

Table S1 Effects of cultivation system and growing season on soil chemical property.

Soil properties	WS season		AW season		Effects		
	C	CA	C	CA	GS	CS	GS×CS
pH	6.9±0.03	6.84±0.04	7.03±0.12	6.83±0.05	0.179	0.010	0.106
EC	948±45.31	949.33±13.05	829.33±19.66	1320.33±8.02	0.000	0.000	0.000
MN	114.87±4.39	112.81±0.47	113.75±0.36	114.19±0.11	0.921	0.544	0.357
AP	98.06±3.51	103.21±13.6	100.54±3.14	110.33±6.48	0.387	0.192	0.670
AK	458.67±26.3	490.67±8.00	456.67±11.89	534.33±12.55	0.004	0.000	0.002
TN	3.53±0.03	3.26±0.02	2.85±0.05	2.84±0.05	0.002	0.289	0.330
SOM	58.05±6.52	62.09±5.52	56.88±7.38	53.07±4.00	0.096	0.967	0.184

Note: GS: Growing season, CS: Cultivation system, C: cucumber monocropping, CA: cucumber-amaranth intercropping, WS: winter-spring season, AW: autumn-winter season, AP: soil available phosphorus; AK: soil available potassium; TN: total nitrogen, SOM: soil organic matter.

Table S2 Effects of cultivation system and growing season on soil ionome.

Ionome (g/kg)	WS season		AW season		Effects		
	C	CA	C	CA	GS	CS	GS×CS
P	4.03±0.05	3.9±0.08	3.4±0.02	3.54±0	0.000	0.792	0.005
K	18.54±1.13	19.19±0.48	19.05±0.24	18.78±0.34	0.915	0.688	0.340
Ca	21.1±0.13	20.32±0.88	20.01±0.02	18.53±0.5	0.004	0.014	0.355
Mg	8.81±0.95	8.85±0.4	8.61±0.59	6.94±0.59	0.055	0.123	0.106
S	0.84±0.03	0.79±0.03	0.66±0.01	0.92±0.18	0.734	0.134	0.045
Cu	0.04±0	0.04±0	0.03±0	0.03±0	0.000	0.023	0.014
Fe	28.38±1.44	27.92±0.69	27.23±0.43	26.37±0.49	0.058	0.307	0.753
Mn	0.51±0.01	0.51±0.02	0.48±0.01	0.48±0	0.007	0.878	0.885
Na	13.3±0.5	13.72±0.16	13.9±0.18	13.75±0.39	0.226	0.583	0.268
Zn	0.18±0	0.17±0	0.16±0	0.16±0	0.000	0.009	0.664
Al	40.06±7.43	41.58±1.06	42.89±4.2	30.16±3.45	0.227	0.125	0.061
Ba	0.46±0.03	0.46±0	0.48±0.01	0.45±0	0.633	0.191	0.316
Co	0.01±0	0.01±0	0.01±0	0.01±0	0.001	0.176	0.053
Cr	0.4±0.01	0.43±0.02	0.35±0.01	0.34±0.01	0.000	0.256	0.063
La	0.01±0	0.01±0	0.01±0	0.01±0	0.416	0.093	0.117
Li	0.02±0	0.02±0	0.02±0	0.02±0	0.026	0.189	0.948
Ni	0.03±0.01	0.02±0	0.02±0	0.02±0	0.057	0.166	0.103
Pb	0.03±0	0.03±0	0.03±0	0.03±0	0.531	0.324	0.256
Sc	0.01±0	0.01±0	0.01±0	0.01±0	0.090	0.083	0.109
Sr	0.27±0.02	0.27±0	0.27±0.01	0.23±0.01	0.070	0.118	0.095
Ti	3.1±0.05	2.98±0.04	2.96±0.05	3.05±0.1	0.468	0.713	0.053
V	0.06±0	0.06±0	0.06±0	0.06±0	0.264	0.477	0.113

Note: GS: Growing season, CS: Cultivation system, C: cucumber monocropping, CA: cucumber-amaranth intercropping, WS: winter-spring season, AW: autumn-winter season.

Table S3 Changes in the abundances (individuals per 100 g soil) of nematode functional guilds.

