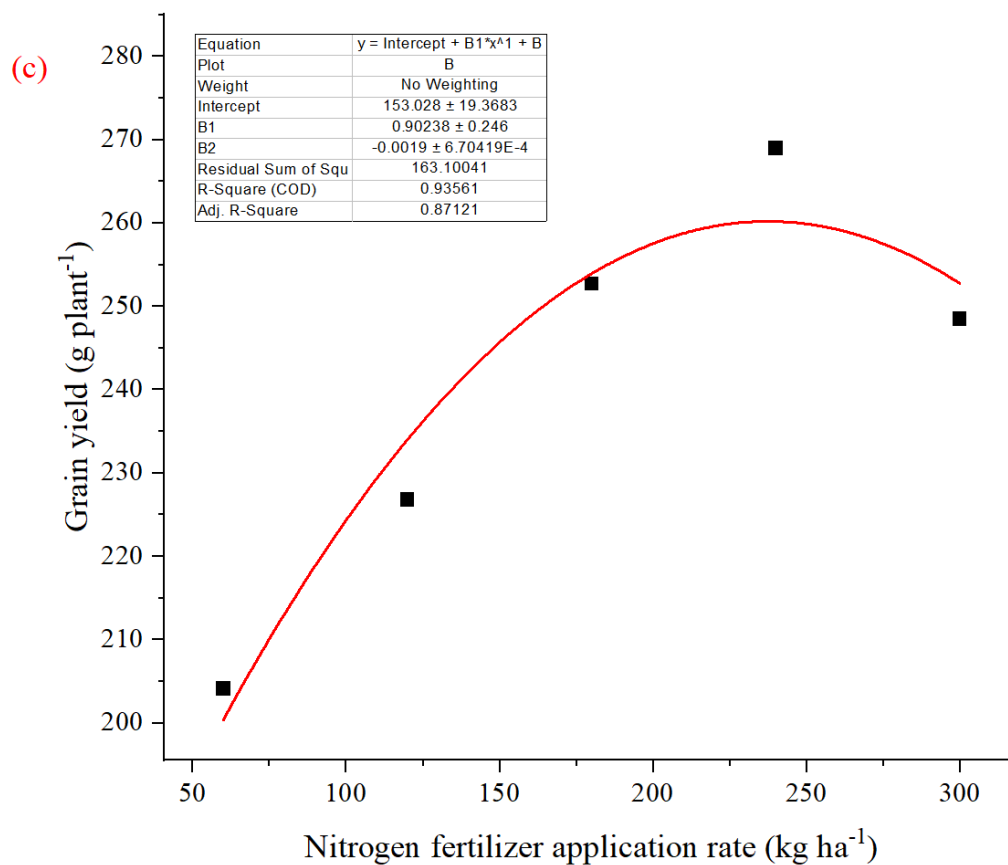
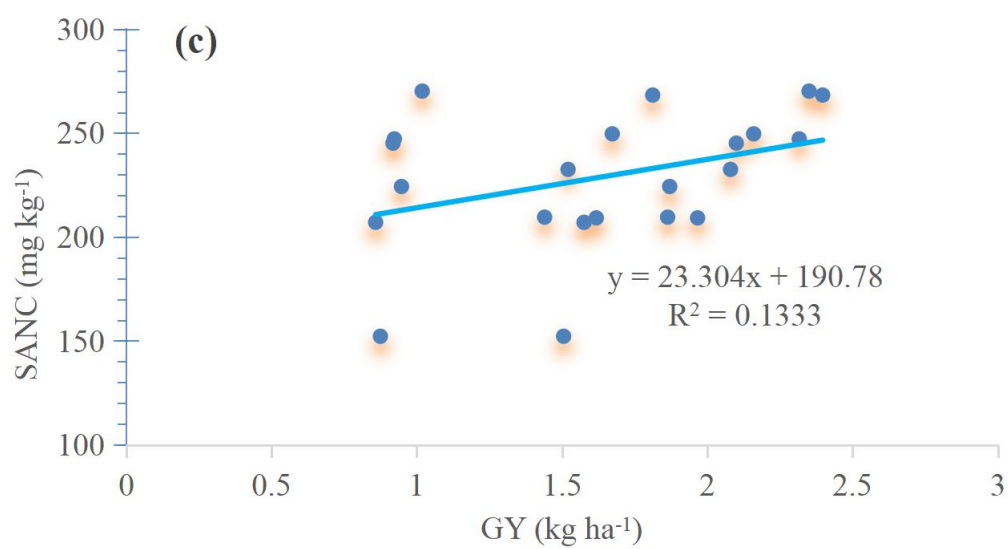
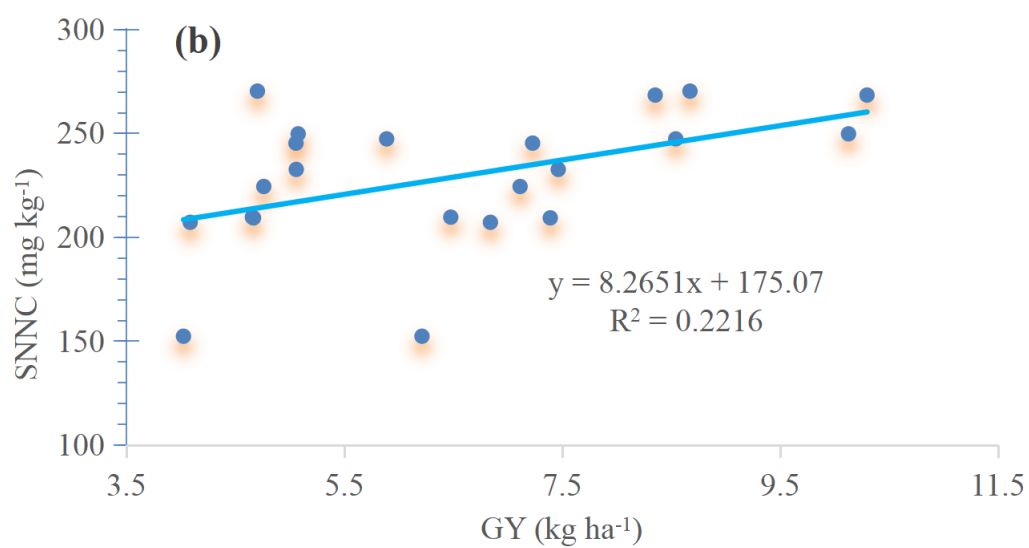
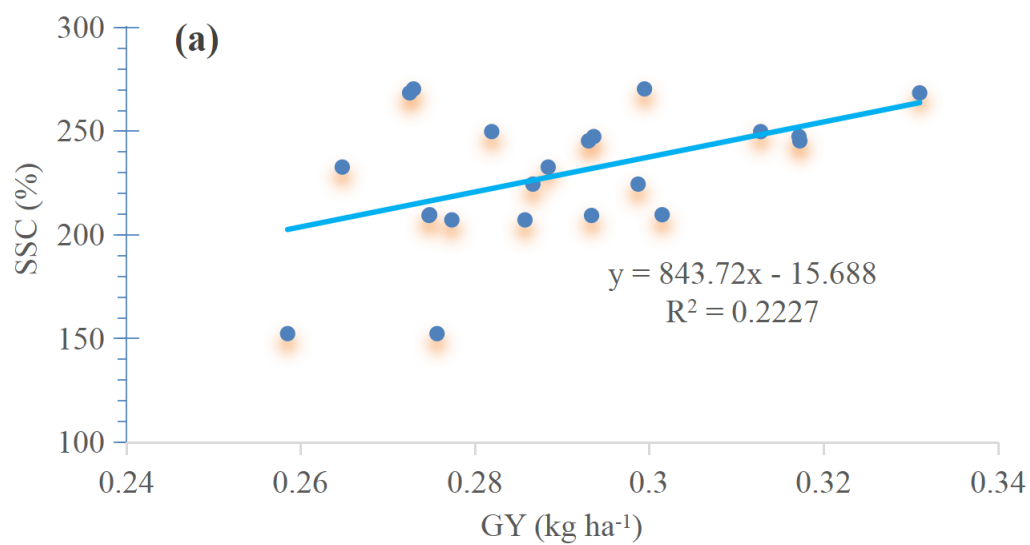
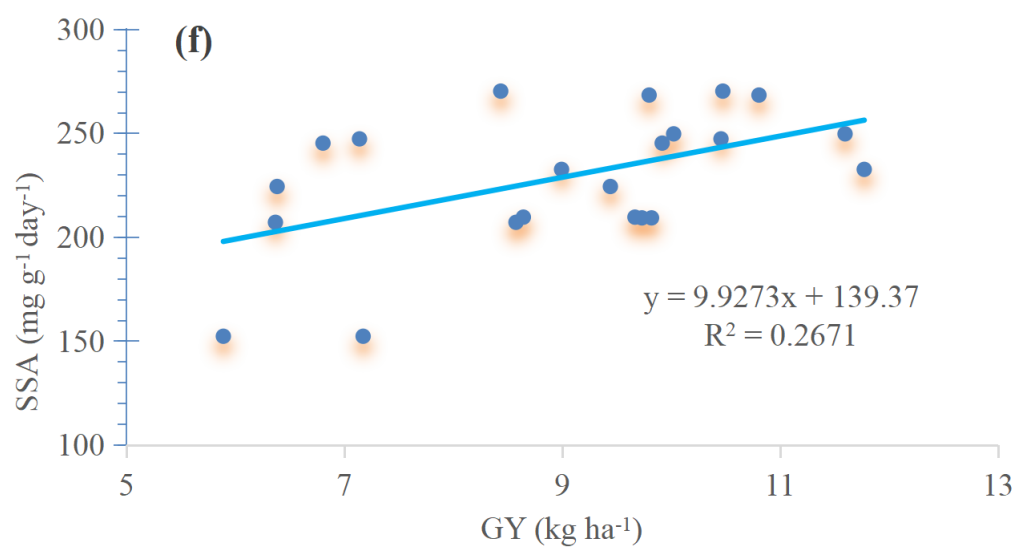
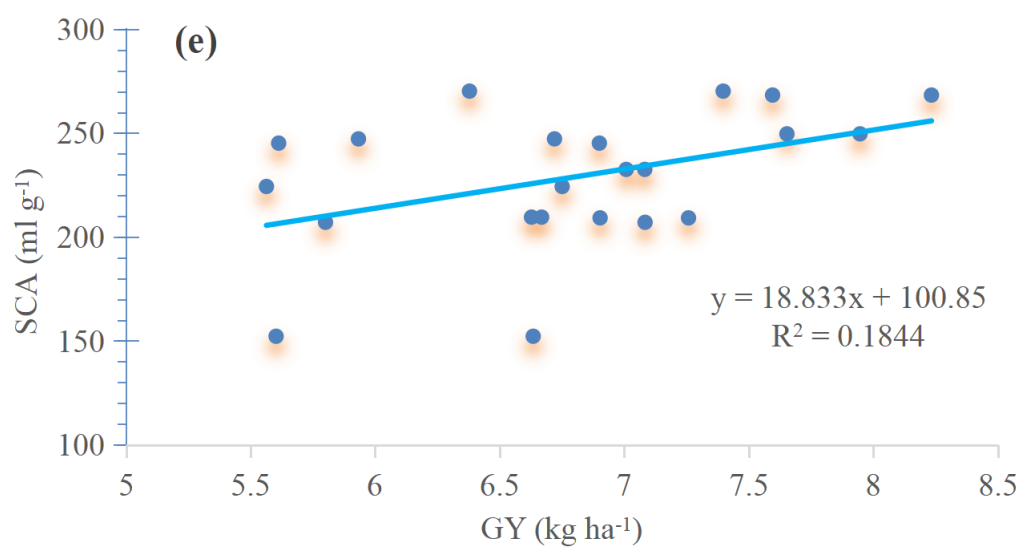
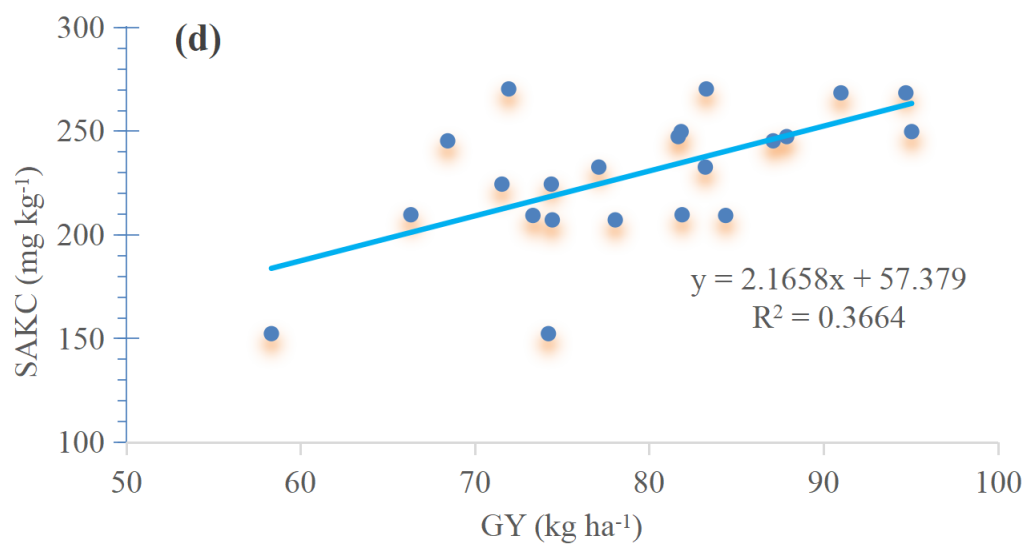


Figure S2. The relationship between maize grain yield and N fertilizer application rate in 2021 (a, chemical fertilizer and b, organic fertilizer) and 2022 (c, chemical fertilizer and d, organic fertilizer).





