

**Figure S1.** Precipitation (mm) and average temperature (°C) in 2019.

**Table S1.** Enzymes assayed in soils and corresponding substrates, abbreviations used in this study, and enzyme commission number.

Enzyme	Substrate	Abbreviation	EC
$\beta$ -glucosidase	4-MUB- $\beta$ -D-glucopyranoside	BG	3.2.1.21
$\beta$ -N-acetylglucosaminidase	4-MUB-N-acetyl- $\beta$ -D-glucosaminide	NAG	3.2.1.52
L-leucine aminopeptidase	L-leucine-7-amino-4-methylcoumarin	LAP	3.4.11.1
Alkaline phosphatase	4-MUB-phosphate	AKP	3.1.3.2

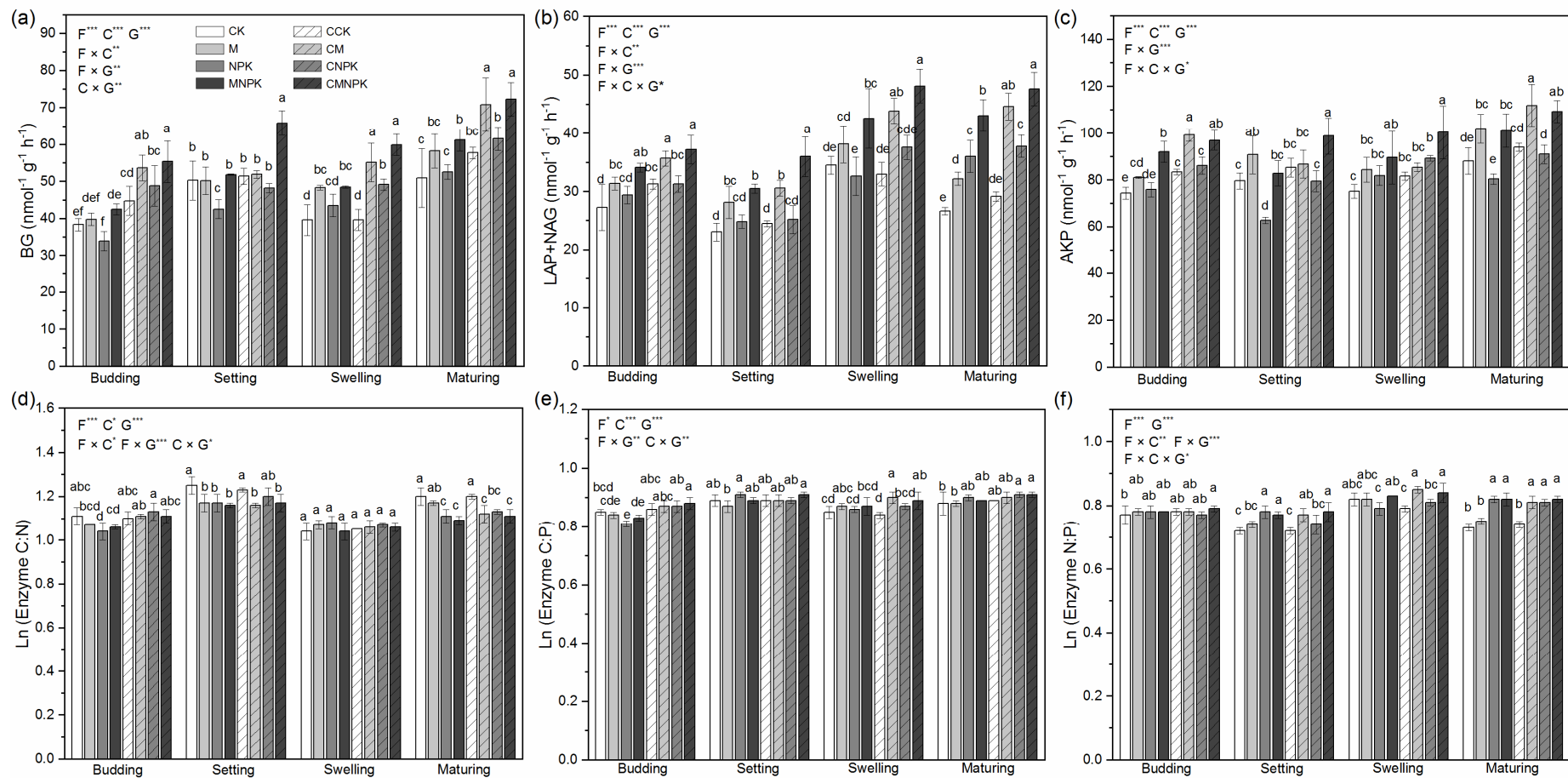
EC, Enzyme Commission number describing enzymatic function at increasing level of detail (the first number distinguishes 1-oxidoreductases, 2-transferases, 3-hydrolases, 4-lyases, 5-isomerases, and 6-ligases).

