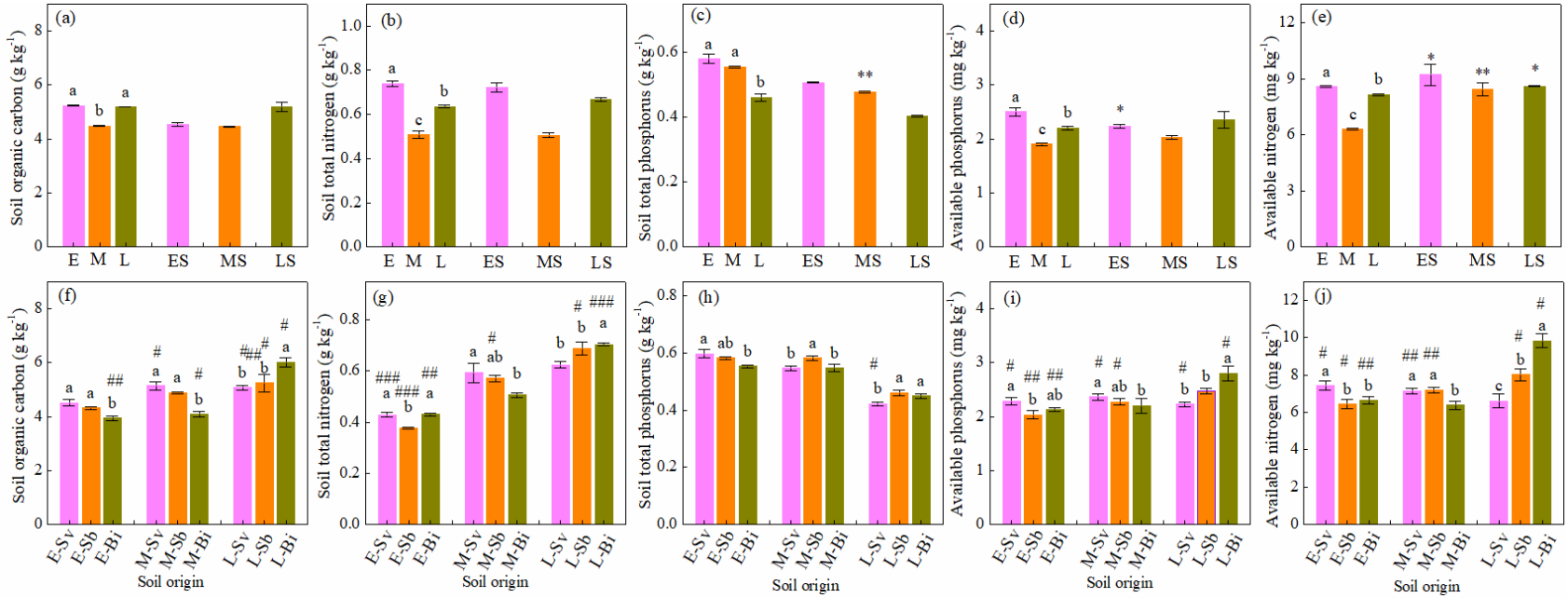

Fig. **S1** Mean (± SE) (n = 5) of soil chemical properties before the first (a-e) and second (f-j) experiments. Notes: E, soil of early- species. M, soil of mid- species. L, soil of late- species. ES, sterilized soil of early- species. MS, sterilized soil of mid- species. LS, sterilized soil of late- species. L-Bi, L-Sb, and L-Sv represent soils after late- species *Bothriochloa ischaemum* (Bi), mid- species *Stipa bungeana* (Sb), and early- species *Setaria viridis* (Sv) were grown in the soil of late- species (L). M-Bi, M-Sb, and M-Sv represent soils after Bi, Sb, and Sv were grown in the soil of mid- species (M). E-Bi, E-Sb, and E-Sv represent soils after Bi, Sb, and Sv were grown in the soil of early- species (E). Different letters indicate significant differences of the soil chemical index among groups based on Duncan's post hoc test ($P < 0.05$). * and ** indicate significant differences between non-sterilized and sterilized field soils at $P < 0.05$ and $P < 0.01$, respectively, based on the t-test. #, ##, and ### indicate significant differences between soils of the first and second growth periods at $P < 0.05$, $P < 0.01$, and $P < 0.001$, respectively, based on the t-test.