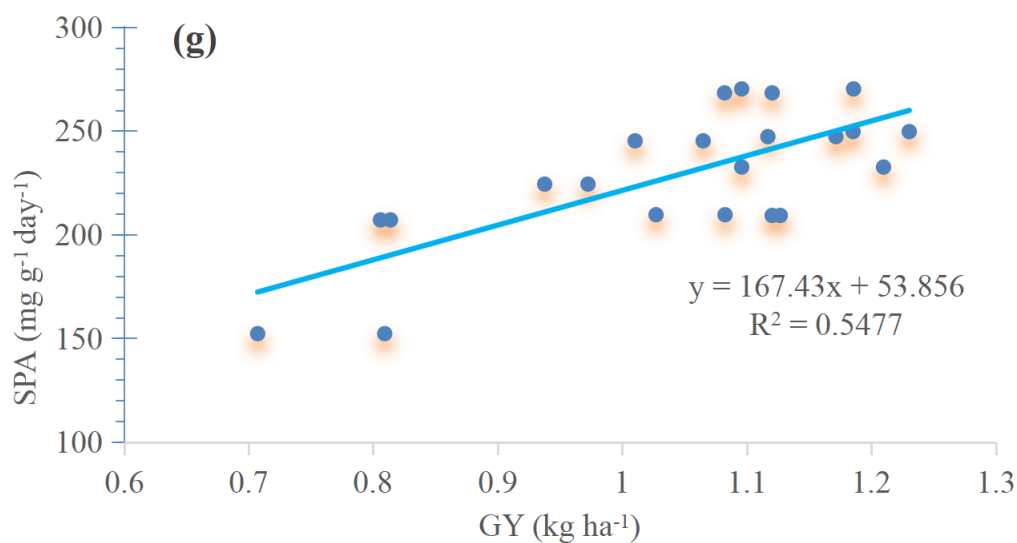
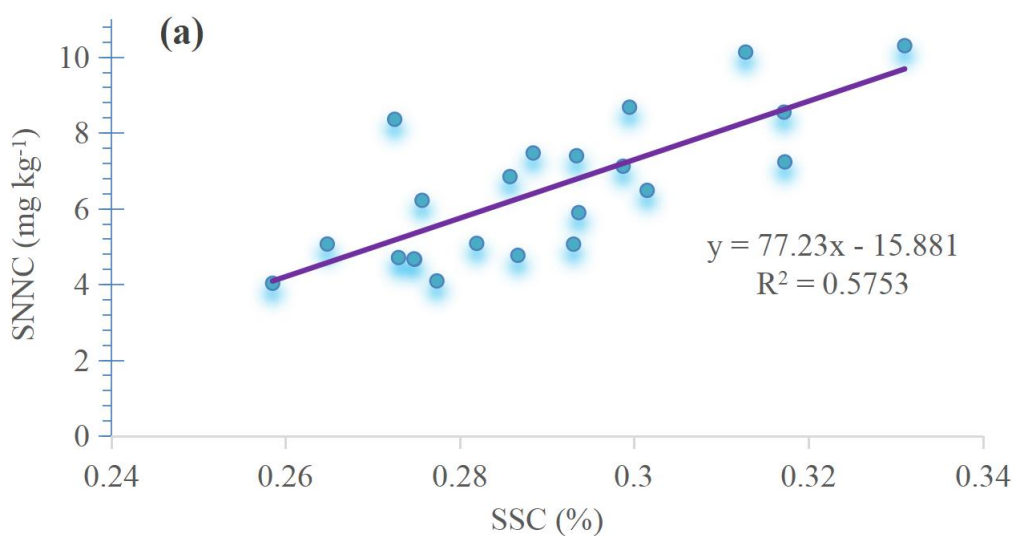


Figure S3. The relationship between maize grain yield (GY) and soil salt content (SSC, a), soil nitrate nitrogen content (SNNC, b), soil alkali-hydrolyzed nitrogen (SANC, c), soil available potassium content (SAKC, d), soil catalase activity (SCA, e), soil sucrase activity (SSA, f), and soil phosphatase activity (SPA, g).



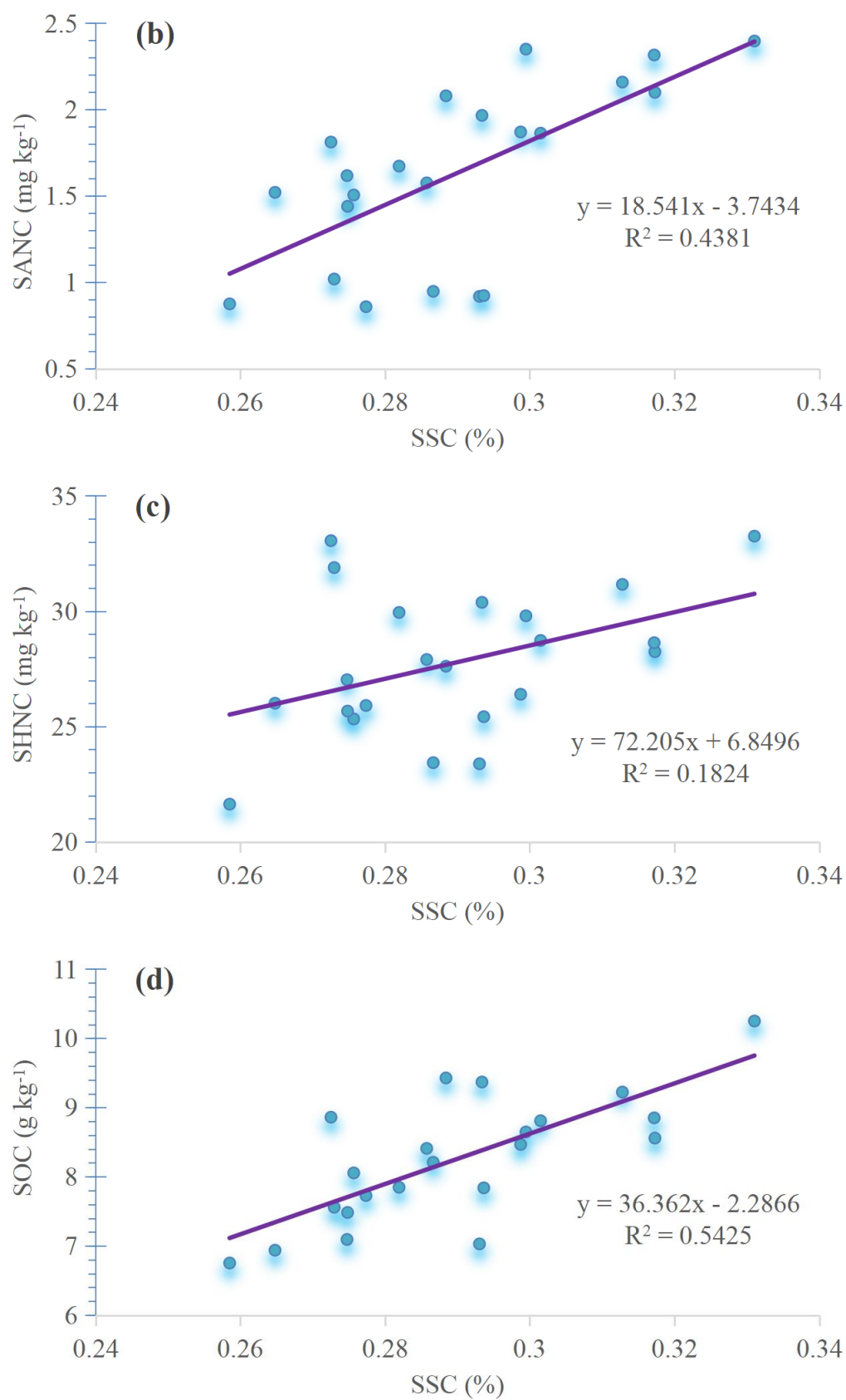
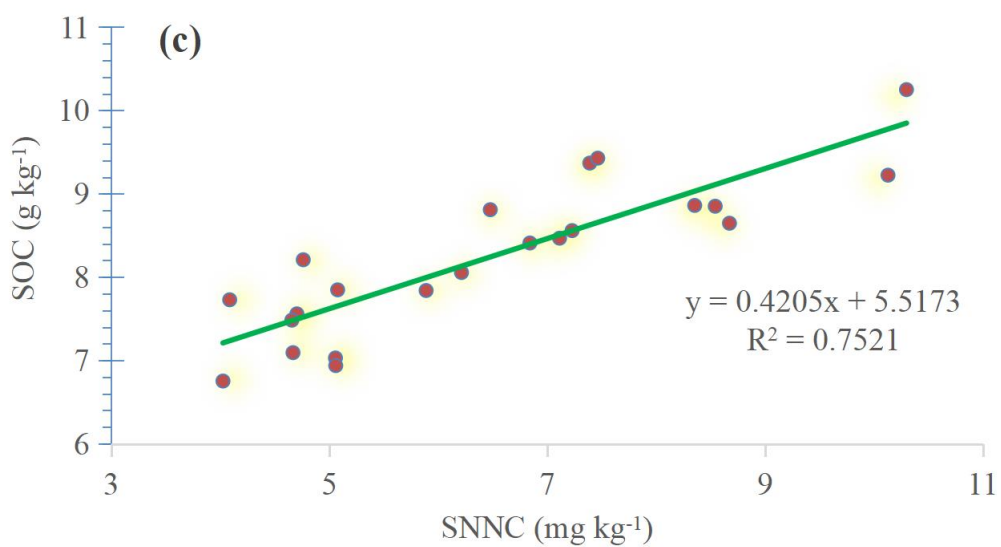
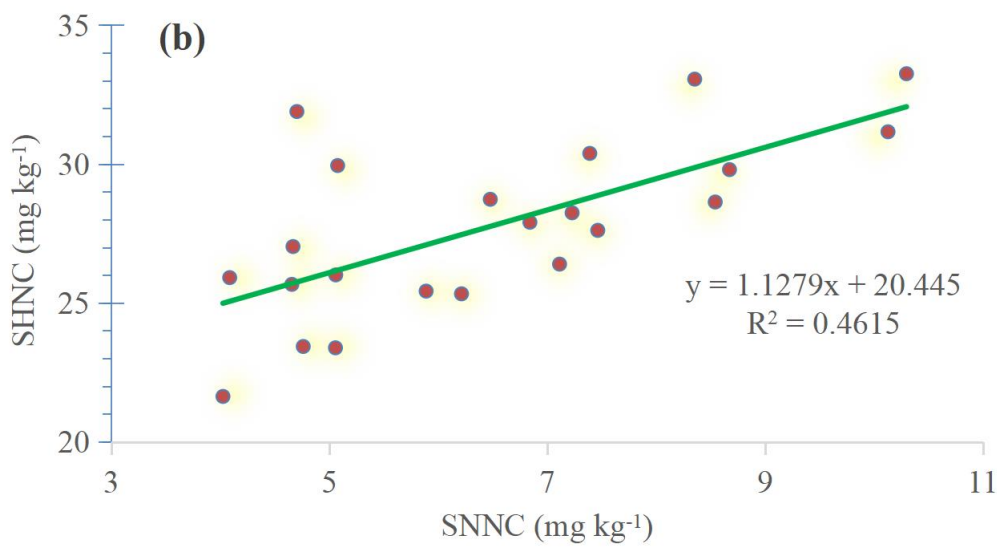
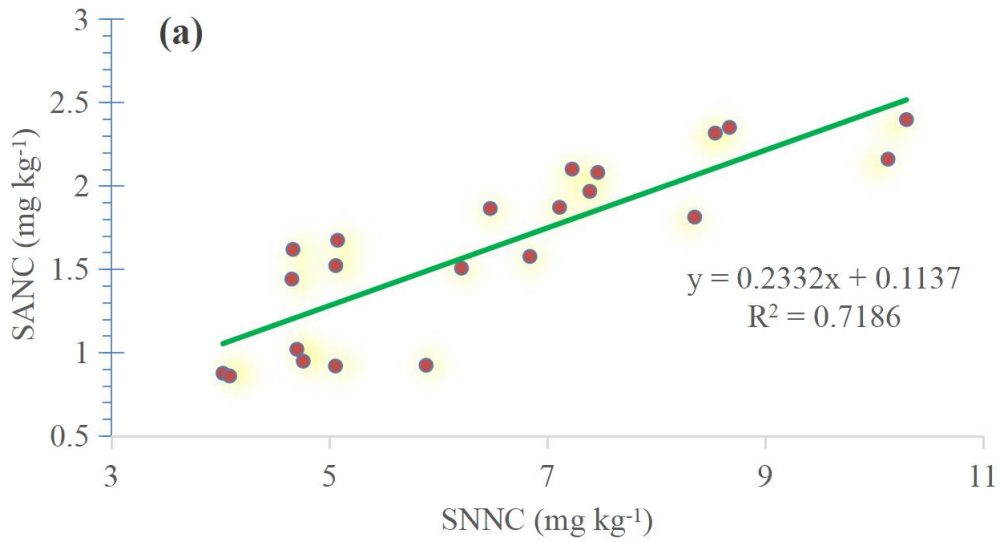


Figure S4. The relationship between soil salt content (SSC) and soil nitrate nitrogen content (SNNC, a), soil ammonium nitrogen content

(SANC, b), soil alkali-hydrolyzed nitrogen content (SHNC, c) and soil organic matter content (SOC, d).



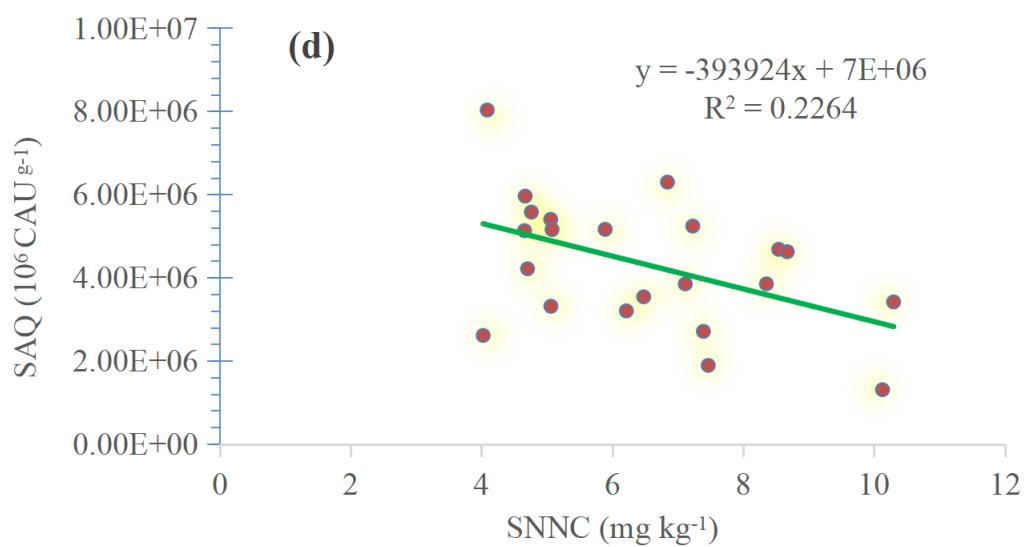
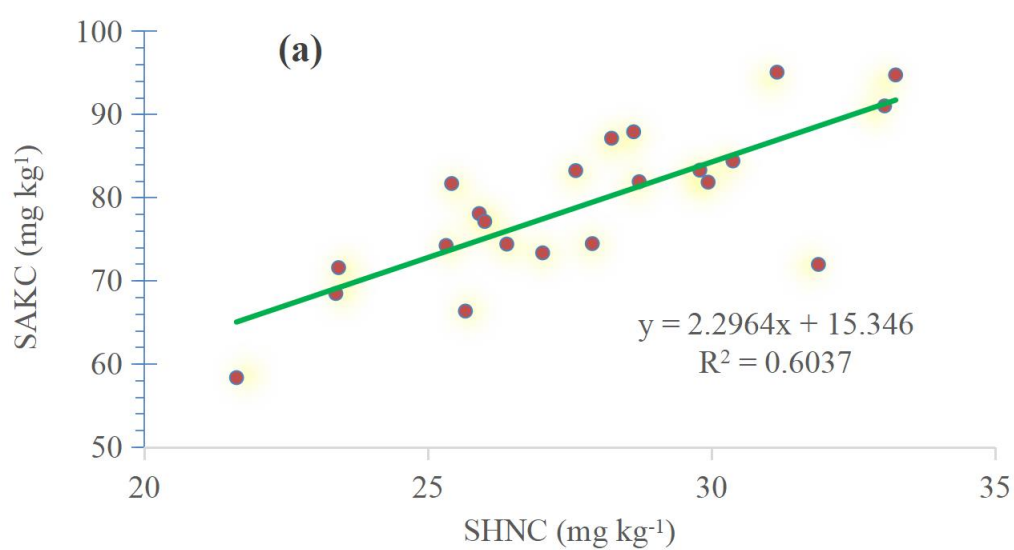


Figure S5. The relationship between soil nitrate nitrogen content (SNNC) and soil ammonium nitrogen content (SANC, a), soil alkali-hydrolyzed nitrogen content (SHNC, b), soil organic matter content (SOC, c) and soil actinomyces quantity (SAQ, d).



