

Table S1 Sampling sites location information and edaphic factors. The value of edaphic factor was mean \pm standard deviation (n=4).

Sample	Location	Longitude	Latitude	Altitude(m)	EE-GRSP (mg/g)	DE-GRSP (mg/g)	T-GRSP (mg/g)	pH	SOM%	Total N(g/kg)	Total P(g/kg)	Urease(mg/g)	ACP(mg/g)
NJ1	Nenjiang1	125.38°E	49.18°N	321.99	0.49 \pm 0.03	0.42 \pm 0.02	0.91 \pm 0.04	6.38 \pm 0.03	3.89 \pm 0.19	1.85 \pm 0.12	0.65 \pm 0.03	16.31 \pm 4.21	76.61 \pm 13.44
NJ2	Nenjiang2	125.88°E	49.02°N	320.68	0.50 \pm 0.02	0.43 \pm 0.03	0.93 \pm 0.04	6.06 \pm 0.10	5.79 \pm 0.15	3.06 \pm 0.08	1.13 \pm 0.04	11.32 \pm 1.38	94.98 \pm 8.27
WD1	Wudalianchi1	126.13°E	48.66°N	304.09	0.44 \pm 0.02	0.54 \pm 0.02	0.98 \pm 0.02	6.35 \pm 0.12	4.12 \pm 0.13	1.94 \pm 0.05	1.01 \pm 0.06	12.55 \pm 3.17	58.28 \pm 5.39
NH2	Nehe2	124.90°E	48.51°N	233.07	0.45 \pm 0.04	0.39 \pm 0.02	0.84 \pm 0.03	6.30 \pm 0.08	3.85 \pm 0.39	1.77 \pm 0.08	0.67 \pm 0.04	16.69 \pm 0.81	81.31 \pm 18.57
BA2	Beian2	126.50°E	48.29°N	312.81	0.49 \pm 0.01	0.53 \pm 0.03	1.02 \pm 0.04	6.11 \pm 0.10	5.43 \pm 0.44	2.24 \pm 0.14	0.88 \pm 0.05	14.91 \pm 1.94	77.28 \pm 8.34
NH1	Nehe1	124.99°E	48.17°N	255.45	0.35 \pm 0.04	0.36 \pm 0.01	0.71 \pm 0.04	6.41 \pm 0.08	4.46 \pm 0.26	2.19 \pm 0.15	0.62 \pm 0.05	22.23 \pm 9.88	95.09 \pm 12.94
KD1	Kedong1	126.25°E	47.98°N	311.60	0.50 \pm 0.02	0.63 \pm 0.02	1.13 \pm 0.02	6.61 \pm 0.12	4.59 \pm 0.31	2.18 \pm 0.13	0.67 \pm 0.01	20.75 \pm 7.01	85.51 \pm 6.02
KS2	Keshan2	125.91°E	47.97°N	245.55	0.39 \pm 0.04	0.38 \pm 0.02	0.77 \pm 0.03	6.88 \pm 0.24	3.29 \pm 0.18	1.62 \pm 0.08	0.53 \pm 0.03	15.02 \pm 1.89	62.44 \pm 6.84
YA2	Yian2	125.27°E	47.92°N	240.83	0.42 \pm 0.04	0.39 \pm 0.01	0.81 \pm 0.04	6.68 \pm 0.19	3.64 \pm 0.26	1.91 \pm 0.18	0.66 \pm 0.07	14.64 \pm 1.72	88.42 \pm 8.92
HL2	Hailun2	126.77°E	47.87°N	220.58	0.45 \pm 0.02	0.53 \pm 0.03	0.98 \pm 0.04	6.06 \pm 0.02	6.31 \pm 0.34	2.60 \pm 0.10	0.98 \pm 0.03	21.03 \pm 3.76	105.92 \pm 5.87
BQ2	Baiquan2	126.05°E	47.53°N	264.88	0.41 \pm 0.03	0.43 \pm 0.02	0.84 \pm 0.03	6.73 \pm 0.29	3.90 \pm 0.13	1.94 \pm 0.11	0.67 \pm 0.07	19.05 \pm 2.06	63.42 \pm 5.18
HL1	Hailun1	126.95°E	47.42°N	266.50	0.43 \pm 0.01	0.51 \pm 0.03	0.94 \pm 0.02	6.02 \pm 0.09	5.27 \pm 0.15	1.80 \pm 0.12	0.81 \pm 0.07	14.64 \pm 3.87	75.98 \pm 3.99
SL1	Suiling1	127.05°E	47.23°N	185.80	0.49 \pm 0.01	0.61 \pm 0.02	1.11 \pm 0.03	5.89 \pm 0.10	5.85 \pm 0.22	2.00 \pm 0.04	0.94 \pm 0.10	21.66 \pm 1.81	74.81 \pm 6.19