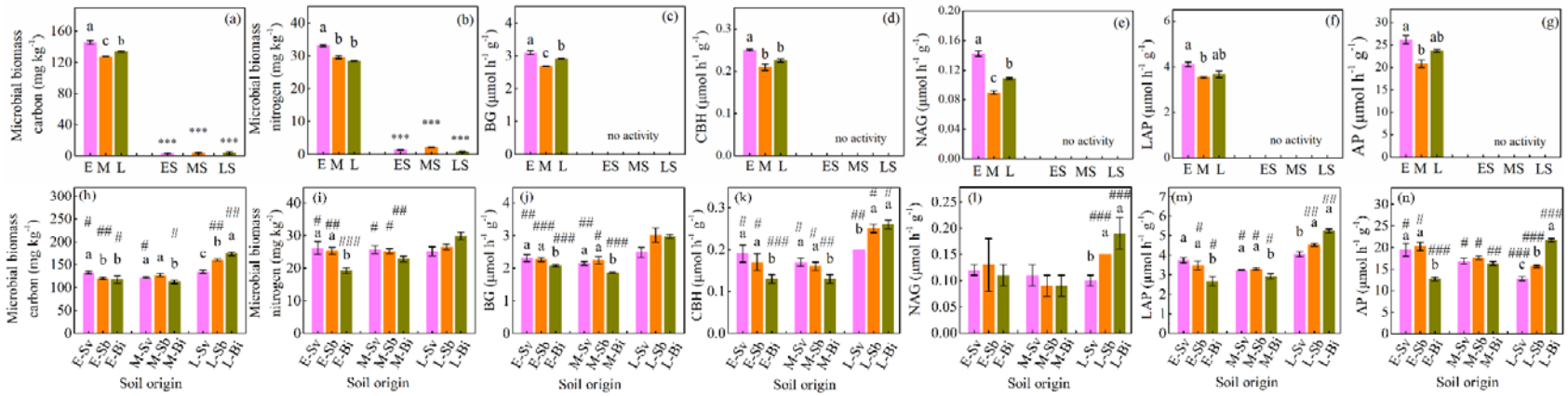

Fig. **S2** Mean (± SE) (n = 5) of the soil biological properties before the first (a–g) and second (h–n) experiments. Notes: E, soil of early- species. M, soil of mid- species. L, soil of late- species. ES, sterilized soil of early- species. MS, sterilized soil of mid- species. LS, sterilized soil of late- species. L-Bi, L-Sb, and L-Sv represent soils after late- species *Bothriochloa ischaemum* (Bi), mid- species *Stipa bungeana* (Sb), and early- species *Setaria viridis* (Sv) were grown in the soil of later- species (L). M-Bi, M-Sb, and M-Sv represent soils after Bi, Sb, and Sv were grown in the soil of mid- species (M). E-Bi, E-Sb, and E-Sv represent soils after Bi, Sb, and Sv were grown in the soil of early- species (E). BG, β-1, 4-glucosidase. CBH, β-D-cellobiosidase. NAG, β-1, 4-N-acetylglucosaminidase. LAP, L-leucine aminopeptidase. AP, acid phosphatase. No enzyme activity was detected in any of the sterilized soil samples in the library analyses. Different letters indicate significant differences of the soil biological properties index among groups based on Duncan's post hoc test ($P < 0.05$). * and ** indicate significant differences between non-sterilized and sterilized field soils at $P < 0.05$ and $P < 0.01$, respectively, based on the t-test. #, ##, and ### indicate significant differences between the soils of the first and second growth periods at $P < 0.05$, $P < 0.01$, and $P < 0.001$, respectively, based on the t-test.