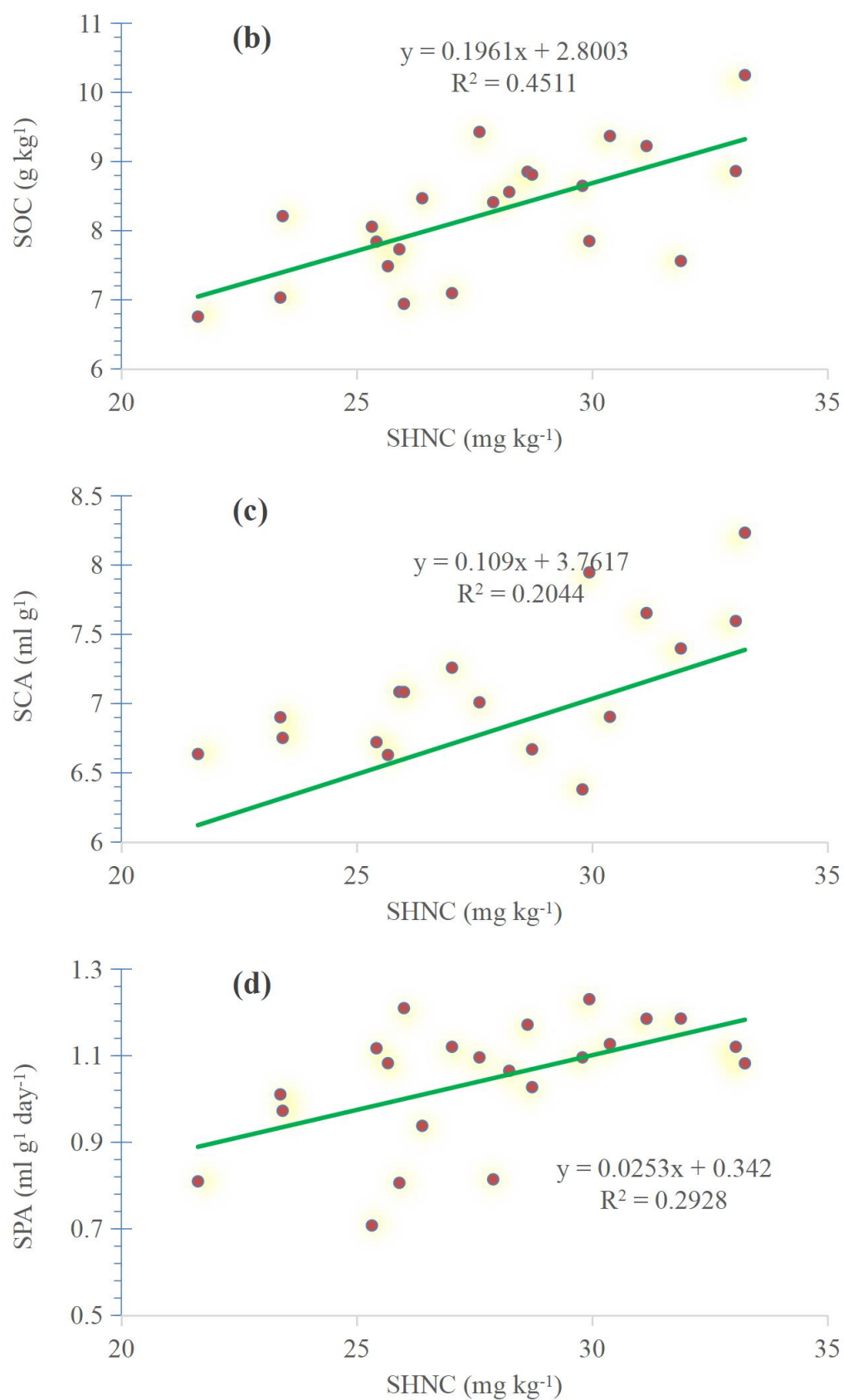


Figure S6. The relationship between soil alkali-hydrolyzed nitrogen content (SHNC) and soil available potassium content (SAKC, a), soil organic matter content (SOC, b), soil catalase activity (SCA, c), and soil

phosphatase activity (SPA, d).

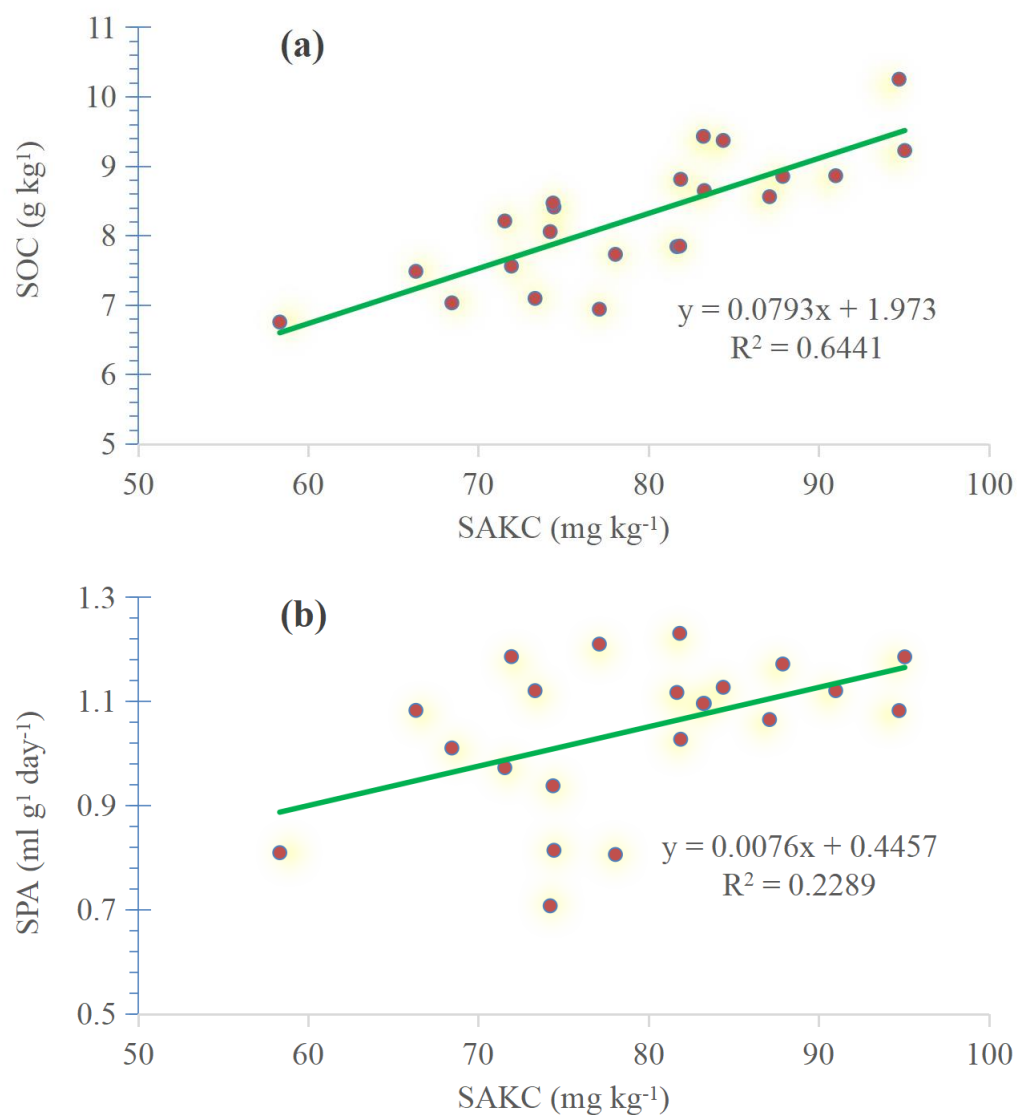
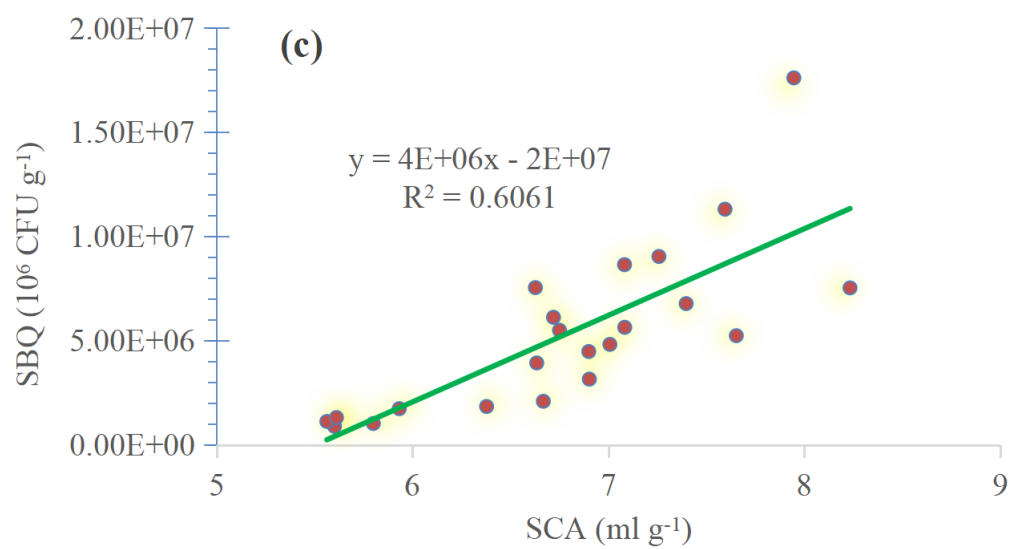
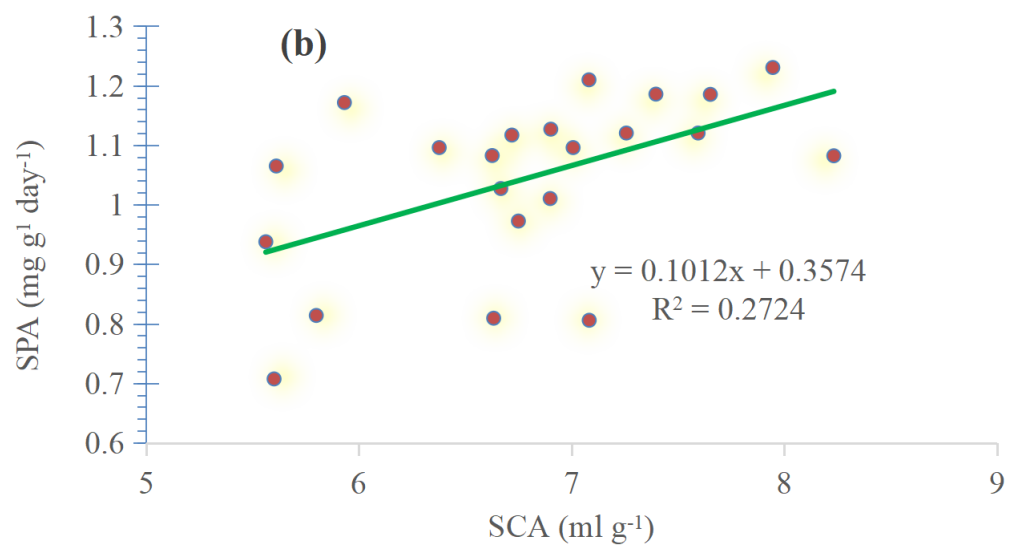
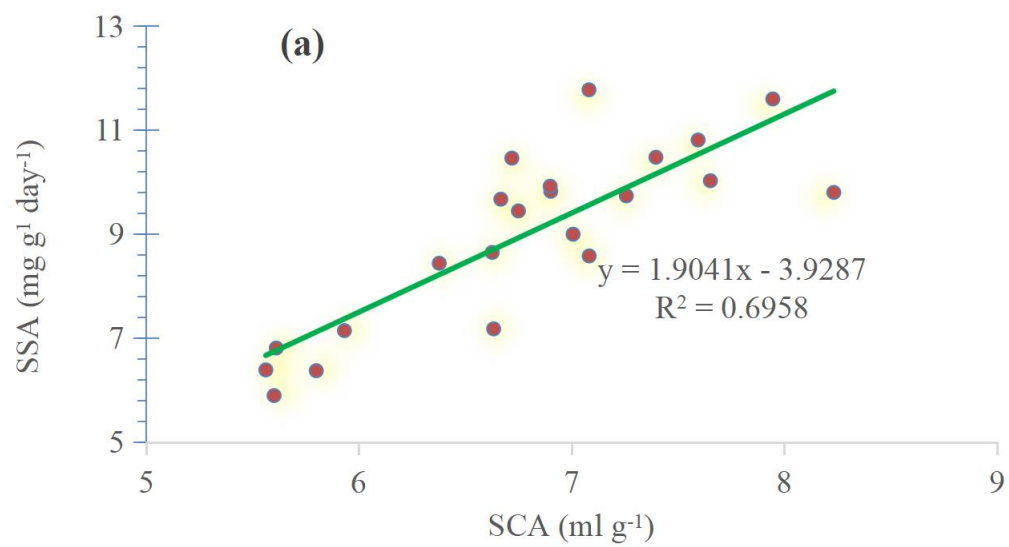


Figure S7. The relationship between and soil available potassium content (SAKC) and soil organic matter content (SOC, a) and soil phosphatase activity (SPA, b).