**Table S2.** Means ( $\pm$  standard deviation) of soil physicochemical properties under different treatments within each growth period.

Period	Treatment	SWC (%)	SOC (g kg <sup>-1</sup> )	TN (g kg <sup>-1</sup> )	TP (g kg <sup>-1</sup> )	DOC (mg kg <sup>-1</sup> )	DON (mg kg <sup>-1</sup> )	AN (mg kg <sup>-1</sup> )	AP (mg kg <sup>-1</sup> )	DOC:DON	C:N	C:P	N:P
Budding	CK	9.62 $\pm$ 0.24ef	8.94 $\pm$ 0.12d	0.82 $\pm$ 0.01d	0.59 $\pm$ 0.06e	9.63 $\pm$ 0.61d	4.23 $\pm$ 0.86g	4.96 $\pm$ 0.08g	7.60 $\pm$ 1.04f	2.34 $\pm$ 0.48b	10.91 $\pm$ 0.16ab	15.28 $\pm$ 1.25a	1.40 $\pm$ 0.13ab
	M	9.33 $\pm$ 0.23f	9.79 $\pm$ 0.33c	0.97 $\pm$ 0.06b	0.66 $\pm$ 0.12cde	19.27 $\pm$ 1.46b	17.61 $\pm$ 0.26c	6.61 $\pm$ 0.18f	14.67 $\pm$ 0.85e	1.09 $\pm$ 0.07c	10.13 $\pm$ 0.98bcd	15.05 $\pm$ 2.10ab	1.51 $\pm$ 0.34a
	NPK	12.01 $\pm$ 0.18c	7.97 $\pm$ 0.14e	0.82 $\pm$ 0.03d	0.63 $\pm$ 0.06de	7.17 $\pm$ 2.96d	13.99 $\pm$ 0.31d	34.00 $\pm$ 0.26b	9.60 $\pm$ 0.93f	0.51 $\pm$ 0.22d	9.73 $\pm$ 0.21cd	12.72 $\pm$ 1.02c	1.31 $\pm$ 0.08ab
	MNPK	17.12 $\pm$ 0.51a	10.86 $\pm$ 0.25b	0.94 $\pm$ 0.03bc	0.79 $\pm$ 0.09abc	16.87 $\pm$ 1.01bc	29.12 $\pm$ 0.55a	4.93 $\pm$ 0.18g	24.27 $\pm$ 0.96b	0.58 $\pm$ 0.04d	11.59 $\pm$ 0.19a	13.84 $\pm$ 1.42abc	1.19 $\pm$ 0.1b
	CCK	8.50 $\pm$ 0.19g	9.97 $\pm$ 0.56c	0.91 $\pm$ 0.01c	0.73 $\pm$ 0.07bcd	17.46 $\pm$ 1.66bc	3.74 $\pm$ 0.22g	11.36 $\pm$ 0.31e	7.67 $\pm$ 1.39f	4.68 $\pm$ 0.58a	10.92 $\pm$ 0.55ab	13.74 $\pm$ 0.71abc	1.26 $\pm$ 0.12ab
	CM	10.00 $\pm$ 0.21e	11.19 $\pm$ 0.48b	1.09 $\pm$ 0.03a	0.85 $\pm$ 0.07ab	23.61 $\pm$ 1.62a	10.43 $\pm$ 0.48e	15.69 $\pm$ 0.21d	17.50 $\pm$ 0.15d	2.27 $\pm$ 0.15b	10.26 $\pm$ 0.53bc	13.26 $\pm$ 0.53bc	1.30 $\pm$ 0.12ab
	CNPK	11.47 $\pm$ 0.46d	8.29 $\pm$ 0.41de	0.89 $\pm$ 0.02c	0.63 $\pm$ 0.07de	8.65 $\pm$ 0.93d	6.04 $\pm$ 0.04f	45.02 $\pm$ 0.63a	20.87 $\pm$ 1.55c	1.43 $\pm$ 0.16c	9.28 $\pm$ 0.49d	13.19 $\pm$ 0.91bc	1.43 $\pm$ 0.18ab
	CMNPK	15.50 $\pm$ 0.23b	12.35 $\pm$ 0.89a	1.06 $\pm$ 0.01a	0.92 $\pm$ 0.06a	15.00 $\pm$ 1.62c	26.44 $\pm$ 1.19b	21.66 $\pm$ 0.79c	31.13 $\pm$ 1.86a	0.57 $\pm$ 0.08d	11.64 $\pm$ 0.73a	13.49 $\pm$ 0.20abc	1.16 $\pm$ 0.06b
Setting	CK	12.76 $\pm$ 0.04g	8.71 $\pm$ 0.21de	0.75 $\pm$ 0.04d	0.65 $\pm$ 0.03de	14.97 $\pm$ 1.14d	4.63 $\pm$ 0.16e	7.80 $\pm$ 0.39e	7.07 $\pm$ 0.76e	3.24 $\pm$ 0.33b	11.59 $\pm$ 0.41ab	13.33 $\pm$ 0.40bc	1.15 $\pm$ 0.02cd