MS1	Mingshui1	125.90°E	47.19°N	268.30	0.43 \pm 0.03	0.36 \pm 0.01	0.80 \pm 0.03	6.12 \pm 0.11	4.35 \pm 0.03	2.23 \pm 0.07	0.85 \pm 0.03	20.95 \pm 2.44	70.15 \pm 5.98
MS2	Mingshui2	126.16°E	47.14°N	232.60	0.52 \pm 0.02	0.59 \pm 0.01	1.11 \pm 0.02	6.54 \pm 0.05	4.15 \pm 0.04	1.90 \pm 0.06	0.55 \pm 0.02	17.87 \pm 3.33	58.54 \pm 6.19
QA2	Qingan2	127.49°E	46.85°N	191.59	0.46 \pm 0.03	0.52 \pm 0.02	0.98 \pm 0.03	5.90 \pm 0.46	4.86 \pm 0.21	1.68 \pm 0.01	0.72 \pm 0.03	14.97 \pm 1.77	42.60 \pm 7.37
WK1	Wangkui1	126.57°E	46.76°N	150.40	0.47 \pm 0.02	0.46 \pm 0.01	0.94 \pm 0.03	6.57 \pm 0.09	4.41 \pm 0.12	2.15 \pm 0.12	0.70 \pm 0.11	17.87 \pm 1.20	67.21 \pm 8.54
SH1	Suihua1	127.02°E	46.67°N	188.20	0.44 \pm 0.04	0.50 \pm 0.02	0.93 \pm 0.03	6.08 \pm 0.09	3.90 \pm 0.30	1.36 \pm 0.11	0.68 \pm 0.05	20.51 \pm 3.52	49.31 \pm 3.80
LX2	Lanxi2	126.41°E	46.25°N	136.70	0.36 \pm 0.05	0.37 \pm 0.04	0.73 \pm 0.08	6.69 \pm 0.10	2.20 \pm 0.47	1.14 \pm 0.24	0.56 \pm 0.06	11.07 \pm 3.43	49.18 \pm 10.83
BY1	Bayan1	126.79°E	46.18°N	164.16	0.44 \pm 0.02	0.48 \pm 0.01	0.92 \pm 0.03	5.89 \pm 0.07	4.22 \pm 0.26	1.68 \pm 0.08	0.70 \pm 0.03	25.03 \pm 3.31	62.87 \pm 5.06
ZD1	Zhaodong1	126.07°E	46.11°N	152.84	0.39 \pm 0.01	0.44 \pm 0.02	0.83 \pm 0.03	7.91 \pm 0.14	4.47 \pm 0.11	2.40 \pm 0.07	0.87 \pm 0.12	23.11 \pm 1.18	21.56 \pm 2.00
HRB1	Harbin1	126.45°E	45.51°N	184.20	0.35 \pm 0.04	0.42 \pm 0.01	0.77 \pm 0.03	6.48 \pm 0.11	2.99 \pm 0.15	1.49 \pm 0.09	0.61 \pm 0.06	19.08 \pm 3.20	58.67 \pm 6.42
HRB2	Harbin2	126.40°E	45.47°N	214.82	0.38 \pm 0.04	0.46 \pm 0.01	0.84 \pm 0.05	6.66 \pm 0.10	3.63 \pm 0.13	1.74 \pm 0.04	0.52 \pm 0.04	17.24 \pm 2.18	71.28 \pm 3.84
AC2	Acheng2	126.97°E	45.43°N	164.91	0.34 \pm 0.02	0.38 \pm 0.01	0.72 \pm 0.03	6.43 \pm 0.09	2.90 \pm 0.30	1.26 \pm 0.23	0.59 \pm 0.02	17.13 \pm 2.48	39.65 \pm 7.60
FY2	Fuyu2	126.18°E	45.13°N	184.10	0.37 \pm 0.02	0.46 \pm 0.02	0.83 \pm 0.03	6.12 \pm 0.13	2.46 \pm 0.19	1.25 \pm 0.05	0.54 \pm 0.16	18.64 \pm 5.57	51.67 \pm 15.28
FY1	Fuyu1	126.08°E	44.95°N	197.80	0.41 \pm 0.04	0.35 \pm 0.02	0.76 \pm 0.04	5.88 \pm 0.09	2.71 \pm 0.21	1.35 \pm 0.17	0.60 \pm 0.08	22.59 \pm 6.76	65.00 \pm 11.00
WC1	Wuchang1	127.03°E	44.90°N	209.00	0.35 \pm 0.02	0.46 \pm 0.02	0.81 \pm 0.01	6.28 \pm 0.29	3.94 \pm 0.22	1.74 \pm 0.05	1.16 \pm 0.09	22.21 \pm 3.15	60.92 \pm 6.52