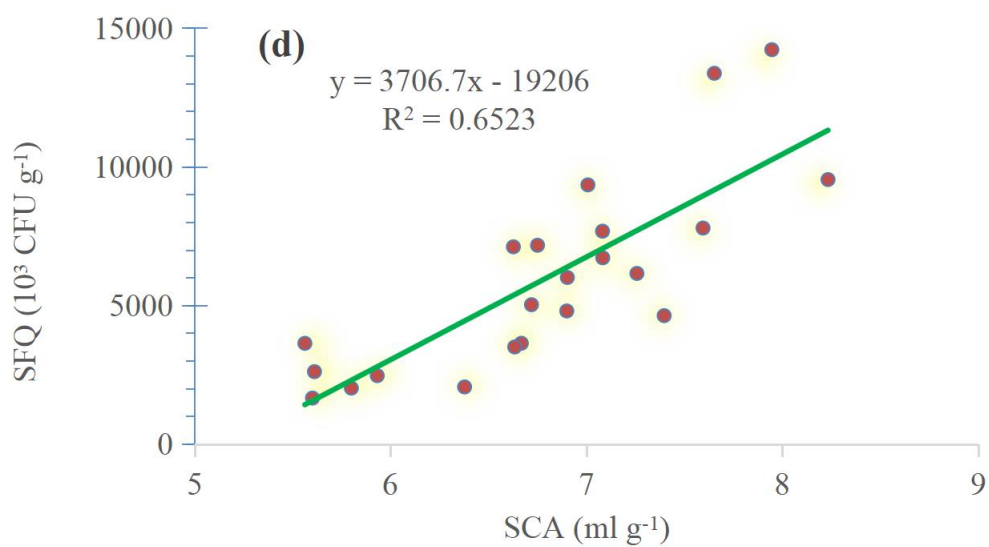
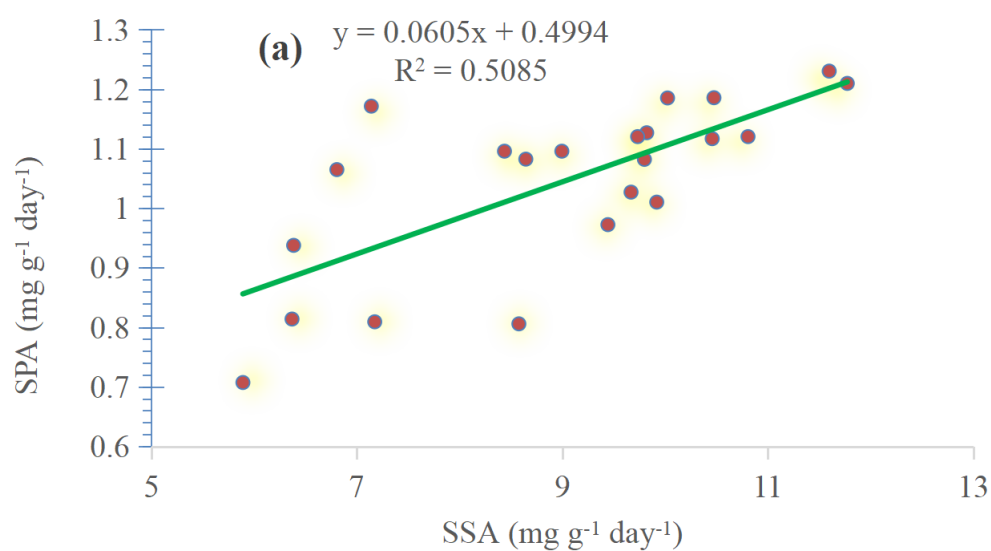


Figure S8. The relationship between and soil catalase activity (SCA) and soil sucrase activity (SSA, a), soil phosphatase activity (SPA, b), soil bacteria quantity (SBQ, c), and soil fungi quantity (SFQ, d).



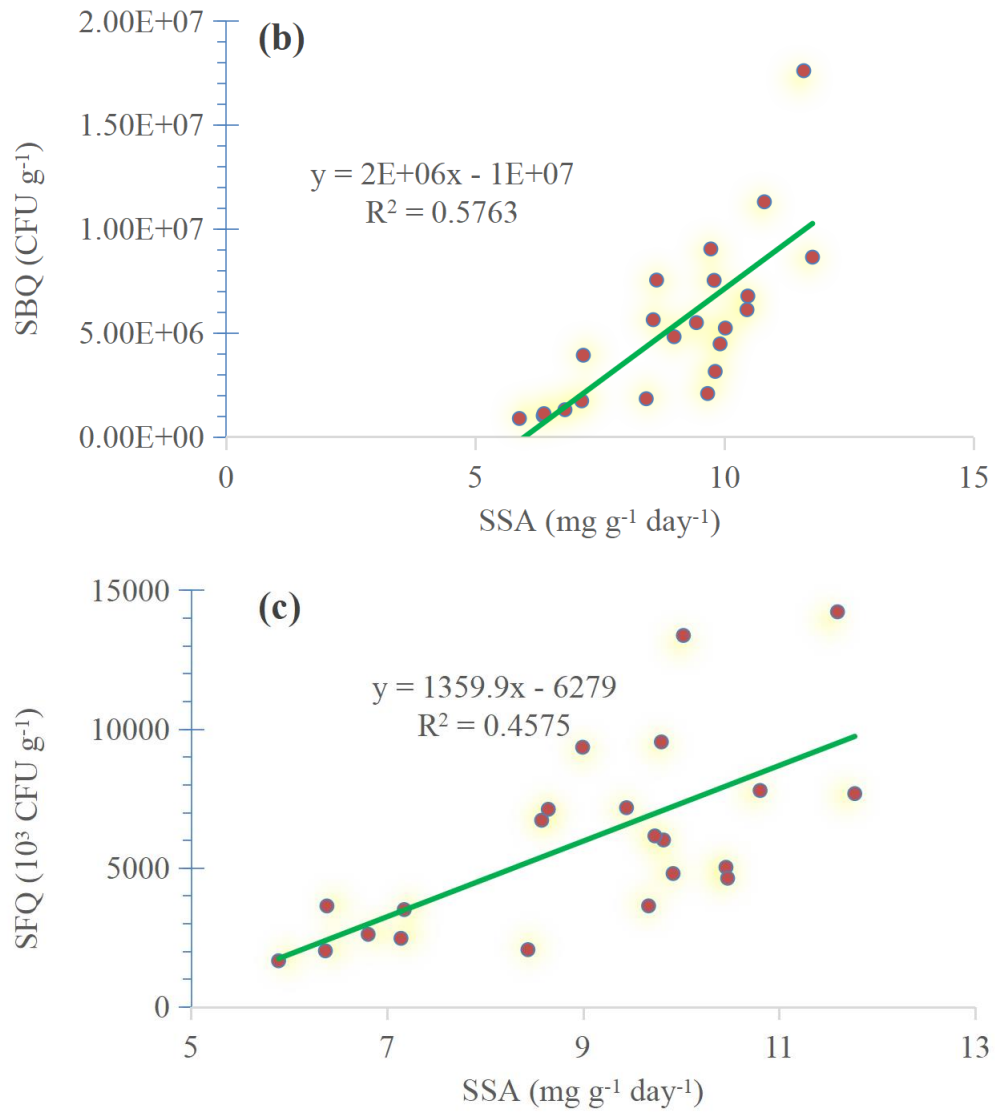


Figure S9. The relationship between and soil sucrose activity (SSA) and soil phosphatase activity (SPA, a), soil bacteria quantity (SBQ, b) and soil fungi quantity (SFQ, c).

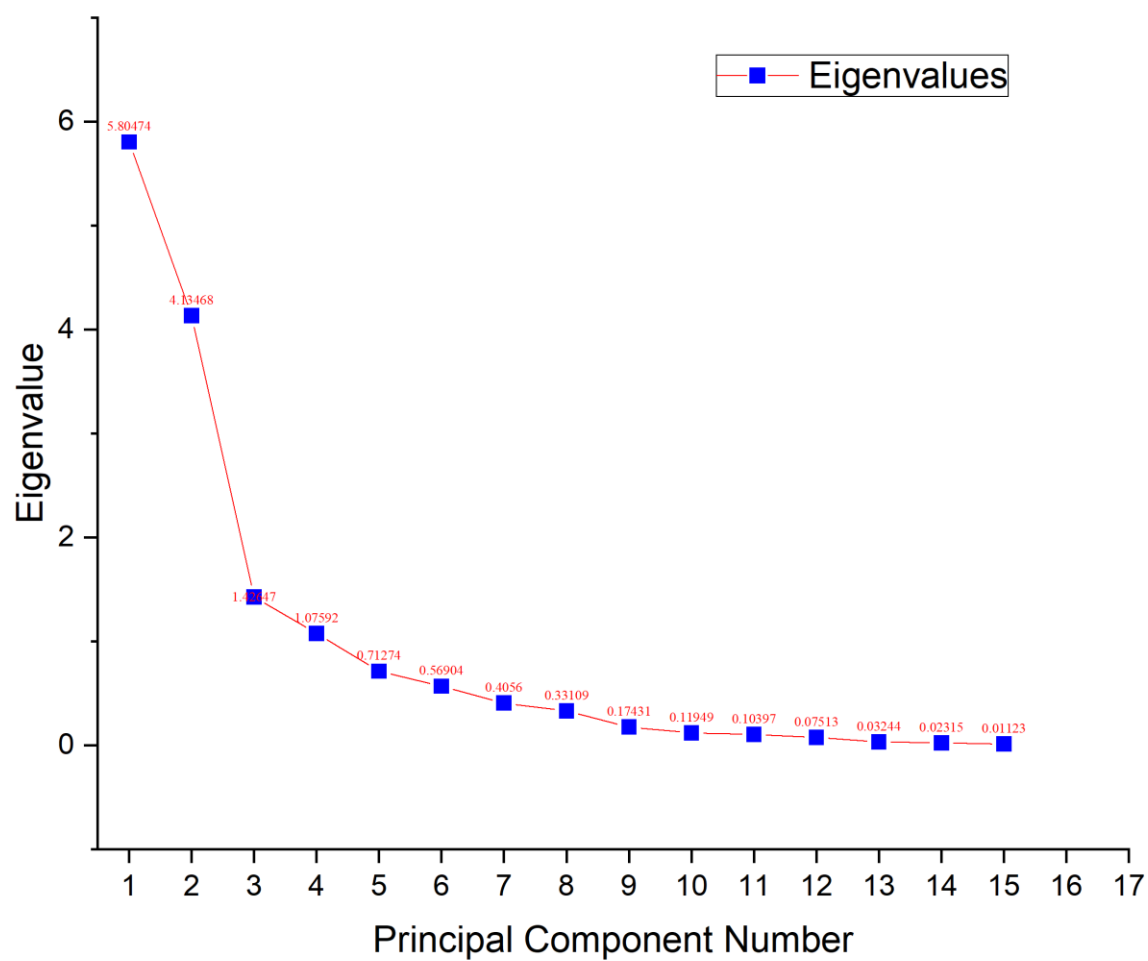


Figure S10. The number of components advocated by principal component analysis.

Table S1. The plant height was affected by fertilizer type and fertilizer application rate in 2021 and 2022.

Treatment	Seedling stage		Jointing stage		Filling stage		Maturing stage	
	2021	2022	2021	2022	2021	2022	2021	2022
CK	26.77±3.06a	25.47±4.12a	209.03±3.75e	198.53±5.47b	284.6±0.79b	271.33±3.13c	232.37±17.3b	211.32±5.17c
N1	26.03±5.96a	26.73±4.91a	220.07±5.23de	218.57±7.91a	310.13±5.71a	294.33±14.02bc	278.17±13.48ab	275.7±10.76ab
N2	33.8±1.6a	29±4.06a	239.93±4.07bc	238.43±4.53a	319.53±1.83a	307.83±5.39ab	301.3±21.77a	272.67±3.79ab
N3	30.2±2.43a	31.7±0.56a	265.43±7.52a	263.93±9.4a	313.23±9.39a	295.87±6.94abc	263.93±24.44ab	293.58±4.32a
N4	28.3±3.96a	34.5±0.82a	242.03±6.63bc	240.53±8.53a	309.4±3.92ab	310.87±9.49ab	257.8±34.24ab	290.88±14.21a
N5	32±1.68a	30.9±2.21a	256.9±8.3ab	253.4±6.47a	301.2±14.04ab	313.17±7.85a	271.4±14.21ab	258.41±6.32abc
TN1	25.2±3.46a	24.2±3.46a	227.8±1.65cd	226.3±4.2a	295.6±16.42ab	308.87±4.2ab	275.8±8.23ab	278.49±9.74ab
TN2	32.97±1.88a	32.97±1.88a	228.07±2.15cd	222.57±4.83a	309.1±3.3ab	314.27±2.2a	292.03±9.69a	290.27±13.21a
TN3	29.37±2.03a	29.37±2.03a	242.37±22.65cd	240.87±24.05a	297.13±9.24ab	311.97±11.58ab	289.33±18.74a	286.82±35.73ab
TN4	27.47±3.88a	27.47±3.88a	245.1±3.41abc	243.6±2.56a	312.13±10.83a	308.13±1.8ab	259.43±9.88ab	257.14±16.03abc
TN5	31.17±1.37a	31.17±1.37a	232.4±4.77cd	230.9±5.12a	319.43±9.32a	299.93±12.55abc	270.57±17.52ab	244.23±15.45bc

Table S2. The plant stem diameter was affected by fertilizer type and fertilizer application rate in 2021 and 2022.

