



Figure S1 Dynamic changes of microbial activities of bacterial keystone taxa in macroaggregate (a-c) and in microaggregates (d-f), and fungal keystone taxa in macroaggregate (g-i) and in microaggregates (j-l).

Note: Treatments including CKS (control + straw) (a), IFS (inorganic fertilizer + straw) (b), IFMS (inorganic fertilizer plus manure + straw) (c) in macroaggregate, and CKS (control + straw) (d), IFS (inorganic fertilizer + straw) (e), IFMS (inorganic fertilizer plus manure + straw) (f) in microaggregate. The values presented in the figures are given as mean \pm standard errors. Different capital letters indicated significant differences ($P < 0.05$) among different incubation periods.

Table S1

Soil basic properties of different fertilizer management strategies in 2018.

Treatment	SOC (g kg ⁻¹)	$\delta^{13}\text{C}$ (‰)	TN (g kg ⁻¹)	C/N ratio	AP (mg kg ⁻¹)	AK (mg kg ⁻¹)
CK	15.0±0.1 b	-18.8±0.0 a	1.4±0.1 c	10.6±0.4 a	15.32±0.75 c	65.04±3.18 c
IF	15.0±0.1 b	-19.4±0.0 c	1.5±0.0 b	9.7±0.0 b	20.90±0.70 b	81.42±1.40 b
IFM	25.2±0.2 a	-19.1±0.1 b	2.6±0.0 a	9.7±0.0 b	80.66±2.56 a	137.37±3.87 a

Note: The C denotes no fertilization control treatment, the IF denotes inorganic fertilizer treatment, the IFM denotes inorganic fertilizer plus manure treatment. SOC denotes soil organic carbon, TN denotes total nitrogen, C/N denotes the ratio of SOC and total nitrogen, AP denotes available phosphorous, AK denotes available potassium. Different lowercase letters mean significant differences ($P < 0.05$) in various fertilizer management strategies.

Table S2

Topological properties of bacterial network in soil aggregates.

Aggregate size	Parameter	CK	CKS	IF	IFS	IFM	IFMS
Macroaggregate	Num.edges	458	301	613	219	108	298
	pos.edges (percentage)	446 (97)	286 (95)	605 (98)	166 (75)	98 (90)	268 (90)
	neg.edges (percentage)	12 (3)	15 (5)	8 (2)	53 (25)	10 (10)	30 (10)
	num.vertices	181	152	186	141	118	150
	connectance	0.03	0.03	0.04	0.02	0.02	0.03
	average.degree	5.06	3.96	6.59	3.11	1.83	3.97
	average.path.length	3.97	4.33	5.75	6.03	4.41	4.10
	diameter	15	12	19	16	14	11
	clustering.coefficient	0.58	0.54	0.52	0.44	0.46	0.43
	no.clusters	22	20	9	16	30	15
	centralization.degree	0.09	0.07	0.12	0.04	0.04	0.09
	centralization.betweenness	0.04	0.09	0.36	0.13	0.03	0.06
Microaggregate	Num.edges	340	321	241	295	212	577
	pos.edges (percentage)	339 (99)	288 (89)	219 (90)	292 (98)	209 (98)	532 (92)
	neg.edges (percentage)	1 (1)	33 (11)	22 (10)	3 (2)	3 (2)	45 (8)
	num.vertices	161	189	153	162	150	190
	connectance	0.03	0.02	0.02	0.02	0.02	0.03
	average.degree	4.22	3.40	3.15	3.64	2.83	6.07
	average.path.length	5.40	4.50	6.84	6.87	4.62	5.88
	diameter	14	14	16	18	12	16
	clustering.coefficient	0.49	0.44	0.47	0.46	0.45	0.53
	no.clusters	16	14	19	17	21	11
	centralization.degree	0.06	0.05	0.06	0.05	0.04	0.08
	centralization.betweenness	0.18	0.04	0.15	0.17	0.05	0.20

Table S3

Topological properties of fungal network in soil aggregates.

Aggregate size	Parameter	CK	CKS	IF	IFS	IFM	IFMS
Macroaggregate	Num.edges	17	15	23	35	28	27
	pos.edges (percentage)	11 (65)	10 (67)	22 (96)	24 (69)	21 (75)	19 (70)
	neg.edges (percentage)	6 (35)	5 (33)	1 (4)	11 (31)	7 (25)	8 (30)
	num.vertices	23	23	32	36	28	33
	connectance	0.07	0.06	0.05	0.06	0.07	0.05
	average.degree	1.48	1.30	1.44	1.94	2.00	1.64
	average.path.length	1.73	1.82	2.04	1.97	1.67	1.75
	diameter	4	5	5	5	4	4
	clustering.coefficient	0.38	0.00	0.35	0.43	0.50	0.55
	no.clusters	8	8	11	9	9	11
	centralization.degree	0.11	0.03	0.05	0.12	0.15	0.07
	centralization.betweenness	0.05	0.02	0.02	0.03	0.03	0.02
Microaggregate	Num.edges	77	43	119	110	65	76
	pos.edges (percentage)	54 (70)	37 (86)	114 (96)	85 (77)	59 (91)	74 (97)
	neg.edges (percentage)	23 (30)	6 (14)	5 (4)	25 (23)	6 (9)	2 (3)
	num.vertices	51	46	60	65	57	54
	connectance	0.06	0.04	0.07	0.05	0.04	0.05
	average.degree	3.02	1.87	3.97	3.38	2.28	2.81
	average.path.length	3.21	3.19	3.61	3.35	3.42	2.35
	diameter	8	9	8	10	8	7
	clustering.coefficient	0.49	0.46	0.63	0.53	0.38	0.57
	no.clusters	6	12	6	7	10	11
	centralization.degree	0.12	0.07	0.10	0.17	0.08	0.15
	centralization.betweenness	0.15	0.05	0.18	0.12	0.10	0.03

Table S4

The keystone taxa in the bacterial networks in soil aggregates.

Aggregate size	Treatment	OTU ID	Phylum	Genus	Degree	Closeness centrality	Betweenness centrality
Macroaggregate	CKS	OTU_326	Acidobacteria	Gp6	15	0.009	62
	IFS	OTU_638	Actinobacteria	Gaiella	9	0.023	664
	IFMS	OTU_66	Proteobacteria	Methyloceanibacter	18	0.014	621
Microaggregate	CKS	OTU_226	Actinobacteria	Solirubrobacter	10	0.008	656
	IFS	OTU_71	Actinobacteria	Marmoricola	11	0.015	340
	IFMS	OTU_80	Acidobacteria	Gp6	21	0.022	1466

Table S5

The keystone taxa in the fungal networks in soil aggregates.

Aggregate size	Treatment	OTU ID	Phylum	Genus	Degree	Closeness centrality	Betweenness centrality
Macroaggregate	CKS	OTU_48	Ascomycota	Podospora	2	0.055	6
	IFS	OTU_919	Ascomycota	Myrothecium	6	0.036	9
	IFMS	OTU_173	Ascomycota	Trichoderma	4	0.038	8
Microaggregate	CKS	OTU_91	Ascomycota	Acremonium	5	0.026	12
	IFS	OTU_1098	Unassigned	Unassigned	14	0.033	255
	IFMS	OTU_65	Unassigned	Unassigned	11	0.028	24