	M	14.33 $\pm$ 0.09d	10.32 $\pm$ 0.84bc	0.98 $\pm$ 0.01bc	0.74 $\pm$ 0.05bc	24.25 $\pm$ 1.01b	30.98 $\pm$ 0.63d	21.74 $\pm$ 0.64d	13.87 $\pm$ 0.56d	0.78 $\pm$ 0.02c	10.54 $\pm$ 0.80bc	13.92 $\pm$ 0.23abc	1.32 $\pm$ 0.08ab
	NPK	13.68 $\pm$ 0.05f	8.32 $\pm$ 0.73e	0.77 $\pm$ 0.03d	0.62 $\pm$ 0.03e	11.97 $\pm$ 0.89e	37.64 $\pm$ 0.77ab	30.01 $\pm$ 1.23c	13.70 $\pm$ 1.50d	0.32 $\pm$ 0.02d	10.79 $\pm$ 0.69abc	13.36 $\pm$ 1.04bc	1.24 $\pm$ 0.03bc
	MNPK	15.62 $\pm$ 0.11a	10.32 $\pm$ 0.42bc	0.93 $\pm$ 0.12c	0.71 $\pm$ 0.02cd	28.69 $\pm$ 1.31a	39.55 $\pm$ 0.48a	22.74 $\pm$ 0.89d	29.83 $\pm$ 3.76b	0.73 $\pm$ 0.02c	11.14 $\pm$ 1.03abc	14.57 $\pm$ 0.29a	1.32 $\pm$ 0.14ab
	CCK	15.12 $\pm$ 0.14b	9.13 $\pm$ 0.21de	0.79 $\pm$ 0.02d	0.74 $\pm$ 0.05bc	13.34 $\pm$ 1.01de	3.21 $\pm$ 0.09e	9.30 $\pm$ 1.15e	9.73 $\pm$ 0.40e	4.17 $\pm$ 0.35a	11.60 $\pm$ 0.06ab	12.30 $\pm$ 0.54d	1.06 $\pm$ 0.05d
	CM	11.88 $\pm$ 0.08h	11.21 $\pm$ 1.05ab	1.04 $\pm$ 0.01b	0.79 $\pm$ 0.07ab	29.85 $\pm$ 1.99a	35.94 $\pm$ 0.16bc	40.14 $\pm$ 1.23b	21.70 $\pm$ 1.29c	0.83 $\pm$ 0.05c	10.81 $\pm$ 1.15abc	14.13 $\pm$ 0.41ab	1.32 $\pm$ 0.13ab
	CNPK	13.87 $\pm$ 0.12e	9.61 $\pm$ 0.41cd	0.81 $\pm$ 0.03d	0.74 $\pm$ 0.04bc	19.62 $\pm$ 0.64c	36.47 $\pm$ 3.79bc	51.51 $\pm$ 1.17a	24.30 $\pm$ 1.07c	0.54 $\pm$ 0.05cd	11.90 $\pm$ 0.26a	13.01 $\pm$ 0.66cd	1.09 $\pm$ 0.07cd
	CMNPK	14.52 $\pm$ 0.02c	12.26 $\pm$ 0.67a	1.19 $\pm$ 0.03a	0.83 $\pm$ 0.04a	28.71 $\pm$ 3.47a	35.06 $\pm$ 0.18c	49.88 $\pm$ 0.59a	35.53 $\pm$ 1.88a	0.82 $\pm$ 0.10c	10.27 $\pm$ 0.59c	14.72 $\pm$ 0.16a	1.44 $\pm$ 0.07a
Swelling	CK	11.68 $\pm$ 0.2c	7.75 $\pm$ 0.13f	0.97 $\pm$ 0.02e	0.55 $\pm$ 0.02f	4.92 $\pm$ 0.62c	1.33 $\pm$ 0.23e	2.75 $\pm$ 0.27d	10.67 $\pm$ 0.93e	3.73 $\pm$ 0.21a	8.02 $\pm$ 0.29e	14.03 $\pm$ 0.64b	1.75 $\pm$ 0.05a
	M	10.76 $\pm$ 0.44d	13.04 $\pm$ 0.48b	1.17 $\pm$ 0.01c	0.84 $\pm$ 0.02b	20.87 $\pm$ 2.41a	8.91 $\pm$ 0.02d	19.32 $\pm$ 0.63c	16.30 $\pm$ 2.55cd	2.34 $\pm$ 0.27bc	11.16 $\pm$ 0.38a	15.53 $\pm$ 0.49a	1.39 $\pm$ 0.05de
	NPK	12.51 $\pm$ 0.08b	8.45 $\pm$ 0.46e	0.91 $\pm$ 0.01e	0.64 $\pm$ 0.05e	5.76 $\pm$ 1.59c	41.22 $\pm$ 0.17c	25.87 $\pm$ 2.93b	19.60 $\pm$ 1.35c	0.14 $\pm$ 0.04d	9.30 $\pm$ 0.51cd	13.34 $\pm$ 1.01bc	1.44 $\pm$ 0.1de