Treatment	Seedling stage		Jointing stage		Filling stage		Maturing stage	
	2021	2022	2021	2022	2021	2022	2021	2022
CK	4.89±1.07a	5.18±1.14a	22.87±0.51a	23.13±0.51a	19.3±0.76a	19.3±0.76a	17.16±0.77a	17.14±0.29a
N1	6.35±0.72a	6.63±0.54a	24.03±0.9a	24.29±0.92a	24.04±2.36a	23.9±2.33a	21.4±2.28a	21.37±2.11a
N2	5.16±0.81a	5.45±0.95a	27.27±1.47a	27.53±1.55a	25.19±3.54a	25.05±3.55a	23.92±0.93a	23.9±0.96a
N3	5.96±0.36a	6.21±0.23a	28.6±3.49a	26.86±3.58a	25.73±0.57a	23.58±0.59a	21.78±2.86a	22.76±2.84a
N4	6.15±1.48a	6.43±1.48a	25.18±1.77a	25.44±1.86a	24.48±0.54a	24.33±0.51a	23.93±1.52a	22.9±1.43a
N5	6.11±1.57a	6.4±1.75a	27.13±0.89a	24.49±0.8a	24.67±2.17a	23.53±2.2a	23.52±2.01a	23.5±2.18a
TN1	6.25±0.35a	6.34±0.17a	25.27±1.2a	25.53±1.29a	26.1±0.55a	25.96±0.57a	20.72±0.35a	20.7±0.52a
TN2	5.07±1.16a	5.35±1.31a	25.03±1.96a	24.29±2.04a	24.24±0.99a	24.1±1.01a	21.71±1.69a	22.69±1.67a
TN3	5.86±0.1a	6.15±0.26a	30.83±1.62a	31.09±1.54a	25.12±2.5a	24.97±2.47a	23.48±0.58a	23.46±0.75a
TN4	6.05±1.37a	6.34±1.41a	26.3±1.17a	26.56±1.09a	24.05±3.5a	24.9±3.52a	22.13±1.29a	21.11±1.15a
TN5	6.01±1.94a	6.3±2.12a	26.6±2.64a	26.86±2.55a	23.82±1.61a	23.68±1.65a	22.35±3.19a	22.33±3.02a

Table S3. The plant leaf area was affected by fertilizer type and fertilizer application rate in 2021 and 2022.

Treatment	Seedling stage		Jointing stage		Filling stage		Maturing stage	
	2021	2022	2021	2022	2021	2022	2021	2022
CK	74.79±3.5b	89.69±11.75a	4574.37±207.23d	4198.94±235c	3273.22±874.48b	3273.22±874.48b	2304.99±81.83a	2356.45±79.11b
N1	101.23±13.5ab	89.46±6.74a	6573.15±346.62ab	6533.37±179.78ab	5831.55±236.45a	4288.54±334.38ab	4308.13±246.58a	4288.54±334.38a
N2	88.93±10.03ab	90.5±13.7a	6296.06±762.54b	6249.65±585.57ab	7362.8±680.97a	4632.83±1147.39a	3940.14±1609.88a	4249.49±644.78a
N3	91.16±3.97ab	92.72±3.28a	6087.78±328.4bc	6084.1±788.94ab	7158.3±659.7a	4591.39±737.52a	4665.28±1129.84a	4591.39±737.52a
N4	98.15±20.13ab	99.71±15.58a	5544.52±767.19bcd	5595.09±542bc	5770.41±547.6a	4062.47±808.21ab	4046.86±1586.26a	4062.47±808.21ab
N5	129.88±37.71a	128.77±45.19a	5794.66±350.14bcd	5466.09±379.99bc	5961.21±933.81a	4300.57±717ab	4301.56±502.83a	4330.57±717a
TN1	100.56±8.23ab	88.79±9.46a	7241.36±602.06a	7498.72±572.57a	6340.17±621.93a	4282.8±475.86ab	4326.21±684.98a	4252.8±475.86a
TN2	88.27±15.72ab	89.83±18.97a	4914.88±501.81cd	4922.86±863.37bc	5976.82±629.62a	3635.01±552.27ab	3980.11±855.75a	3968.34±990.58ab
TN3	90.49±2.44ab	92.55±5.12a	5650.05±299.09bcd	5641.38±660.94bc	6758.38±240.96a	4532.02±1021.03ab	4517.91±712.54a	4532.02±1021.03a
TN4	97.48±17.15ab	99.04±12.53a	5578±296.54bcd	5561.05±545.96bc	6231.35±850.86a	3891.83±639.35ab	4347.51±1169.48a	3894.83±639.35ab
TN5	129.21±32.26a	124.11±39.4a	5535.61±506.34bcd	5528.6±811.56bc	6288.27±489.26a	4695.67±1068.74a	4278.94±1873.29a	4129.01±159.23ab

Table S4. The plant dry matter accumulation was affected by fertilizer type and fertilizer application rate in 2021 and 2022.

Treatment	Seedling stage		Jointing stage		Filling stage		Maturing stage	
	2021	2022	2021	2022	2021	2022	2021	2022
CK	6.01±0.71a	6.3±0.84a	94.94±3.54b	86.36±6.96b	139.7±10.48b	138.77±3.66b	268.53±34.76b	216.96±12.85c
N1	7.47±0.87a	7.76±0.76a	113.93±17.86ab	143.8±28.66ab	170.61±21.38ab	169.68±10.88ab	391.56±29.99ab	393.32±31.28a
N2	6.29±0.71a	6.57±0.89a	124.73±20.67ab	150.54±29.24ab	183.7±57.84ab	182.77±47.52ab	352.03±62.94ab	353.8±52.92ab
N3	7.08±0.72a	7.37±0.7a	147.14±50.2ab	120.48±1.4ab	213.34±7.99a	212.41±10.86a	422.33±25.29ab	424.09±28.29a
N4	7.27±1.97a	7.56±1.98a	135.64±19.03ab	168.35±18.8a	185.95±4.32ab	185.02±11.7ab	414.28±50.2ab	413.05±38.84a
N5	7.23±1.67a	7.52±1.86a	128.03±15.96ab	136.67±6.27ab	182.12±11.4ab	181.19±12.63ab	410.92±51.64ab	402.69±60.01a
TN1	5.92±0.48a	6.21±0.62a	143.67±34.23ab	118.4±16.41ab	173.08±16.91ab	182.14±26.66ab	358.11±113.28ab	249.88±20.28bc
TN2	7.38±1.09a	7.66±0.98a	150.41±23.49ab	129.19±22.37ab	190.37±0.72ab	189.43±10.55ab	469.26±65.46ab	411.03±60.06a
TN3	6.19±0.53a	6.48±0.72a	126.34±4.39ab	141.6±51.85ab	188.76±13.28ab	187.83±3.34ab	441.2±22.64a	442.97±16.35a
TN4	6.99±0.91a	7.28±0.86a	168.22±22.08a	150.1±17.26ab	182.61±23.59ab	171.67±14.17ab	347.7±26.83ab	339.47±39.85ab
TN5	7.18±2.12a	7.46±2.12a	111.54±11.02ab	132.49±15.44ab	185.36±25.52ab	187.43±27.51ab	351.55±74.35ab	353.32±65.57ab

Table S5. The average soil water content in different growth stage (n=3).

Treatments		Jointing stage			Silking stage			Maturing stage		
		0-20 cm	20-40 cm	40-60 cm	0-20 cm	20-40 cm	40-60 cm	0-20 cm	20-40 cm	40-60 cm
2021	CK	17.70%	14.25%	7.55%	12.65%	16.16%	16.51%	12.97%	14.76%	15.58%
	N1	17.86%	13.90%	7.87%	12.02%	16.23%	16.87%	10.46%	14.29%	16.00%
	N2	18.40%	12.20%	11.42%	12.55%	16.82%	19.61%	11.86%	14.14%	14.59%
	N3	18.23%	13.33%	7.59%	13.61%	17.47%	18.21%	11.41%	14.20%	15.08%
	N4	17.32%	14.12%	7.91%	11.84%	16.11%	17.32%	13.00%	14.55%	14.22%
	N5	17.75%	13.17%	9.02%	11.92%	15.46%	17.77%	11.96%	14.02%	14.58%
	TN1	13.16%	8.32%	10.26%	13.81%	16.05%	17.17%	11.01%	14.08%	15.23%
	TN2	16.21%	8.89%	8.41%	15.69%	17.08%	19.86%	11.98%	15.23%	17.39%
	TN3	17.44%	12.22%	7.55%	13.98%	16.99%	17.57%	10.63%	14.00%	14.05%
	TN4	15.78%	9.70%	9.57%	15.70%	17.44%	19.60%	11.09%	15.02%	14.41%
	TN5	17.85%	11.91%	8.38%	14.38%	17.02%	17.80%	11.92%	14.13%	15.64%
2022	CK	18.37%	8.80%	8.24%	14.91%	16.32%	16.32%	14.30%	15.05%	15.95%
	N1	17.86%	9.51%	7.96%	14.36%	16.91%	16.92%	13.35%	14.62%	15.40%
	N2	16.62%	8.21%	8.76%	14.04%	17.79%	19.31%	13.85%	14.70%	14.59%
	N3	17.94%	9.59%	8.12%	15.49%	17.08%	17.88%	14.05%	15.14%	14.38%
	N4	16.37%	8.08%	8.90%	13.89%	18.11%	17.09%	14.76%	15.42%	15.02%
	N5	17.70%	7.41%	8.17%	12.16%	17.07%	17.48%	13.63%	14.84%	14.82%
	TN1	12.50%	8.12%	10.26%	15.31%	16.57%	17.49%	13.21%	15.00%	15.47%
	TN2	11.85%	8.16%	10.52%	16.11%	18.02%	20.24%	14.94%	17.63%	17.44%
	TN3	14.16%	8.85%	9.23%	16.07%	17.49%	16.74%	13.10%	13.82%	13.97%
	TN4	13.89%	8.80%	10.70%	16.92%	18.36%	20.00%	13.65%	15.19%	15.47%
	TN5	16.96%	8.76%	8.35%	16.14%	17.69%	17.31%	13.03%	15.45%	15.07%

Table S6. The average soil pH in different growth stage (n=3).

Treatments		Jointing stage			Silking stage			Maturing stage		
		0-20 cm	20-40 cm	40-60 cm	0-20 cm	20-40 cm	40-60 cm	0-20 cm	20-40 cm	40-60 cm
2021	CK	8.59±0.03	8.65±0.05	8.76±0.03	8.46+0.05	8.5+0.04	8.43+0.04	8.51+0.04	8.56+0.01	8.59+0.08
	N1	8.42+0.04	8.55+0.09	8.71+0.05	8.54+0.01	8.5+0.01	8.44+0.05	8.24+0.07	8.21+0.05	8.17+0.05
	N2	8.34+0.11	8.53+0.08	8.62+0.01	8.47+0.06	8.54+0.03	8.43+0.06	8.56+0.1	8.53+0.05	8.51+0.1
	N3	8.49+0.07	8.48+0.05	8.69+0.02	8.54+0.02	8.41+0.08	8.57+0.02	8.35+0.01	8.33+0.02	8.43+0.02
	N4	8.31+0.05	8.59+0.01	8.61+0.03	8.47+0.03	8.63+0.04	8.4+0.04	8.45+0.03	8.49+0.03	8.47+0.16
	N5	8.33+0.2	8.53+0.16	8.61+0.09	8.41+0.02	8.62+0.02	8.57+0.12	8.28+0.01	8.38+0.02	8.39+0.01
	TN1	8.57+0.02	8.62+0.04	8.62+0.02	8.28+0.05	8.32+0.02	8.39+0.04	8.36+0.04	8.49+0.02	8.52+0.06
	TN2	8.4+0.07	8.6+0.02	8.58+0.08	8.17+0.02	8.49+0.04	8.38+0.06	8.34+0.04	8.46+0.04	8.55+0.05
	TN3	8.54+0.18	8.68+0.01	8.66+0.03	8.56+0.03	8.43+0.03	8.51+0.03	8.59+0.02	8.52+0.05	8.51+0.06
	TN4	8.49+0.03	8.63+0.06	8.54+0.02	8.35+0.04	8.45+0.07	8.54+0.02	8.43+0.04	8.5+0.02	8.43+0.08
	TN5	8.45+0.15	8.6+0.05	8.63+0.05	8.63+0.01	8.5+0.01	8.4+0.06	8.52+0.06	8.45+0.08	8.49+0.01
2022	CK	8.68+0.04	8.63+0.05	8.58+0.01	8.63+0.03	8.49+0.03	8.4+0.09	8.51+0.03	8.56+0.07	8.51+0.05
	N1	8.51+0.06	8.73+0.02	8.62+0.04	8.41+0.01	8.36+0.08	8.55+0.02	8.26+0.02	8.14+0.07	8.16+0.08
	N2	8.25+0.06	8.6+0.08	8.54+0.02	8.44+0.11	8.49+0.02	8.51+0.11	8.69+0.07	8.5+0.09	8.45+0.08
	N3	8.35+0.14	8.66+0.05	8.6+0.03	8.45+0.08	8.65+0.03	8.6+0.06	8.3+0.02	8.42+0.02	8.37+0.01
	N4	8.41+0.05	8.65+0.02	8.59+0.05	8.52+0.05	8.53+0.03	8.54+0.03	8.55+0.06	8.55+0.02	8.51+0.06
	N5	8.29+0.05	8.65+0.02	8.62+0.05	8.5+0.02	8.59+0.04	8.62+0.01	8.24+0.02	8.38+0.06	8.3+0.03
	TN1	8.6+0.04	8.63+0.03	8.54+0.03	8.29+0.02	8.37+0.02	8.41+0.02	8.45+0.04	8.49+0.04	8.56+0.04
	TN2	8.46+0.02	8.58+0.05	8.5+0.02	8.23+0.1	8.44+0.02	8.37+0.07	8.4+0.05	8.42+0.03	8.43+0.02
	TN3	8.48+0.02	8.65+0.04	8.61+0.05	8.59+0.06	8.66+0.05	8.61+0.08	8.45+0.04	8.51+0.06	8.43+0.07
	TN4	8.56+0.04	8.56+0.02	8.55+0.01	8.41+0.06	8.48+0.04	8.52+0.01	8.46+0.05	8.45+0.06	8.53+0.04
	TN5	8.52+0.1	8.64+0.04	8.54+0.04	8.53+0.07	8.45+0.03	8.54+0.04	8.5+0.02	8.52+0.01	8.47+0.04

Table S7. The average soil salt content in different growth stage (n=3).