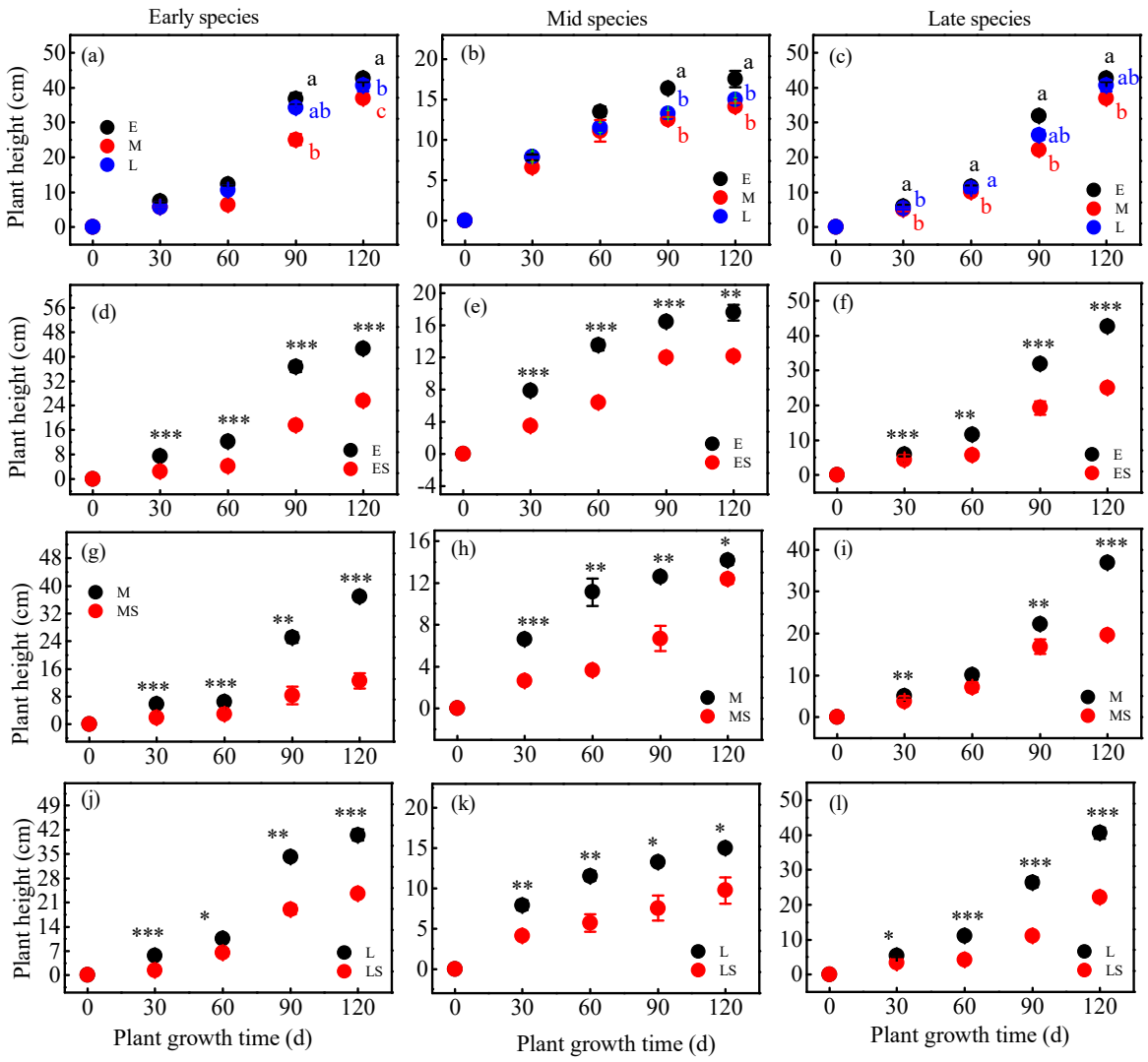

Fig. S3 Plant height of early-, mid-, and late- species on "own" and "foreign" field soils. Notes: E, soil of early- species. M, soil of mid- species. L, soil of late- species. ES, sterilized soil of early- species. MS, sterilized soil of mid- species. LS, sterilized soil of late- species. Different letters indicate significant differences in plant height between soil of different origins for the same plant growth period based on Duncan's post hoc test ($P < 0.05$). *, **, and *** indicate significant differences for non-sterilized and sterilized soil at $P < 0.05$, $P < 0.01$, and $P < 0.001$, respectively, based on the t-test.

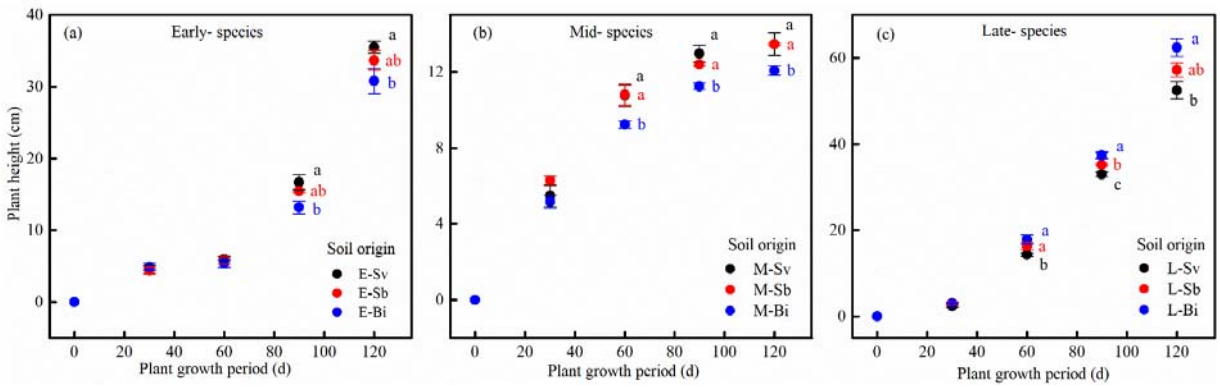

Fig. S4 Plant height of late-, mid-, and early- species on "own" and "foreign" soils. Notes: E-Bi, E-Sb, and E-Sv represent soil conditioned by monocultures of late- species *Bothriochloa ischaemum* (Bi), mid- species *Stipa bungeana* (Sb), and early- species *Setaria viridis* (Sv) in the soil of early- species (E). M-Bi, M-Sb, and M-Sv represent soil conditioned by monocultures of Bi, Sb, and Sv in the soil of mid- species (M). L-Bi, L-Sb, and L-Sv represent soil conditioned by monocultures of Bi, Sb, and Sv in the soil of late- species (L). Different letters indicate significant differences to plant height between soil of different origins for the same plant growth period based on Duncan's post hoc test ($P < 0.05$).