Guild ^a	Treatment	Growing seasons		Effects		
		WS	AW	GS	CS	GS×CS
Ba1	C	17.57±5.26	2.29±0.47a	0.002	0.971	0.629
	CA	19.89±8.88	0.3±0.18b			
Ba2	C	25.79±1.88	7.86±1.87b	0.000	0.112	0.593
	CA	28.59±4.56	13.25±0.28a			
Ba3	C	1.17±0.18	1.64±0.6a	0.263	0.097	0.037
	CA	1.39±0.33	0±0b			
Ba4	C	0±0	0.71±0.46	0.731	0.731	0.038
	CA	0.96±0.54	0±0			
Fu2	C	1.66±0.89	0.26±0.26	0.038	0.545	0.390
	CA	3.09±2.03	0±0			
OP3	C	0±0	0±0	0.260	0.260	0.260
	CA	1.19±1.19	0±0			
OP4	C	0.67±0.67	0.6±0.36	0.058	0.090	0.065
	CA	5.27±2.65	0.36±0.12			
OP5	C	0±0	0±0	0.755	0.089	0.755
	CA	0.34±0.34	0.48±0.28			
PP2	C	4.47±0.81b	5.63±2.64	0.052	0.814	0.017
	CA	9.89±1.49a	1.05±0.49			
PP3	C	50.69±5.24a	1.93±0.32a	0.000	0.001	0.002
	CA	27.8±3.42b	0.24±0.07b			

Note: Guild^a refers to feeding habits & c-p value, GS: Growing season, CS: Cultivation system, C: cucumber monocropping, CA: cucumber-amaranth intercropping, WS: winter-spring season, AW: autumn-winter season.

Table S4 The mean proportion (%) of various nematodes on genus level in cucumber root-zone soil under monocropping and intercropping system.

Trophic groups	C-p value	Genus	WS season		AW season	
			C	CA	C	CA
Ba	1	<i>Protorhabditis</i>	4.32	0.96	1.43	0.47
Ba	1	<i>Rhabditis</i>	11.75	13.88	6.25	0.71
Ba	1	<i>Pseudodiplogaster</i>	1.00	2.35	0.00	0.00
Ba	1	<i>Panagrolaimus</i>	0.51	1.45	0.72	0.00
Ba	1	<i>Plectonchus</i>	0.00	0.00	0.77	0.00
Ba	1	<i>Mesorhabditis</i>	0.00	1.25	0.00	0.00
Ba	2	<i>Acrobeloides</i>	12.82	11.17	30.80	50.20
Ba	2	<i>Eucephalobus</i>	1.15	0.99	0.24	0.50
Ba	2	<i>Caenorhabditis</i>	2.82	4.31	0.00	0.00
Ba	2	<i>Cervidellus</i>	1.84	3.97	4.05	5.25
Ba	2	<i>Chiloplacus</i>	0.00	0.31	3.79	14.35
Ba	2	<i>Cephalobus</i>	0.00	2.32	7.83	5.63
Ba	2	<i>Acrobeles</i>	0.00	0.00	0.95	1.20
Ba	2	<i>monhystera</i>	0.00	0.34	0.00	0.00
Ba	2	<i>chronogaster</i>	0.00	1.05	0.00	0.00
Ba	3	<i>Prismatolaimus</i>	0.32	0.34	2.37	0.00
Ba	3	<i>Cylindrolaimus</i>	0.84	0.74	0.91	0.00
Ba	3	<i>bastiania</i>	0.00	0.31	0.00	0.00
Ba	4	<i>Alaimus</i>	0.00	0.96	0.71	0.00
Fu	2	<i>Aphelenchus</i>	7.16	4.14	7.34	15.64
Fu	2	<i>Aphelenchoides</i>	0.65	1.67	0.26	0.00
Fu	2	<i>Ditylenchus</i>	0.00	0.40	0.00	0.00
Fu	2	<i>Paraphelenchus</i>	1.01	1.02	0.00	0.00
OP	3	<i>tripyla</i>	0.00	0.40	0.00	0.00
OP	3	<i>trischistom</i>	0.00	0.79	0.00	0.00
OP	4	<i>Mylonchulus</i>	0.67	5.27	1.19	0.00
OP	4	<i>Microdorylaimus</i>	0.00	0.00	0.00	0.72
OP	5	<i>Nygolaimus</i>	0.00	0.34	0.00	0.48
PP	2	<i>Tylenchus</i>	0.83	1.02	1.21	0.00
PP	2	<i>Malenchus</i>	0.00	0.99	0.00	0.00
PP	2	<i>Filenchus</i>	0.00	3.83	0.24	0.47
PP	2	<i>Cephalenchus</i>	3.31	3.37	2.40	2.68
PP	2	<i>coslenchus</i>	0.32	0.00	0.00	0.00
PP	2	<i>Psilenchus</i>	0.00	0.68	0.00	0.00
PP	3	<i>Pratylenchus</i>	1.01	0.68	0.00	0.00
PP	3	<i>Rotylenchus</i>	0.34	0.71	14.26	0.00
PP	3	<i>Merlinius</i>	6.28	8.79	0.00	0.00
PP	3	<i>Helicotylenchus</i>	0.00	0.00	2.16	1.69
PP	3	<i>Pararotylenchus</i>	0.00	0.00	1.41	0.00
PP	3	<i>Tylenchorhynchus</i>	22.66	11.70	3.31	0.00