Treatments		Jointing stage			Silking stage			Maturing stage		
		0-20 cm	20-40 cm	40-60 cm	0-20 cm	20-40 cm	40-60 cm	0-20 cm	20-40 cm	40-60 cm
2021	CK	1.05+0.11	0.38+0.07	0.25±0.02	0.31±0.02	0.28±0	0.27±0.01	0.27±0.01	0.27±0.01	0.27±0.01
	N1	0.44+0.03	0.43+0.03	0.26±0	0.28±0.01	0.27±0	0.29±0.01	0.29±0.03	0.29±0.03	0.29±0.03
	N2	0.43+0.06	0.29+0.02	0.24±0.02	0.34±0.02	0.27±0.01	0.28±0.01	0.28±0.02	0.28±0.02	0.28±0.02
	N3	0.33+0.02	0.31+0.01	0.31±0.01	0.31±0.01	0.32±0.01	0.32±0.01	0.28±0.01	0.28±0.01	0.28±0.01
	N4	0.37+0.01	0.3+0.01	0.29±0.01	0.31±0.03	0.33±0.01	0.33±0.01	0.27±0.01	0.27±0.01	0.27±0.01
	N5	0.43+0.06	0.29+0.01	0.24±0.01	0.34±0.02	0.28±0.01	0.27±0.01	0.25±0	0.25±0	0.25±0
	TN1	0.35+0.03	0.29+0.01	0.29±0	0.29±0.01	0.3±0.02	0.29±0.03	0.24±0.01	0.24±0.01	0.24±0.01
	TN2	0.37+0.02	0.26+0.01	0.28±0.02	0.3±0.01	0.31±0.01	0.27±0.01	0.27±0.01	0.27±0.01	0.27±0.01
	TN3	0.48+0.07	0.28+0.01	0.25±0	0.3±0	0.3±0	0.28±0.01	0.28±0.01	0.28±0.01	0.28±0.01
	TN4	0.48+0.06	0.32+0.02	0.24±0.01	0.33±0.02	0.29±0.01	0.3±0.02	0.32±0.06	0.32±0.06	0.32±0.06
	TN5	0.41+0.03	0.32+0.01	0.32±0.02	0.33±0	0.3±0.02	0.35±0.02	0.27±0.01	0.27±0.01	0.27±0.01
2022	CK	0.71+0.15	0.26+0.01	0.27+0.01	0.27±0	8.56+0.01	8.56+0.01	0.27±0.02	0.27±0.01	0.27±0.01
	N1	0.47+0.12	0.26+0.01	0.3+0.01	0.29±0.02	8.21+0.05	8.21+0.05	0.27±0.02	0.29±0.03	0.29±0.03
	N2	0.35+0.02	0.24+0.01	0.29+0.01	0.32±0	8.53+0.05	8.53+0.05	0.27±0.04	0.28±0.02	0.28±0.02
	N3	0.31+0.01	0.31+0.01	0.31+0.01	0.32±0.01	8.33+0.02	8.33+0.02	0.3±0.03	0.28±0.01	0.28±0.01
	N4	0.33+0.03	0.29+0.01	0.32+0.01	0.32±0.01	8.49+0.03	8.49+0.03	0.25±0	0.27±0.01	0.27±0.01
	N5	0.34+0.03	0.24+0	0.3+0.01	0.31±0	8.38+0.02	8.38+0.02	0.27±0.01	0.25±0	0.25±0
	TN1	0.31+0.03	0.26+0.01	0.33+0.01	0.31±0.01	8.49+0.02	8.49+0.02	0.27±0.01	0.24±0.01	0.24±0.01
	TN2	0.29+0.01	0.26+0.02	0.33+0.04	0.27±0.02	8.46+0.04	8.46+0.04	0.26±0.01	0.27±0.01	0.27±0.01
	TN3	0.37+0.03	0.27+0.01	0.29+0.01	0.29±0.01	8.52+0.05	8.52+0.05	0.27±0.01	0.28±0.01	0.28±0.01
	TN4	0.56+0.04	0.24+0.01	0.34+0.02	0.31±0.02	8.5+0.02	8.5+0.02	0.28±0.02	0.32±0.06	0.32±0.06
	TN5	0.38+0.05	0.3+0	0.36+0.01	0.27+0.01	8.45+0.08	8.45+0.08	0.27±0.01	0.27±0.01	0.27±0.01

Table S8. The average soil alkali-hydrolyzale nitrogen content in different growth stage (n=3).

Treatments		Jointing stage			Silking stage			Maturing stage		
		0-20 cm	20-40 cm	40-60 cm	0-20 cm	20-40 cm	40-60 cm	0-20 cm	20-40 cm	40-60 cm
2021	CK	40.83±3.95	29.75±1.75	23.04±2.53	36.46±1.82	20.71±1.34	20.71±1.34	27.42±2.2	23.33±0.51	18.38±1.52
	N1	45.21±1.34	30.63±0.88	19.25±0.88	36.17±2.67	28±2.63	22.17±2.81	35.29±2.67	25.96±4.49	23.63±6.13
	N2	49.29±2.02	30.63±4.01	21±0.88	37.33±4.82	24.5±4.01	21.88±0.88	28.58±1.82	24.21±4.14	22.46±1.34
	N3	47.54±2.2	32.38±2.63	21.88±0.88	39.08±2.81	28.58±0.51	22.17±0.51	34.71±4.32	21.29±1.34	16.92±0.51
	N4	47.54±3.64	35±4.01	23.33±2.67	48.42±1.34	24.33±1.15	23.45±2.64	37.04±2.81	24.5±6.06	21.88±1.75
	N5	47.54±2.2	33.54±1.01	24.5±0.88	42±1.52	32.67±5.35	21.58±4.14	40.25±2.32	29.46±3.95	30.92±1.34
	TN1	40.25±1.75	27.71±0.51	25.08±5.35	48.71±3.95	29.75±3.03	19.83±4.4	36.46±3.31	26.25±0.88	19.54±1.34
	TN2	41.08±1.28	30.92±0.51	27.71±0.51	42.29±0.51	27.42±4.82	28±1.52	35.29±1.34	21.29±2.2	26.25±0.88
	TN3	45.21±2.67	32.08±3.54	22.17±2.53	42.88±0.88	29.17±3.31	21.58±2.2	33.54±2.67	28.29±1.82	22.17±4.82
	TN4	40.92±3.26	30.92±1.82	28.88±2.32	42.58±2.81	33.54±1.34	21.88±2.32	42±2.32	29.17±1.34	23.92±3.54
	TN5	48.71±4.82	34.71±5.27	28.58±0.51	48.71±1.34	37.92±2.2	21.29±2.2	47.54±3.54	30.92±1.34	26.25±1.52
2022	CK	35.58±2.2	28±1.52	16.63±0.88	32.08±2.2	19.83±1.34	22.17±0.51	25.67±1.34	19.25±4.01	15.75±6.83
	N1	37.33±2.02	28±3.03	18.96±3.31	35.58±1.34	22.75±0.88	22.75±0.88	29.17±2.53	18.67±3.95	22.75±2.63
	N2	42.88±0.88	23.33±1.01	15.17±2.53	28.58±3.31	25.08±3.07	21±2.32	24.79±1.82	20.71±1.01	19.83±3.07
	N3	41.71±2.53	24.5±2.32	20.42±2.67	34.71±1.34	22.75±3.03	22.17±3.54	28±1.75	16.92±3.31	22.46±3.54
	N4	42.88±2.63	25.38±1.52	21.88±0.88	38.73±2.83	22.46±2.67	14.41±1.97	27.42±2.2	20.13±1.75	21.58±0.51
	N5	37.92±2.67	28.29±1.34	26.54±0.51	39.96±3.31	22.75±1.75	19.83±4.04	34.71±1.34	27.71±1.34	28.29±1.34
	TN1	36.17±1.01	28.29±1.82	19.25±1.75	36.75±2.63	23.04±3.64	14.29±1.01	28.29±2.02	23.92±3.64	19.54±2.81
	TN2	33.83±1.82	30.04±1.34	21.88±2.63	34.42±1.82	24.21±3.07	25.96±0.51	30.04±1.34	22.17±2.02	27.13±2.32
	TN3	36.75±3.15	25.96±2.81	20.71±1.34	35.88±2.32	20.42±0.51	15.75±0.88	28.88±0.88	22.75±2.63	20.42±1.82
	TN4	47.83±5.05	30.92±1.34	29.17±5.83	33.54±0.51	33.83±4.32	21.58±0.51	35.29±3.07	23.33±1.82	25.96±4.4
	TN5	44.04±2.67	31.79±3.07	28±0.88	40.25±2.32	27.42±1.34	23.92±1.82	33.25±3.15	31.21±3.07	29.17±0.51

Table S9. The average soil nitrate nitrogen content in different growth stage (n=3).

Treatments		Jointing stage			Silking stage			Maturing stage		
		0-20 cm	20-40 cm	40-60 cm	0-20 cm	20-40 cm	40-60 cm	0-20 cm	20-40 cm	40-60 cm
2021	CK	24.95±6.71b	10.98±1.99bc	7.35±0.33e	9.53±1.86b	6.5±1.01bc	4.34±0.78e	5.23±0.68bc	4.34±0.75c	2.83±0.21b
	N1	23.06±0.9b	12.01±3.01abc	11.93±1.6de	9.91±0.43b	6.99±0.65abc	4.82±1.33de	4.31±0.85c	4.93±0.77bc	3.72±1.51b
	N2	31.51±5.21ab	16.31±1.37c	6.82±1.51bcd	11.21±0.42ab	5.67±1.38c	6.52±0.61bcd	5.81±0.99bc	4.48±0.2c	5.39±0.87ab
	N3	68.75±14.04ab	17.62±3.39abc	10.08±0.8bcde	10.46±1.91ab	8.76±2.42abc	5.61±0.37bcde	5.91±0.76bc	4.6±0.56c	4.93±0.8ab
	N4	94.86±3.01a	23.94±2.47c	8.43±0.41abc	13.74±1.4a	5.66±1.27c	7.08±0.6abc	8.47±0.35b	6.66±0.99ab	3.83±0.35b
	N5	88.53±7.45ab	25.09±2.44a	10.93±1.77abcd	11.09±0.63ab	10.08±0.78a	6.94±1.06abcd	7.45±1.96bc	3.43±0.26c	2.9±1.31b
	TN1	22.36±0.52b	13.82±1.89abc	8.29±2de	9.42±0.62b	7.01±0.62abc	4.84±0.29de	4.98±0.14bc	4.6±0.69c	5±0.7ab
	TN2	29.94±1.8b	12.58±1.75abc	9.19±0.74bcde	9.19±0.64b	7.65±1.04abc	6.27±0.69bcde	6.02±0.8bc	4.23±0.26c	4.15±0.8b
	TN3	42.91±4.5ab	14.93±2.12abc	10.05±0.85cde	11.64±0.68ab	7.4±0.68abc	5.23±0.17cde	7.4±1.52bc	5.36±0.12bc	3.71±0.41b
	TN4	54.3±3.92ab	34.8±2.57ab	16.09±6.96a	12.17±1.12ab	9.14±0.61ab	8.56±1.03a	5.48±0.85bc	5.12±0.19bc	4.92±1.01ab
	TN5	74.59±5.04ab	39.12±3.51ab	12.06±3.35ab	12.48±1.97ab	9.58±0.3ab	7.37±0.64ab	13.83±2.75a	7.66±1.43a	7.3±2.33a
2022	CK	32.09±0.41c	10.21±0.89d	7.3±0.41cde	8.23±0.75c	5.09±0.53d	3.6±0.36cde	5.61±0.71a	2.44±0.03e	3.72±0.83ab
	N1	29.06±1.89c	12.37±1.35d	10.55±1.97cde	9.58±1.26c	5.62±0.5d	4.13±1.18cde	5.34±0.11a	3.25±0.49de	2.97±0.64b
	N2	49.48±4.29bc	15.41±1.48d	8.72±2.25e	10.73±0.75bc	5.84±1.48d	2.72±1e	5.61±1.45a	4.18±0.47bcd	3.11±1.26b
	N3	75.64±7.73c	17.19±0.65d	8.47±0.63cde	8.69±2.11c	6.25±0.49d	3.61±0.5cde	5.81±0.63a	4.45±0.91bcd	4.65±1.04ab
	N4	92.67±5.55ab	19.88±1.75d	10.47±1.59bc	13.19±0.57ab	4.95±0.45d	6.64±2.13bc	8.1±1.21a	5.59±0.64b	2.69±0.29b
	N5	94.66±3.42c	24.46±1.38bc	11.7±0.86bcd	9.91±0.9c	8.18±0.2bc	5.84±0.45bcd	6.42±1.52a	5.07±0.24bc	2.96±0.17b
	TN1	16.05±4.08c	11.79±1.61d	6.86±0.35de	8.45±0.31c	5.72±0.48d	3.44±0.39de	5.56±1.05a	3.82±0.46cde	3.99±0.23ab
	TN2	24.76±0.87c	12.59±1.29cd	8.23±1.43bcd	8.81±0.37c	6.49±0.86cd	5.95±0.75bcd	5.58±0.75a	4.27±0.59bcd	3.77±1.36ab
	TN3	28.13±3.62c	14.26±3.64d	8.79±0.81cde	9.38±0.73c	6.16±0.9d	5±0.78cde	5.95±0.69a	3.46±0.64cde	4.49±0.32ab
	TN4	56.42±6.22bc	28.34±3.93ab	12.94±0.59a	10.65±0.7bc	9.45±0.45ab	10.8±1.79a	6.27±0.4a	4.42±1.01bcd	4.27±1.39ab
	TN5	68.69±5.37a	23.46±4.37a	16.86±5.49b	13.85±2.47a	10.46±1.06a	8.05±1.12b	7.76±1.64a	7.6±0.82a	5.97±0.63a

Table S10. The average soil ammonium nitrogen content in different growth stage (n=3).