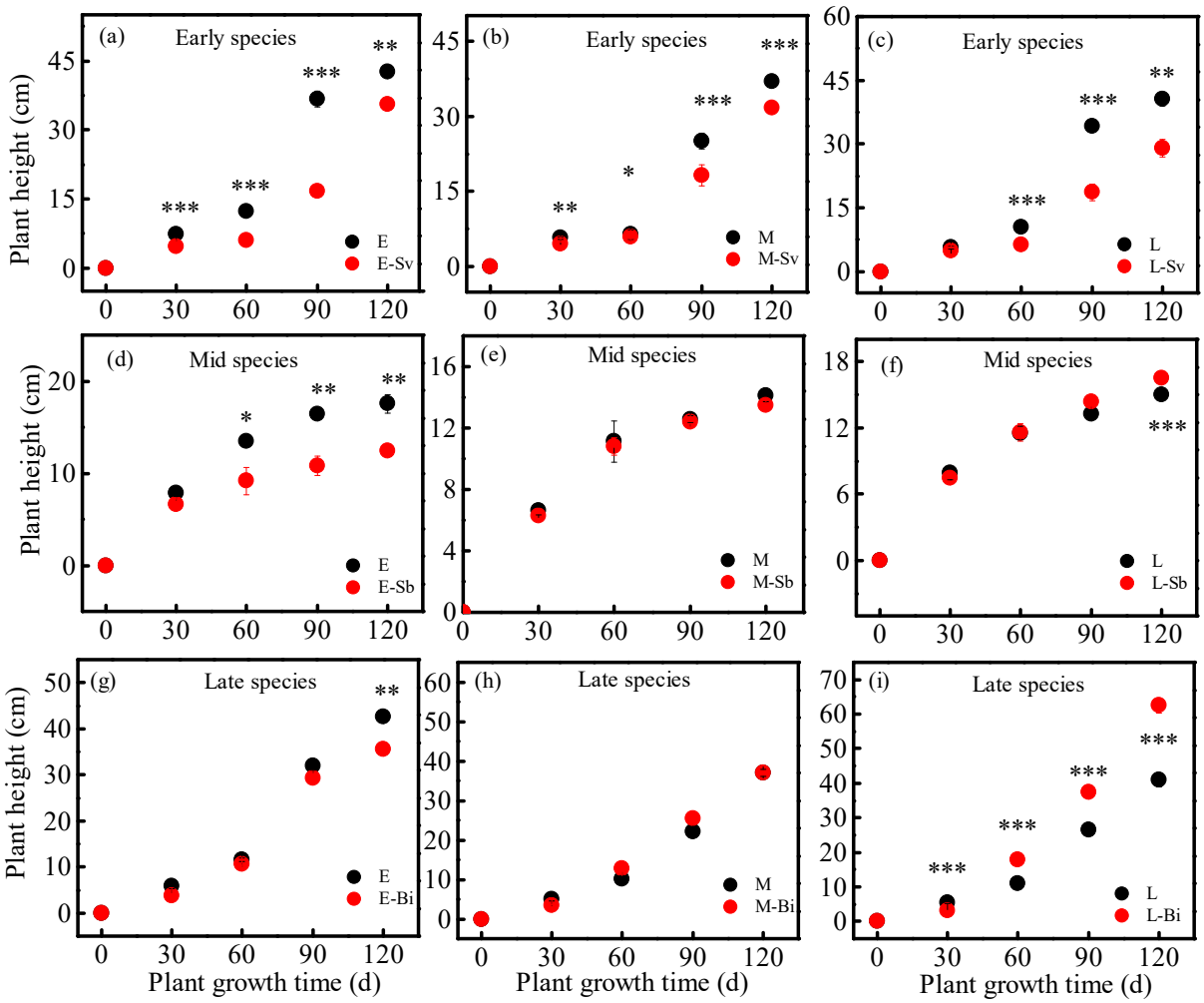

Fig. S5 Plant height of late-, mid-, and early- species during two growth periods. Notes: E-Bi, E-Sb, and E-Sv represent soil conditioned by monocultures of late- species *Bothriochloa ischaemum* (Bi), mid- species *Stipa bungeana* (Sb), and early- species *Setaria viridis* (Sv) in the soil of early- species (E). M-Bi, M-Sb, and M-Sv represent soil conditioned by monocultures of Bi, Sb, and Sv in the soil of mid- species (M). L-Bi, L-Sb, and L-Sv represent soil conditioned by monocultures of Bi, Sb, and Sv in the soil of late- species (L). Different letters indicate significant differences to plant height between soils of different origin for the same plant growth period based on Duncan's post hoc test ($P < 0.05$).

Tables

Table S1 Enzymes included in this study.