YS2	Yushu2	126.58°E	44.86°N	226.06	0.40±0.01	0.43±0	0.83±0.01	5.97±0.24	3.29±0.16	1.37±0.05	0.67±0.07	24.18±4.25	62.72±5.53
DH1	Dehui1	125.82°E	44.58°N	191.86	0.44±0.03	0.51±0.04	0.95±0.07	5.70±0.14	3.31±0.07	1.61±0.11	0.71±0.20	21.66±1.18	59.17±8.34
NAN2	Nongan2	125.24°E	44.43°N	195.09	0.37±0.02	0.33±0.02	0.70±0.04	8.08±0.12	2.70±0.21	1.48±0.12	0.81±0.09	16.45±1.75	14.24±2.17
SLA2	Shulan2	126.96°E	44.38°N	275.90	0.34±0.01	0.43±0.02	0.77±0.03	5.68±0.21	3.71±0.29	1.55±0.08	0.85±0.17	27.55±5.86	73.08±18.44
JL2	Jilin2	126.56°E	44.06°N	203.75	0.35±0.01	0.35±0.01	0.70±0.01	5.30±0.52	3.08±0.34	1.18±0.10	0.83±0.10	21.85±1.77	46.41±5.17
CC2	Changchun2	125.40°E	44.00°N	218.51	0.33±0.07	0.46±0.05	0.80±0.11	7.18±0.09	3.31±0.13	1.22±0.07	0.46±0.01	19.21±1.14	40.51±8.34
CC1	Changchun1	125.40°E	44.00°N	218.51	0.24±0.02	0.44±0.04	0.68±0.05	7.15±0.09	4.16±0.28	1.57±0.10	0.61±0.11	22.21±2.32	29.14±3.17
YJ1	Yongji1	126.42°E	43.66°N	271.86	0.33±0.02	0.29±0.01	0.62±0.02	5.43±0.04	2.29±0.15	0.99±0.01	0.72±0.01	29.80±5.87	32.11±1.90
GZL1	Gongzhuling1	124.83°E	43.49°N	255.83	0.33±0.01	0.40±0.01	0.73±0.02	6.36±0.41	2.29±0.29	0.83±0.12	0.36±0.08	18.81±2.04	34.32±7.38
YT1	Yitong1	125.27°E	43.34°N	287.36	0.33±0.05	0.40±0.01	0.73±0.06	5.58±0.11	2.88±0.29	1.14±0.17	0.65±0.13	27.75±3.18	50.55±11.03
LS1	Lishu1	124.40°E	43.29°N	208.71	0.40±0.03	0.29±0.01	0.69±0.04	5.76±0.15	2.57±0.13	1.17±0.04	0.62±0.08	26.65±2.35	74.53±11.96
SP1	Siping1	124.32°E	43.10°N	190.81	0.36±0.01	0.23±0.01	0.60±0.02	5.64±0.10	2.43±0.18	1.06±0.08	0.54±0.06	32.71±4.66	77.84±6.37
DL1	Dongliao1	125.05°E	42.90°N	279.65	0.35±0.02	0.41±0.01	0.76±0.01	5.14±0.19	2.75±0.26	1.23±0.09	0.87±0.12	24.43±5.56	55.68±22.09
CT2	Changtu2	124.13°E	42.84°N	172.27	0.35±0.05	0.47±0.02	0.82±0.07	6.71±0.07	3.37±0.48	1.28±0.21	0.47±0.05	16.39±0.88	32.00±3.39