PP	3	<i>Meloidogyne</i>	11.50	5.13	2.82	0.00
PP	3	<i>Dolichorhynchus</i>	8.91	0.79	0.00	0.00
PP	3	<i>Nagelus</i>	0.00	0.00	1.41	0.00
PP	3	<i>Paratylenchus</i>	0.00	0.00	1.19	0.00

Note: GS: Growing season, CS: Cultivation system, C: cucumber monocropping, CA: cucumber-amaranth intercropping, WS: winter-spring season, AW: autumn-winter season. Nematode trophic groups: bacterivores (Ba), fungivores (Fu), omnivore–predators (OP) and plant parasites (PP).

Table S5 Effects of cultivation system and growing season on soil nematode diversity and maturity indices.

Indices	Treatments	Growing season		Effects		
		WS	AW	GS	CS	GS×CS
H'	C	2.37±0.11	2.24±0.33	0.000	0.166	0.002
	CA	2.69±0.15	1.58±0.15			
Total genus (S)	C	16.33±0.58	18.5±2.65	0.000	0.943	0.000
	CA	24±2.65	11±1.63			
Hmax(lnS)	C	2.79±0.03	2.91±0.14	0.000	0.323	0.000
	CA	3.17±0.11	2.39±0.15			
J'(Evenness)	C	0.15±0.01	6.34±0.59	0.000	0.002	0.002
	CA	0.11±0.01	4.58±0.4			
GR	C	3.43±0.16	3.76±0.57	0.000	0.981	0.000
	CA	5.03±0.48	2.15±0.37			
λ	C	0.14±0.01	0.19±0.08	0.000	0.191	0.01
	CA	0.09±0.02	0.31±0.04			
MI	C	0.79±0.17	1.37±0.37	0.000	0.003	0.514
	CA	1.18±0.06	1.92±0.05			
PPI	C	1.61±0.3	0.74±0.44	0.000	0.003	0.873
	CA	1.03±0.14	0.11±0.08			
PPI/MI	C	2.18±0.96	0.64±0.5	0.002	0.007	0.220
	CA	0.88±0.09	0.06±0.05			
MI25	C	0.61±0.09	1.28±0.39	0.000	0.003	0.331
	CA	0.98±0.19	1.91±0.05			

Note: GS: Growing season, CS: Cultivation system, C: cucumber monocropping, CA: cucumber-amaranth intercropping, WS: winter-spring season, AW: autumn-winter season. The diversity indices including H' (Shanon-Weiner index), Total genus (S), Hmax(lnS), J'(Evenness), GR and λ; The maturity indices including MI, PPI, PPI/MI, MI25.

Table S6 Results of Kruskal-Wallis test the abundance of bacterial taxa at phylum level.

WS season				AW season			
phylum	C	CA	P	phylum	C	CA	P
<i>Acidobacteriota</i>	9.09±0.98	8.45±1.34	0.5127	<i>Acidobacteriota</i>	11.47±1.79	8.04±2.17	0.1266
<i>Actinobacteriota</i>	17.76±0.36	19.83±1.18	0.0495	<i>Actinobacteriota</i>	18.59±1.18	19.52±1.94	0.2752
<i>Bacteroidota</i>	2.28±0.2	2.4±0.17	0.8273	<i>Bacteroidota</i>	2.11±0.42	2.34±0.11	0.5127
<i>Chloroflexi</i>	15.32±0.88	15.18±0.3	0.8273	<i>Chloroflexi</i>	15.46±0.6	14.46±0.92	0.2752
<i>Crenarchaeota</i>	7.86±1.47	7.06±0.79	0.2752	<i>Crenarchaeota</i>	2.78±0.65	4.15±1.07	0.2752
<i>Gemmatimonadota</i>	4.14±0.2	3.97±0.22	0.2752	<i>Gemmatimonadota</i>	4.87±0.41	4.96±0.23	0.5127
<i>Methyloirabilota</i>	0.96±0.11	1±0.13	0.5127	<i>Methyloirabilota</i>	1.32±0.11	1.01±0.08	0.0495
<i>Myxococcota</i>	2.01±0.22	2.02±0.19	0.8273	<i>Myxococcota</i>	2.32±0.26	2.5±0.23	0.8273
<i>Planctomycetota</i>	6.26±0.29	5.53±1.04	0.5127	<i>Planctomycetota</i>	6±1.25	5.08±1.46	0.5127
<i>Proteobacteria</i>	18.74±0.73	20.34±0.82	0.1266	<i>Proteobacteria</i>	18.73±1.54	20.79±2.21	0.2752