Enzymes	Abbreviation	Substrate	Function
β-1,4-glucosidase	BG	4-MUB-β-D-glucoside	C-acquiring enzyme
β-D-Cellobiosidase	CBH	4-MUB-β-D-cellobioside	C-acquiring enzyme
β-1,4-N-Acetylglucosaminidase	NAG	4-MUB-N-acetyl-β-D-glucosaminide	N-acquiring enzymes
L-Leucine aminopeptidase	LAP	L-Leucine-7-amino-4-methylcoumarin	N-acquiring enzymes
Acid phosphatase	AP	4-MUB-phosphate disodium salt	P-acquiring activity

Table S2 Mean (± SE) of plant carbon, nitrogen, and phosphorus concentrations of the three species planted in soils of different origin in Experiment 1.

Species	Soil origin	Shoot carbon ($g\ kg^{-1}$)	Root carbon ($g\ kg^{-1}$)	Shoot nitrogen ($g\ kg^{-1}$)	Root nitrogen ($g\ kg^{-1}$)	Shoot phosphorus ($g\ kg^{-1}$)	Root phosphorus ($g\ kg^{-1}$)
Early-	E	402.31±4.61a	348.64±4.10	10.85±0.56a	8.56±0.29a	0.51±0.01c	0.47±0.01
	M	354.30±9.31b	335.94±4.86	7.16±0.73b	6.40±0.05b	0.81±0.03a	0.27±0.09
	L	387.10±5.72a	349.84±4.97	8.23±0.11b	8.06±0.12a	0.72±0.03b	0.38±0.05
	ES	378.17±5.25**	312.02±3.40***	6.06±0.51***	6.06±0.05**	0.49±0.03	0.27±0.04**
	MS	365.02±6.99	338.16±2.35	6.11±0.16	2.96±0.08*	1.13±0.06**	0.41±0.04
	LS	343.30±7.22**	366.56±4.87*	6.14±0.39**	2.41±0.15***	0.97±0.13	0.31±0.01
Mid-	E	435.16±6.98a	361.39±4.43a	8.36±0.15a	8.36±0.15	1.16±0.02	0.36±0.02
	M	369.63±1.93c	321.94±2.74b	7.71±0.10b	8.37±0.38	1.04±0.04	0.43±0.09
	L	391.45±0.85b	299.47±9.03c	7.69±0.11b	7.88±0.20	0.98±0.11	0.45±0.05
	ES	349.31±3.94***	316.18±5.16***	6.92±0.75*	5.72±0.21***	0.53±0.03***	0.34±0.01
	MS	399.59±10.67*	332.62±4.40	6.98±0.56	6.09±0.57*	1.02±0.11	0.57±0.02
	LS	404.66±1.64***	339.13±9.93*	8.11±0.27	7.27±0.29	0.85±0.02	0.55±0.02
Late-	E	394.81±2.45a	386.79±0.74a	9.72±0.54a	8.34±0.66a	0.81±0.02	0.62±0.01a
	M	379.30±2.73b	374.70±3.84b	6.93±0.30b	6.29±0.32b	0.83±0.05	0.46±0.01b
	L	400.02±4.19a	392.36±3.79a	8.69±0.09a	7.66±0.41ab	0.79±0.02	0.57±0.04a
	ES	388.08±12.63	372.19±2.13**	4.15±0.28***	4.59±0.74**	0.38±0.02***	0.32±0.01***
	MS	410.64±9.74*	380.09±2.8	4.65±0.48**	2.17±0.08***	0.54±0.03**	0.41±0.01*
	LS	369.74±10.20*	405.43±5.63	6.82±0.61*	3.16±0.43***	0.63±0.09	0.40±0.04*

Notes: E, early- species soil. M, mid- species soil. L, late- species soil. ES, sterilized soil of early- species soil. MS, sterilized soil of mid- species soil. LS, sterilized soil of late- species soil. Different letters indicate significant differences among groups based on Duncan's post hoc test ($P < 0.05$). *, **, and *** indicate significant differences between non-sterilized and sterilized field soils at $P < 0.05$, $P < 0.01$, and $P < 0.001$, respectively, based on the t-test.