EE-GRSP, easily extractable glomalin-related soil protein; DE-GRSP, difficultly extractable glomalin-related soil protein; T-GRSP, total glomalin-related soil protein; SOM, soil

organic matter; ACP, acid phosphatase.

Table S2 Descriptive statistical parameters of different variables from 164 samples in black soil of northeast China.

Variable	Minimum	Maximum	Mean	SD	CV (%)
Longitude (°E)	124.13	127.49	126.00	0.82	0.654
Latitude (°N)	42.84	49.18	45.93	1.89	4.121
Altitude (m)	136.70	321.99	227.31	49.64	21.839
EE-GRSP(mg/g)	0.22	0.55	0.40	0.07	16.597
DE-GRSP (mg/g)	0.22	0.65	0.44	0.09	19.890
T-GRSP (mg/g)	0.57	1.17	0.84	0.13	15.954
pH	4.92	8.20	6.28	0.62	9.935
SOM (%)	1.75	6.67	3.75	1.05	28.003
Total N (g/kg)	0.68	3.12	1.67	0.48	28.971
Total P (g/kg)	0.29	1.29	0.71	0.19	26.520
Urease (mg/g)	6.96	39.43	19.97	5.80	29.058
ACP (mg/g)	11.77	114.63	60.76	21.91	36.058

SD, standard deviation; CV, coefficient of variation; EE-GRSP, easily extractable glomalin-related soil protein; DE-GRSP, difficultly extractable glomalin-related soil protein; T-GRSP, total glomalin-related soil protein; SOM, soil organic matter; ACP, acid phosphatase.

Table S3 Pearson's correlation coefficients among different edaphic variables. Pearson's correlation was calculated from 164 samples at 41 sampling sites.

Variable	EE-GRSP	DE-GRSP	T-GRSP	pH	SOM	Total N	Total P	Urease
DE-GRSP	0.513**							
T-GRSP	0.830**	0.904**						
pH	-0.082	0.073	0.007					
SOM	0.569**	0.638**	0.697**	0.057				
Total N	0.600**	0.452**	0.591**	0.224**	0.856**			
Total P	0.306**	0.237**	0.306**	-0.176*	0.549**	0.561**		
Urease	-0.268**	-0.268**	-0.308**	-0.364**	-0.200*	-0.261**	-0.016	
ACP	0.468**	0.161*	0.337**	-0.305**	0.495**	0.529**	0.221**	0

EE-GRSP, easily extractable glomalin-related soil protein; DE-GRSP, difficultly extractable glomalin-related soil protein; T-GRSP, total glomalin-related soil protein; SOM, soil organic matter; ACP, acid phosphatase. * $P < 0.05$; ** $P < 0.01$.