Note: GS: Growing season, CS: Cultivation system, C: cucumber monocropping, CA: cucumber-amaranth intercropping, WS: winter-spring season, AW: autumn-winter season.

Table S7 Results of Kruskal-Wallis test of the abundance of fungal taxa at phylum level.

WS season				AW season			
phylum	C	CA	P	phylum	C	CA	P
<i>Ascomycota</i>	65.84±6.11	65.86±1.72	0.8273	<i>Ascomycota</i>	64.16±1.94	75.85±3.47	0.0495
<i>Basidiomycota</i>	4.28±3.72	2.83±1.28	0.8273	<i>Basidiomycota</i>	2.44±0.54	1.34±0.7	0.1840
<i>Chytridiomycota</i>	0.69±0.4	3.33±1.67	0.0495	<i>Chytridiomycota</i>	0.28±0.11	0.62±0.25	0.1266
<i>Mortierellomycota</i>	21.32±2.09	19.48±2.03	0.5127	<i>Mortierellomycota</i>	23.39±1.85	15.58±2.65	0.0495
<i>Rozellomycota</i>	1.82±0.48	2.16±0.82	0.8273	<i>Rozellomycota</i>	0.35±0.04	0.71±0.32	0.1266

Note: GS: Growing season, CS: Cultivation system, C: cucumber monocropping, CA: cucumber-amaranth intercropping, WS: winter-spring season, AW: autumn-winter season.

Table S8 Results of Kruskal-Wallis test of the abundance of bacterial taxa at family level.

WS season				AW season			
phylum	C	CA	P	phylum	C	CA	P
<i>Nitrososphaeraceae</i>	7.64±0.78	7±1.42	0.5127	<i>Bacillaceae</i>	4.48±0.47	4.91±0.18	0.2752
<i>Bacillaceae</i>	3.5±0.26	3.26±0.12	0.2752	<i>Nitrososphaeraceae</i>	2.72±1.04	4.07±0.63	0.1266
<i>JG30KFCM45</i>	3.02±0.06	3.26±0.14	0.0495	<i>JG30KFCM45</i>	3±0.1	3.03±0.08	0.8273
<i>Sphingomonadaceae</i>	2.22±0.3	3.63±0.13	0.0495	<i>Nocardiodaceae</i>	2.93±0.62	2.87±0.84	0.5127
<i>Nocardiodaceae</i>	2.5±0.4	3.11±0.32	0.2752	<i>Vicinamibacteraceae</i>	3.13±0.69	2.15±0.51	0.1266
<i>Vicinamibacteraceae</i>	2.3±0.44	2.21±0.25	1.0000	<i>Gemmatimonadaceae</i>	2.44±0.17	2.63±0.23	0.2752
<i>Pirellulaceae</i>	2.29±0.44	2.14±0.01	0.8273	<i>Gaiellaceae</i>	2.17±0.24	1.99±0.19	0.2752
<i>Gemmatimonadaceae</i>	2.15±0.16	2.03±0.09	0.5127	<i>Pirellulaceae</i>	2.02±0.49	1.61±0.43	0.5127
<i>Gaiellaceae</i>	1.83±0.21	1.94±0.09	0.8273	<i>Micromonosporaceae</i>	1.53±0.35	1.92±0.17	0.1266
<i>Micromonosporaceae</i>	1.46±0.34	1.74±0.29	0.2752	<i>Sphingomonadaceae</i>	1.57±0.12	1.86±0.14	0.0495
<i>Gemmataceae</i>	1.5±0.28	1.29±0.19	0.5127	<i>norank_o__Actinomarinales</i>	1.52±0.11	1.83±0.07	0.0495
<i>Xanthobacteraceae</i>	1.25±0.04	1.19±0.06	0.2752	<i>Xanthobacteraceae</i>	1.38±0.13	1.46±0.13	0.5127
<i>Thermoactinomycetaceae</i>	1.19±0.03	1.21±0.17	0.5127	<i>6714</i>	1.38±0.18	1.4±0.05	0.5127
<i>AKYG1722</i>	1.07±0.11	1.12±0.08	0.5127	<i>Gemmataceae</i>	1.57±0.43	1.22±0.37	0.5127
<i>Geminicoccaceae</i>	0.97±0.19	1.14±0.05	0.2752	<i>Nitrosomonadaceae</i>	1.25±0.11	1.32±0.11	0.2752
<i>Xanthomonadaceae</i>	0.81±0.19	1.23±0.02	0.0495	<i>Geminicoccaceae</i>	1.22±0.22	1.34±0.1	0.8273
				<i>Methylobacteriaceae</i>	0.98±0.16	1.19±0.07	0.1266
				<i>Thermoactinomycetaceae</i>	0.88±0.24	1.26±0.07	0.0495