	MNPK	13.90 $\pm$ 0.28a	9.88 $\pm$ 0.54c	1.29 $\pm$ 0.03b	0.77 $\pm$ 0.03c	17.59 $\pm$ 2.49a	56.21 $\pm$ 1.84a	36.47 $\pm$ 3.40a	23.97 $\pm$ 2.38b	0.31 $\pm$ 0.04d	7.66 $\pm$ 0.49e	12.87 $\pm$ 0.22c	1.68 $\pm$ 0.08ab
	CCK	13.75 $\pm$ 0.22a	9.29 $\pm$ 0.32cd	0.94 $\pm$ 0.06e	0.70 $\pm$ 0.01d	6.06 $\pm$ 0.07bc	2.22 $\pm$ 0.05e	3.70 $\pm$ 0.12d	14.10 $\pm$ 1.56de	2.73 $\pm$ 0.05b	9.86 $\pm$ 0.90bc	13.29 $\pm$ 0.42bc	1.35 $\pm$ 0.10e
	CM	10.71 $\pm$ 0.34d	13.14 $\pm$ 0.22b	1.29 $\pm$ 0.03b	0.86 $\pm$ 0.04ab	20.28 $\pm$ 4.22a	8.74 $\pm$ 0.58d	19.41 $\pm$ 0.50c	18.27 $\pm$ 1.89c	2.33 $\pm$ 0.53c	10.16 $\pm$ 0.27b	15.30 $\pm$ 0.44a	1.51 $\pm$ 0.08cd
	CNPK	11.09 $\pm$ 0.17d	8.81 $\pm$ 0.24de	1.04 $\pm$ 0.01d	0.66 $\pm$ 0.04de	5.85 $\pm$ 2.79c	51.25 $\pm$ 6.41b	24.29 $\pm$ 1.40b	27.80 $\pm$ 2.25ab	0.11 $\pm$ 0.05d	8.46 $\pm$ 0.24de	13.38 $\pm$ 0.83bc	1.58 $\pm$ 0.09bc
	CMNPK	11.92 $\pm$ 0.11c	13.91 $\pm$ 0.46a	1.39 $\pm$ 0.07a	0.92 $\pm$ 0.05a	9.94 $\pm$ 1.16b	56.58 $\pm$ 2.33a	25.76 $\pm$ 1.69b	30.70 $\pm$ 3.84a	0.18 $\pm$ 0.02d	10.03 $\pm$ 0.50bc	15.16 $\pm$ 0.42a	1.51 $\pm$ 0.05cd
Maturing	CK	18.87 $\pm$ 0.26c	9.11 $\pm$ 0.29de	0.79 $\pm$ 0.03f	0.68 $\pm$ 0.10cd	8.14 $\pm$ 0.71g	2.93 $\pm$ 0.22e	6.09 $\pm$ 0.43c	29.67 $\pm$ 2.52b	2.78 $\pm$ 0.09c	11.55 $\pm$ 0.17a	13.65 $\pm$ 1.81bc	1.18 $\pm$ 0.14e
	M	19.37 $\pm$ 0.55b	12.53 $\pm$ 0.27b	1.21 $\pm$ 0.09c	0.81 $\pm$ 0.01ab	23.58 $\pm$ 2.61d	3.03 $\pm$ 0.12e	4.92 $\pm$ 0.13d	15.60 $\pm$ 1.23e	7.78 $\pm$ 0.87a	10.54 $\pm$ 1.09ab	15.53 $\pm$ 0.45a	1.48 $\pm$ 0.11cd
	NPK	17.74 $\pm$ 0.15e	8.66 $\pm$ 0.41e	1.03 $\pm$ 0.05d	0.67 $\pm$ 0.08cd	9.51 $\pm$ 2.07g	6.07 $\pm$ 0.22d	6.43 $\pm$ 0.15c	23.73 $\pm$ 2.22c	1.56 $\pm$ 0.32d	8.38 $\pm$ 0.51c	12.99 $\pm$ 0.93c	1.55 $\pm$ 0.17c
	MNPK	20.69 $\pm$ 0.06a	13.09 $\pm$ 0.39ab	1.14 $\pm$ 0.06c	0.87 $\pm$ 0.04a	30.68 $\pm$ 0.81b	9.64 $\pm$ 0.95b	7.56 $\pm$ 0.09b	33.70 $\pm$ 1.23a	3.21 $\pm$ 0.39bc	11.54 $\pm$ 0.87a	15.12 $\pm$ 0.43ab	1.31 $\pm$ 0.1de
	CCK	18.25 $\pm$ 0.22d	9.94 $\pm$ 0.27c	0.91 $\pm$ 0.02e	0.74 $\pm$ 0.05bc	12.82 $\pm$ 0.37f	7.55 $\pm$ 1.06c	3.20 $\pm$ 0.29e	19.23 $\pm$ 3.23d	1.72 $\pm$ 0.27d	10.90 $\pm$ 0.45ab	13.50 $\pm$ 0.74bc	1.24 $\pm$ 0.10e
	CM	20.72 $\pm$ 0.03a	13.43 $\pm$ 0.38a	1.31 $\pm$ 0.04b	0.86 $\pm$ 0.03a	27.37 $\pm$ 1.83c	7.32 $\pm$ 0.28c	2.55 $\pm$ 0.22f	22.37 $\pm$ 0.67cd	3.75 $\pm$ 0.34b	10.34 $\pm$ 0.55b	15.56 $\pm$ 0.77a	1.51 $\pm$ 0.08c