Treatments		Jointing stage			Silking stage			Maturing stage		
		0-20 cm	20-40 cm	40-60 cm	0-20 cm	20-40 cm	40-60 cm	0-20 cm	20-40 cm	40-60 cm
2021	CK	2.33±0.22	1.73±0.21	1.48±0.32	1.71±0.07	1.46±0.16	1.39±0.19	1.16±0.14	0.93±0.11	0.73±0.06
	N1	2.09±0.11	1.9±0.04	1.97±0.07	1.95±0.06	1.56±0.05	1.38±0.02	1.18±0.16	0.68±0.13	0.77±0.09
	N2	2.85±0.24	1.95±0.22	1.85±0.07	2.35±0.28	1.72±0.1	1.82±0.09	1.34±0.32	0.72±0.05	0.88±0.02
	N3	2.55±0.03	2.05±0.09	1.96±0.17	2.75±0.59	1.84±0.2	2.03±0.11	1.42±0.08	0.74±0.01	0.92±0.06
	N4	2.88±0.27	2.32±0.02	1.35±0.08	4.45±0.23	2.25±0.33	1.59±0.15	1.48±0.31	0.92±0.17	0.71±0.08
	N5	3.65±0.42	2.43±0.21	2.04±0.08	4.17±0.53	1.79±0.08	1.7±0.15	1.35±0.05	0.99±0.01	0.74±0.01
	TN1	2.09±0.05	1.53±0.03	1.79±0.2	2.14±0.44	1.72±0.06	1.67±0.26	1.87±0.01	1.27±0.13	1.37±0.18
	TN2	1.65±0.15	1.78±0.17	1.5±0.12	2.24±0.12	2.07±0.21	1.57±0.04	2.04±0.09	1.39±0.09	1.54±0.09
	TN3	1.98±0.18	1.84±0.28	1.88±0.08	2.59±0.14	2.08±0.17	1.89±0.12	1.89±0.07	1.23±0.02	1.45±0.04
	TN4	2.52±0.45	1.64±0.1	1.41±0.22	2.59±0.1	2.17±0.09	1.98±0.27	2.07±0.03	1.69±0.09	1.48±0.14
	TN5	2.18±0.11	1.96±0.11	1.27±0.05	3.04±0.19	1.76±0.13	2.33±0.09	2.34±0.19	1.51±0.12	1.64±0.01
2022	CK	1.64±0.2	1.39±0.12	1.7±0.24	1.73±0.09	1.26±0.15	1.48±0.16	0.79±0.1	0.89±0.12	0.75±0.04
	N1	2.03±0.13	2.37±0.22	1.74±0.28	1.61±0.39	1.58±0.25	1.38±0.12	0.97±0.2	0.68±0.02	0.88±0.07
	N2	2.14±0.09	1.91±0.01	1.72±0.16	2.24±0.38	1.74±0.2	1.36±0.11	1.03±0.06	0.79±0.02	0.92±0.08
	N3	2.19±0.1	2.02±0.08	1.82±0.41	2.2±0.07	1.86±0.05	1.92±0.16	0.91±0.08	0.68±0.07	0.85±0.09
	N4	2.28±0.16	1.6±0.12	1.34±0.22	2.06±0.07	1.68±0.09	1.86±0.18	0.99±0.12	0.74±0.09	0.71±0.04
	N5	3.3±0.11	2.17±0.05	1.79±0.2	2.69±0.3	1.74±0.18	2.02±0.21	1.32±0.07	0.83±0.02	0.87±0.1
	TN1	1.93±0.12	1.85±0.03	1.44±0.2	2.1±0.16	1.72±0.16	1.84±0.35	1.55±0.06	1.24±0.05	1.34±0.11
	TN2	1.95±0.21	1.88±0.05	1.59±0.15	2.1±0.05	1.86±0.27	1.95±0.09	1.6±0.07	1.48±0.22	1.65±0.06
	TN3	1.77±0.09	1.57±0.13	1.74±0.15	2.14±0.22	2.01±0.32	1.76±0.13	1.66±0.12	1.37±0.12	1.53±0.02
	TN4	1.94±0.13	1.73±0.09	1.88±0.04	2.2±0.13	1.88±0.07	2.14±0.09	1.7±0.04	1.47±0.12	1.63±0.1
	TN5	2.01±0.18	1.79±0.08	1.91±0.37	3.34±0.12	1.74±0.14	2.17±0.17	2.03±0.03	1.78±0.14	1.58±0.07

Table S11. The average soil available potassium content in different growth stage (n=3).

Treatments		Jointing stage			Silking stage			Maturing stage		
		0-20 cm	20-40 cm	40-60 cm	0-20 cm	20-40 cm	40-60 cm	0-20 cm	20-40 cm	40-60 cm
2021	CK	97±7.21	61.33±3.06	57.33±3.79	79.67±5.86	76.67±2.08	72±1	81.33±14.01	49.67±1.15	54.33±0.58
	N1	109.33±10.41	54.67±1.15	61±2.65	92±7.94	65.67±2.08	72.33±2.08	92.67±8.39	69±1.73	78.67±5.69
	N2	93.67±3.06	59.67±3.51	51.67±3.21	88.67±5.13	67±1	67.67±7.02	90±4.58	69.33±1.53	67.33±3.21
	N3	86±7	89.67±2.08	87±1.73	83.67±6.81	83±1	89±4.36	85.33±5.77	62.33±1.53	63.67±4.62
	N4	77.33±6.66	46±2.65	45±1	82.67±4.51	91.33±6.81	84.33±3.21	89.67±2.52	68.33±2.52	80.33±5.51
	N5	84±2	51.67±1.15	51.33±1.53	98±10	74±2.65	76.33±1.53	88.67±6.11	62.33±1.53	63±2.65
	TN1	87±4.58	93.33±4.51	89±0	94.33±5.03	83.67±3.79	74.33±2.08	88±6.56	63.33±6.81	62.67±6.03
	TN2	77.33±14.64	87.33±3.51	88±3.61	90.33±6.51	81.33±2.08	80.67±1.15	91±5.2	69.67±20.23	66±1
	TN3	76±7	85.67±0.58	78±7.81	95±6.56	75.67±2.31	80.67±4.93	91±3	71±3	76.67±2.08
	TN4	82±4.58	93±2.65	89±7	96.33±4.73	93±5	94.33±4.16	94.67±5.51	78.33±5.77	80±6.93
	TN5	88.33±4.51	75±4.58	70.67±2.08	98±3.61	89±2.65	96±2.65	89.67±7.02	91.67±8.62	94.33±6.81
2022	CK	91.33±6.66	55±1	63±2	78±7.21	70.33±4.73	68.67±2.52	60.33±2.52	52.33±2.52	52±1
	N1	92±1	59.33±2.08	58±4.36	75.67±1.15	64±2.65	77±2	77.33±4.16	73.33±5.03	77.33±3.21
	N2	98±1	53.67±3.21	53.67±3.06	84.67±5.51	68.33±0.58	70±1	66.67±6.03	70.33±4.93	65.67±3.21
	N3	85.33±4.04	81±4.36	98.33±1.15	90.67±5.13	91.33±4.62	85±2.65	65±5.2	58.67±6.66	75.67±1.15
	N4	94±1	43.33±3.21	42.33±2.08	86.33±10.41	94.33±4.04	88.33±2.31	76.33±6.11	79.67±2.89	95.67±2.08
	N5	96±2	53.67±0.58	52±1.73	97.67±9.24	71±3.61	82.67±4.93	89.33±4.04	65±3.46	63.33±2.31
	TN1	84±4.36	95.33±2.31	93.33±2.31	89±0	77.33±2.89	72.67±2.31	65.67±6.51	60±2.65	58.33±2.52
	TN2	64.67±7.09	93.33±3.79	84.67±6.66	91.33±6.35	83±1	79.67±1.15	69.33±1.53	78±21.93	66±4.36
	TN3	75.33±4.04	83±8.54	77.67±4.16	95.67±5.03	75±3.61	77.33±4.73	84±16.37	73.33±5.13	66.67±5.03
	TN4	79±4.36	91.67±0.58	84.67±2.31	98±7	94.67±2.89	94±5.2	81.67±5.03	79.67±2.08	76.67±9.45
	TN5	90.33±2.31	75.67±4.16	74.67±0.58	97±7.21	93±3.61	95.33±3.79	91.67±9.5	91.33±2.08	87.33±4.16

Table S12. The average soil organic matter content in different growth stage (n=3).

Treatments		Jointing stage			Silking stage			Maturing stage		
		0-20 cm	20-40 cm	40-60 cm	0-20 cm	20-40 cm	40-60 cm	0-20 cm	20-40 cm	40-60 cm
2021	CK	10.5±0.26	7.7±0.64	7.54±0.52	11.02±0.1	8.29±1.18	6.34±0.46	6.08±1.67	5.85±0.44	5.93±0.87
	N1	11.26±1.57	7.97±0.65	6.85±0.88	10.51±0.17	8.09±0.39	6.9±0.27	7.47±0.87	7.7±0.85	7.65±0.19
	N2	10.5±0.77	7.52±0.88	6.71±0.68	10±0.93	8.22±0.43	7.39±0.47	8.33±0.87	6.57±0.23	7.67±0.85
	N3	8.92±0.52	7.68±0.21	7.72±0.38	11.39±0.6	8.38±0.05	7.11±0.34	7.56±0.92	5.67±0.51	6.16±0.3
	N4	10.13±0.28	7.4±0.81	6.57±0.77	12.31±1.03	9.18±0.34	6.98±0.08	9.01±0.89	7.14±0.3	8.11±0.23
	N5	8.8±0.12	8.15±0.8	5.96±0.65	10.48±0.06	8.33±0.41	7.85±0.66	7.35±1.02	7.21±0.37	6.25±0.78
	TN1	9.46±0.07	7.64±0.21	6.28±0.32	11.16±0.44	8.29±0.73	7.47±0.31	6.53±1.46	7.01±0.97	6.44±0.22
	TN2	9.25±0.24	7.45±0.31	7.58±1.92	11.22±0.6	9.58±0.27	8.59±0.12	6.27±0.31	6.33±1.38	5.92±0.78
	TN3	8.85±0.3	6.98±0.3	7.03±0.49	12.11±0.5	9.89±0.41	8.35±1.05	6.87±0.75	5.48±0.3	6.39±0.76
	TN4	8.43±0.48	6.92±0.61	6.15±0.26	11.21±0.24	8.81±0.12	8.14±0.79	7.96±0.55	6.49±0.3	6.63±0.07
	TN5	9.63±0.9	7.79±0.33	7.04±1	12.6±0.89	9.38±0.37	9.01±0.08	8.3±0.15	8.65±0.6	7.66±0.4
2022	CK	11.75±1.77	7.06±0.76	7.51±0.29	9.94±0.68	6.53±0.12	6.2±0.08	6.78±1.29	8.44±0.17	7.44±0.54
	N1	12.04±1.97	6.8±0.26	6.65±1.12	9.57±0.42	7.92±0.38	7.48±1.01	6.52±0.16	8.94±0.68	8.1±0.64
	N2	12.72±0.88	6.72±0.64	6.28±0.23	9.87±0.52	8.02±0.16	7.3±0.41	7.7±1.42	10.01±0.51	8.97±0.56
	N3	9.85±0.44	7.32±0.48	8.38±0.43	10.62±0.1	7.23±0.36	6.62±0.48	5.5±0.4	8.8±0.16	8.5±1.13
	N4	11.55±0.9	8.05±1.44	6.93±1.62	11.08±0.05	6.72±1.38	6.84±0.46	7.57±0.47	6.8±1.72	8.41±1.45
	N5	9.44±0.22	6.63±0.37	6.02±0.24	9.56±0.25	7.93±0.28	7.72±1.07	7.33±0.55	9.18±1.04	8.03±0.84
	TN1	10.55±0.83	6.86±0.31	6.28±0.25	9.13±0.22	8.38±0.44	8.43±0.68	7.06±0.7	9.65±0.19	8.21±0.36
	TN2	10.66±1.24	7.29±0.23	8.4±0.53	10.9±0.33	8.54±0.74	7.38±0.87	6.46±1.28	9.09±0.98	8.5±0.32
	TN3	9.38±0.48	6.69±0.81	7.33±1.18	10.66±0.59	8.05±0.23	7.51±0.12	5.8±1.2	9±0.27	8.07±0.5
	TN4	10.32±0.38	5.66±0.47	8.1±1.21	10.27±0.36	8.58±0.23	8.33±0.26	6.95±0.76	9.49±0.13	9.56±0.29
	TN5	12.17±1.33	6.91±0.74	5.99±0.93	12.76±0.68	8.2±0.09	9.55±1.04	9.68±0.21	10.3±0.9	8.57±0.91

Table S13. The average soil urease activity in different growth stage (n=3).

Treatments		Jointing stage			Silking stage			Maturing stage		
		0-20 cm	20-40 cm	40-60 cm	0-20 cm	20-40 cm	40-60 cm	0-20 cm	20-40 cm	40-60 cm
2021	CK	1.18±0.05	0.99±0.12	0.85±0.03	1.04±0.03	0.59±0.03	0.26±0.01	1.24±0.02	1.01±0.07	0.99±0.03
	N1	1.19±0.09	0.98±0.15	0.85±0.06	1.09±0.05	0.95±0.03	0.85±0.08	1.18±0.04	1.08±0.06	0.97±0.06
	N2	1.03±0.11	0.86±0.08	0.71±0.02	1.19±0.07	0.91±0.1	0.85±0.09	1.22±0.17	1.01±0.04	0.92±0.06
	N3	1.02±0.14	0.81±0.04	0.76±0.16	1.15±0.11	1.02±0.17	0.74±0.08	1.19±0.11	0.9±0.02	0.74±0.13
	N4	1.06±0.07	0.84±0.04	0.72±0.07	1.06±0.05	0.6±0.03	0.28±0.05	1.13±0.15	0.97±0.08	0.69±0.04
	N5	1.13±0.06	0.72±0.13	0.41±0.05	1.26±0.06	0.91±0.07	0.94±0.07	1.13±0.09	0.62±0.18	0.49±0.04
	TN1	1.25±0.09	0.95±0.11	0.85±0.04	1.32±0.06	0.81±0.11	0.86±0.09	1.21±0.13	0.89±0.06	0.84±0.04
	TN2	1.16±0.06	0.83±0.11	0.73±0.09	1.24±0.06	0.86±0.06	0.83±0.07	1.25±0.03	0.98±0.04	0.78±0.06
	TN3	1.25±0.05	0.94±0.07	0.74±0.13	1.27±0.05	0.95±0.05	0.45±0.03	1.21±0.05	0.94±0.09	1.02±0.03
	TN4	1.23±0.07	0.71±0.08	0.86±0.1	1.14±0.04	1.02±0.06	0.9±0.03	1.18±0.13	0.99±0.05	0.83±0.08
	TN5	1.19±0.06	0.9±0.04	0.89±0.03	1.22±0.04	1.02±0.07	0.89±0.02	1.25±0.04	1.09±0.04	1.02±0.07
2022	CK	1.1±0.05	0.91±0.12	0.77±0.03	1.04±0.1	0.59±0.07	0.26±0.08	1.23±0.07	1±0.12	0.98±0.12
	N1	1.13±0.09	0.92±0.15	0.79±0.06	1.08±0.04	0.95±0.1	0.85±0.17	1.18±0.08	1.08±0.03	0.97±0.04
	N2	1±0.11	0.83±0.08	0.68±0.02	1.19±0.14	0.91±0.13	0.85±0.08	1.22±0.08	1.01±0.06	0.92±0.15
	N3	1±0.14	0.79±0.04	0.74±0.16	1.15±0.08	1.02±0.09	0.74±0.07	1.12±0.08	0.89±0.1	0.74±0.2
	N4	0.99±0.07	0.77±0.04	0.65±0.07	1.05±0.14	0.59±0.06	0.27±0.06	1.19±0.15	0.97±0.1	0.68±0.05
	N5	1.21±0.06	0.8±0.13	0.49±0.05	1.26±0.1	0.91±0.16	0.93±0.12	1.13±0.13	0.62±0.2	0.49±0.07
	TN1	1.18±0.1	0.98±0.07	0.83±0.1	1.29±0.07	0.81±0.12	0.86±0.07	1.14±0.11	0.89±0.12	0.83±0.05
	TN2	1.19±0.06	0.86±0.11	0.76±0.09	1.24±0.14	0.86±0.09	0.82±0.13	1.25±0.07	0.98±0.13	0.78±0.09
	TN3	1.27±0.05	0.96±0.07	0.76±0.13	1.27±0.12	0.95±0.12	0.45±0.08	1.2±0.12	0.93±0	1.01±0.11
	TN4	1.3±0.07	0.78±0.08	0.93±0.1	1.14±0.05	1.01±0.03	0.9±0.11	1.17±0.07	0.99±0.14	0.82±0.15
	TN5	1.27±0.06	0.98±0.04	0.97±0.03	1.22±0.11	1.01±0.15	0.88±0.09	1.24±0.1	1.08±0.1	1.02±0.16

Table S14. The average soil catalase activity in different growth stage (n=3).