Note: GS: Growing season, CS: Cultivation system, C: cucumber monocropping, CA: cucumber-amaranth intercropping, WS: winter-spring season, AW: autumn-winter season.

Table S9 Results of Kruskal-Wallis test of the abundance of fungal taxa at family level.

WS season				AW season			
family	C	CA	P	family	C	CA	P
<i>Mortierellaceae</i>	21.32±2.04	19.46±2.09	0.5127	<i>Mortierellaceae</i>	23.39±2.65	15.58±1.85	0.0495
<i>Aspergillaceae</i>	16.24±0.84	7.76±1.33	0.0495	<i>Nectriaceae</i>	14.02±0.82	18.64±2.23	0.0495
<i>Plectosphaerellaceae</i>	7.49±3.08	10.42±2.03	0.1266	<i>Aspergillaceae</i>	8.74±0.49	8.81±4.72	0.5127
<i>Nectriaceae</i>	6.77±1.21	10.86±0.85	0.0495	<i>Chaetomiaceae</i>	5.94±1.17	10.76±0.33	0.0495
<i>Chaetomiaceae</i>	6.6±0.75	6.57±1.13	0.8273	<i>Microascaceae</i>	6.15±3.79	9.55±0.7	0.1266
<i>Microascaceae</i>	6.45±2	5.7±0.96	0.5127	<i>unclassified_k_Fungi</i>	7.6±0.42	4.78±1.24	0.0495
<i>Pyronemataceae</i>	4.88±0.52	6.52±2.29	0.5127	<i>Plectosphaerellaceae</i>	3.63±0.9	6.89±0.58	0.0495
<i>unclassified_k_Fungi</i>	5.55±0.82	5.82±1.02	0.8273	<i>Pyronemataceae</i>	7.73±0.56	1.18±2.16	0.0495
<i>Cladosporiaceae</i>	1.52±0.46	4.37±0.47	0.0495	<i>Cladosporiaceae</i>	1.27±0.67	3.94±0.38	0.0495
<i>Gymnoascaceae</i>	3±0.13	1.6±0.18	0.0463	<i>Gymnoascaceae</i>	2.67±0.38	2.31±0.18	0.5127
<i>unclassified_p_Rozellomycota</i>	1.81±0.82	2.16±0.49	0.8273	<i>unclassified_p_Ascomycota</i>	2.22±0.1	1.11±0.93	0.0495
<i>Entolomataceae</i>	3.21±0.2	0.43±3.92	0.8273	<i>unclassified_c_Sordariomycetes</i>	2.55±0.35	0.74±0.59	0.0495
<i>unclassified_p_Chytridiomycota</i>	0.65±1.96	2.8±0.38	0.0495	<i>unclassified_o_Sordariales</i>	0.17±2.83	2.47±0.01	0.0495
<i>Hypocreales_fam_Incertae_sedis</i>	1.69±0.13	1.58±0.32	0.5127	<i>Hypocreales_fam_Incertae_sedis</i>	1.25±0.34	1.21±0.17	0.5127
<i>unclassified_o_Coniochaetales</i>	1.73±0.26	0.69±0.89	0.1266	<i>Ascodesmidaceae</i>	1.6±0.23	0.68±1.56	0.8273
<i>Pleosporaceae</i>	1.37±0.2	0.98±1.28	0.5127				

Note: GS: Growing season, CS: Cultivation system, C: cucumber monocropping, CA: cucumber-amaranth intercropping, WS: winter-spring season, AW: autumn-winter season.