CNPK	17.85 ± 0.24de	9.36 ± 0.38cd	1.14 ± 0.03c	0.62 ± 0.01d	16.19 ± 1.46e	8.91 ± 0.06b	9.66 ± 0.60a	30.47 ± 0.58ab	1.82 ± 0.17d	8.25 ± 0.50c	15.13 ± 0.68ab	1.84 ± 0.04b
CMNPK	18.81 ± 0.32c	12.83 ± 0.62ab	1.75 ± 0.02a	0.82 ± 0.02ab	35.62 ± 1.97a	13.27 ± 0.21a	4.62 ± 0.25d	33.43 ± 2.66a	2.68 ± 0.16c	7.33 ± 0.43c	15.67 ± 1.07a	2.14 ± 0.03a

Note: Different letters indicate significant differences ( $P < 0.05$ ) under different treatments within each growth period. Effects of fertilization (F), cover crop (C), and growth period (G) on these parameters were estimated by three-way repeated measures ANOVAs.



**Figure S2.** Variations in soil enzymatic activity and enzymatic stoichiometry under different treatments within each growth period. (a), C-acquiring enzymes: BG; (b), N-acquiring enzymes: LAP + NAG; (c), P-acquiring enzymes AKP; (d), enzyme C:N; (e), enzyme C:P; (f), enzyme N:P. Effects of fertilization (F), cover crop (C), and growth period (G) on these parameters were estimated by three-way repeated measures ANOVAs. \*,  $P < 0.05$ ; \*\*,  $P < 0.01$ ; \*\*\*,  $P < 0.001$ . Different letters indicate significant differences ( $P < 0.05$ ) under different treatments within each growth period. CK, no cover crop with no fertilizer; M, no cover crop with organic fertilizer; NPK, no cover crop with chemical fertilizer; MNPK, no cover crop with chemical fertilizer and organic fertilizer. CCK, cover crop with no fertilizer; CM, cover crop with organic fertilizer; CNPK, cover crop with chemical fertilizer; CMNPK, cover crop with chemical fertilizer and organic fertilizer.