Treatments		Jointing stage			Silking stage			Maturing stage		
		0-20 cm	20-40 cm	40-60 cm	0-20 cm	20-40 cm	40-60 cm	0-20 cm	20-40 cm	40-60 cm
2021	CK	6.17±0.18	5.51±0.21	6±0.18	5.58±0.73	5.54±0.07	5.71±0.14	6.46±0.03	6.79±0.23	6.68±0.18
	N1	5.84±0.34	5.58±0.09	5.23±0.18	6.02±0.3	5.4±0.28	6.01±0.43	7.24±0.2	7.21±0.39	6.83±0.14
	N2	6.16±0.42	6.01±0.26	5.43±0.37	5.25±0.11	5.81±0.07	5.67±0.38	6.65±0.06	6.8±0.29	6.83±0.27
	N3	6.07±0.11	5.56±0.15	5.57±0.17	5.43±0.08	5.51±0.44	5.93±0.3	6.77±0.13	7.04±0.25	6.91±0.09
	N4	6.6±0.78	5.92±0.51	6.72±1.15	5.85±0.32	6.14±0.25	5.83±0.57	6.7±0.24	6.68±0.12	6.8±0.04
	N5	6.83±0.17	5.44±0.34	5.15±0.58	6.12±0.55	6.23±0.22	6.82±0.46	7.25±0.27	7.42±0.31	7.54±0.41
	TN1	5.87±0.2	5.85±0.24	6.25±0.25	7.31±0.64	6.75±0.28	5.98±0.19	6.68±0.07	6.54±0.36	6.7±0.36
	TN2	6.35±0.44	5.42±0.15	6.27±0.3	5.83±0.14	6.94±0.14	7.97±0.53	7.5±0.14	7.26±0.18	7.03±0.39
	TN3	6.21±0.36	5.77±0.63	6.42±0.61	6.4±0.36	6.84±0.3	7.82±0.11	6.72±0.04	7.1±0.05	7.45±0.14
	TN4	6.92±0.08	6.52±0.2	5.32±0.37	7.65±0.54	8.1±0.71	7.24±0.56	8.1±0.34	8.05±0.7	7.72±0.41
	TN5	6.99±0.38	6.61±0.33	7.77±0.39	8.38±0.42	8.14±0.42	8.21±0.45	7.25±0.32	7.92±0.18	7.64±0.15
2022	CK	6.15±0.13	5.49±0.27	5.98±0.18	5.56±0.73	5.52±0.14	5.69±0.13	6.44±0.1	6.77±0.15	6.67±0.18
	N1	5.82±0.4	5.56±0.02	5.21±0.18	6±0.37	5.38±0.21	5.99±0.44	7.22±0.17	7.19±0.34	6.81±0.03
	N2	6.14±0.49	5.99±0.34	5.41±0.44	5.23±0.12	5.79±0.15	5.65±0.42	6.64±0.15	6.78±0.28	6.81±0.28
	N3	6.05±0.18	5.54±0.09	5.55±0.19	5.41±0.15	5.49±0.48	5.91±0.35	6.75±0.06	7.03±0.36	6.9±0.06
	N4	6.58±0.71	5.9±0.45	6.7±1.09	5.83±0.39	6.12±0.3	5.81±0.58	6.69±0.2	6.67±0.21	6.78±0.1
	N5	6.81±0.16	5.42±0.41	5.13±0.63	6.1±0.48	6.21±0.19	6.8±0.41	7.23±0.34	7.41±0.27	7.53±0.38
	TN1	5.85±0.14	5.83±0.22	6.23±0.18	7.29±0.61	6.73±0.26	5.96±0.23	6.66±0.08	6.52±0.34	6.68±0.25
	TN2	6.33±0.42	5.4±0.12	6.25±0.29	5.81±0.09	6.92±0.06	7.95±0.6	7.48±0.17	7.25±0.23	7.02±0.3
	TN3	6.19±0.38	5.75±0.57	6.4±0.54	6.38±0.34	6.82±0.36	7.8±0.05	6.7±0.1	7.09±0.15	7.44±0.25
	TN4	6.9±0.03	6.5±0.13	5.3±0.43	7.63±0.61	8.08±0.73	7.22±0.63	8.08±0.45	8.03±0.77	7.7±0.48
	TN5	6.97±0.39	6.59±0.34	7.75±0.43	8.36±0.44	8.12±0.38	8.19±0.47	7.24±0.37	7.9±0.13	7.62±0.17

Table S15. The average soil sucrase activity in different growth stage (n=3).

Treatments		Jointing stage			Silking stage			Maturing stage		
		0-20 cm	20-40 cm	40-60 cm	0-20 cm	20-40 cm	40-60 cm	0-20 cm	20-40 cm	40-60 cm
2021	CK	11.6±0.55	7.59±1.47	6.31±0.47	8.4±1.1	4.43±0.52	3.9±0.93	7.85±0.43	7.62±0.41	5.61±0.44
	N1	12.32±0.4	7.96±0.11	5.48±1.62	8.64±1.14	5.35±0.18	4.67±0.92	11.16±0.9	7.35±1.66	7.27±0.75
	N2	15.45±3.9	6.63±0.87	4.97±1.33	8.46±0.44	5.59±0.51	4.65±0.44	10.86±1.53	8.41±0.85	8.15±0.66
	N3	20.3±1.22	7.02±1.06	8.28±1.31	9.16±0.35	6.09±0.57	4.73±0.59	11.2±0.14	7.92±0.59	8.07±0.77
	N4	17.72±2.01	13.22±4.52	5.26±0.37	8.77±0.3	5.36±0.32	6.84±1.12	11.04±1.1	9.69±1.22	8.9±0.86
	N5	26.05±7.36	14.47±3.93	7.09±1.09	7.57±0.87	7.17±1.01	10.13±1.16	12.44±2.73	8.24±0.04	8.03±0.43
	TN1	13.96±4.02	6.96±0.46	5.01±0.28	8.89±1.4	10.43±1.59	9.23±0.64	10.67±2.09	8.45±0.18	5.87±0.34
	TN2	23.61±5.84	9.01±1.24	8.49±1.21	10.7±0.56	9.2±0.91	9.12±1.08	11.32±0.87	9.68±1.95	8.21±0.82
	TN3	20.26±4.54	9.57±0.96	5.5±0.34	9.6±0.98	8.12±1.04	8.83±1.07	13.33±0.61	11.64±2.52	12.03±3.75
	TN4	18.57±3.5	12.87±0.58	7.95±0.83	11.24±1.42	7.73±0.63	10.65±1.47	12.34±3.97	11.31±2.1	12±2.31
	TN5	25.02±7.15	11.28±1.52	10.65±0.64	10.95±1.83	9.13±0.54	8.87±0.2	14.71±1.14	9.41±0.75	10.13±0.59
2022	CK	11.9±1.67	7.32±2.71	6.61±1.2	8.7±2.39	4.73±1.78	5.2±0.92	8.15±1.52	7.92±1.75	5.91±1.86
	N1	20.6±2.85	7.89±0.18	5.78±1.84	8.94±2.75	5.65±1.8	4.97±1.34	11.46±1.95	7.65±1.38	7.57±1.78
	N2	18.02±3.65	8.26±1.55	5.27±2.4	8.76±1.68	5.89±1.59	4.95±1.28	11.16±3	8.71±2.49	8.45±1.32
	N3	26.35±8.58	9.31±2.3	8.58±1.19	9.46±1.78	6.39±2.18	5.03±1.37	11.5±1.78	8.22±1.13	8.37±2.32
	N4	12.62±1.27	13.52±5.75	5.56±1.96	9.07±1.35	5.66±1.62	7.14±1.65	11.34±2.1	9.99±2.65	9.2±0.8
	N5	15.75±2.42	14.77±4.07	7.39±1.76	7.87±2.45	7.47±2.35	10.43±2.67	12.74±2.31	8.54±1.67	8.33±1.29
	TN1	14.26±4.89	6.93±2.05	5.31±1.82	9.19±2.62	10.73±0.38	9.53±2.22	10.97±3.67	8.75±1.61	6.17±1.55
	TN2	23.91±4.2	7.26±1.37	5.8±1.87	11±1.17	9.5±2.55	9.42±2.6	11.62±1.74	9.98±1.6	8.51±2.2
	TN3	20.56±3.22	9.87±2.6	8.25±2.16	9.9±2.6	8.42±0.7	9.13±1.52	13.63±1.35	11.94±3.51	12.33±4.76
	TN4	18.87±4.6	13.17±1.59	10.95±2.26	11.54±0.99	8.03±1.81	10.95±1.68	12.64±5	11.61±3.22	12.3±3.37
	TN5	25.32±8.46	11.58±1.8	8.79±2.45	11.25±3.06	9.43±1.14	9.17±1.66	15.01±1.92	9.71±1.08	10.43±1.1

Table S16. The average soil phosphatase activity in different growth stage (n=3).

Treatments		Jointing stage			Silking stage			Maturing stage		
		0-20 cm	20-40 cm	40-60 cm	0-20 cm	20-40 cm	40-60 cm	0-20 cm	20-40 cm	40-60 cm
2021	CK	1.51±0.14	0.88±0.02	0.44±0.05	1.15±0.11	0.61±0.02	0.41±0.05	1.3±0.06	0.7±0.05	0.41±0.11
	N1	1.34±0.02	1.06±0.02	0.86±0.22	1.43±0.04	0.7±0.07	0.35±0.04	1.36±0.08	0.51±0.28	0.54±0.11
	N2	1.57±0.13	1.01±0.02	0.69±0.06	1.48±0.09	0.7±0.08	0.68±0.11	1.47±0.18	0.81±0.06	0.63±0.02
	N3	1.72±0.05	1±0.05	0.78±0.06	1.61±0.11	0.87±0.03	0.76±0.02	1.27±0.02	0.96±0.02	0.79±0.07
	N4	1.44±0.05	1.07±0.09	1±0.04	1.69±0.12	1.06±0.13	0.8±0.06	1.56±0.06	0.97±0.07	0.81±0.13
	N5	1.64±0.09	1.26±0.06	0.74±0.08	1.59±0.25	0.98±0.19	0.76±0.02	1.52±0.05	1.15±0.08	0.88±0.08
	TN1	2±0.09	1±0.02	0.73±0.1	1.87±0.39	0.82±0.04	0.44±0.04	1.35±0.13	1.17±0.09	0.71±0.06
	TN2	1.97±0.22	1.06±0.04	0.75±0.04	1.47±0.05	0.99±0.03	0.97±0.04	1.58±0.1	1.07±0.08	0.69±0.13
	TN3	1.73±0.05	0.93±0.05	0.76±0.08	1.52±0.09	1.08±0.08	0.73±0.13	1.49±0.09	1.16±0.05	0.97±0.13
	TN4	1.93±0.08	1.19±0.04	1.17±0.05	1.48±0.12	1.16±0.1	0.97±0.06	1.54±0.06	1.11±0.17	1.03±0.06
	TN5	2.03±0.3	1.35±0.04	1.04±0.14	1.55±0.12	1.04±0.22	0.7±0.14	1.64±0.09	0.85±0.16	0.86±0.06
2022	CK	1.48±0.09	0.85±0.13	0.41±0.07	1.12±0.21	0.58±0.12	0.38±0.12	1.31±0.1	0.71±0.17	0.42±0.16
	N1	1.31±0.11	1.03±0.1	0.83±0.31	1.4±0.07	0.67±0.17	0.32±0.12	1.37±0.15	0.52±0.17	0.55±0.08
	N2	1.54±0.18	0.98±0.12	0.66±0.15	1.45±0.11	0.67±0.17	0.65±0.08	1.48±0.14	0.82±0.11	0.64±0.1
	N3	1.69±0.06	0.97±0.07	0.75±0.15	1.58±0.13	0.84±0.08	0.73±0.12	1.28±0.1	0.97±0.1	0.8±0.18
	N4	1.41±0.15	1.04±0.11	0.97±0.12	1.66±0.1	1.03±0.06	0.77±0.17	1.57±0.17	0.98±0.11	0.82±0.05
	N5	1.61±0.19	1.23±0.13	0.71±0.06	1.56±0.23	0.95±0.09	0.73±0.11	1.53±0.14	1.16±0.14	0.89±0.06
	TN1	1.97±0.2	0.97±0.11	0.7±0.02	1.84±0.31	0.79±0.14	0.41±0.12	1.36±0.23	1.18±0.2	0.72±0.18
	TN2	1.94±0.28	1.03±0.12	0.72±0.14	1.44±0.07	0.96±0.12	0.94±0.14	1.59±0.2	1.08±0.18	0.7±0.11
	TN3	1.7±0.16	0.9±0.11	0.73±0.12	1.49±0.08	1.05±0.09	0.7±0.02	1.5±0.09	1.17±0.09	0.98±0.08
	TN4	1.9±0.14	1.16±0.07	1.14±0.07	1.45±0.07	1.13±0.06	0.94±0.06	1.55±0.12	1.12±0.1	1.04±0.17
	TN5	2±0.24	1.32±0.09	1.01±0.1	1.52±0.03	1.01±0.21	0.67±0.04	1.65±0.21	0.86±0.25	0.87±0.17