Table S3 Mean (± SE) of plant carbon, nitrogen, and phosphorus concentrations of the three species planted in soils of different origin in Experiment 2.

Species	Soil origin	Shoot carbon ($g\ kg^{-1}$)	Root carbon ($g\ kg^{-1}$)	Shoot nitrogen ($g\ kg^{-1}$)	Root nitrogen ($g\ kg^{-1}$)	Shoot phosphorus ($g\ kg^{-1}$)	Root phosphorus ($g\ kg^{-1}$)
Early-	E- Sv	376.20±4.64a	333.16±1.86a	6.94±0.79	3.60±0.53a	0.57±0.01a	0.36±0.02a
	E- Sb	358.39±4.30b	291.96±3.87c	5.83±0.61	2.04±0.13b	0.43±0.03b	0.30±0.02b
	E- Bi	358.52±5.95b	309.97±2.29b	5.54±0.24	2.37±0.37b	0.54±0.06ab	0.25±0.00c
Mid-	M- Sv	363.41±2.34a	325.54±0.69a	7.69±0.10a	6.72±0.19	0.47±0.05	0.47±0.01
	M- Sb	346.60±2.11b	315.68±6.21a	7.24±0.09b	6.74±0.37	0.51±0.06	0.47±0.01
	M- Bi	321.24±4.81c	277.55±8.08b	5.67±0.18c	6.62±0.40	0.46±0.05	0.44±0.02
Late-	L-Sv	439.91±3.29b	364.06±6.48b	7.47±0.21c	7.18±0.13c	0.32±0.03b	0.21±0.02c
	L-Sb	446.48±3.04ab	378.43±5.23ab	8.49±0.09b	7.87±0.06b	0.37±0.03ab	0.24±0.01b
	L-Bi	453.77±3.02a	393.68±7.34a	9.45±0.21a	8.67±0.12a	0.46±0.03a	0.29±0.01a

Notes: L-Bi, L-Sb, and L-Sv were soils created after late- species *Bothriochloa ischaemum* (Bi), mid- species *Stipa bungeana* (Sb), and early- species *Setaria viridis* (Sv) were grown in the soil of late- species (L). M-Bi, M-Sb, and M-Sv were soils that were created after Bi, Sb, and Sv were grown in the soil of mid- species (M). E-Bi, E-Sb, and E-Sv were soils that were created after Bi, Sb, and Sv were grown in the soil of early- species (E). Different letters indicate significant differences among groups based on Duncan's post hoc test ($P < 0.05$).

Table S4 Mean (± SE) of plant carbon, nitrogen, and phosphorus concentrations of the three species planted in soil of different origins in the first and second growth periods.

Species	Soil origin	Shoot carbon ($g\ kg^{-1}$)	Root carbon ($g\ kg^{-1}$)	Shoot nitrogen ($g\ kg^{-1}$)	Root nitrogen ($g\ kg^{-1}$)	Shoot phosphorus ($g\ kg^{-1}$)	Root phosphorus ($g\ kg^{-1}$)
Early-	E	402.31±4.61**	348.64±4.10**	10.85±0.56**	8.56±0.29***	0.51±0.01***	0.47±0.01**
	E- Sv	376.20±4.64	333.16±1.86	6.94±0.79	3.60±0.53	0.57±0.01	0.36±0.02
Mid-	E	435.16±6.98*	361.39±4.43***	8.36±0.15**	8.36±0.15***	1.16±0.02***	0.36±0.02**
	E- Sb	377.05±3.84	334.47±7.87	9.75±0.24	6.20±0.21	0.69±0.06	0.44±0.01
Late-	E	394.81±2.45**	386.79±0.74	9.72±0.54	8.34±0.66*	0.81±0.02***	0.62±0.01***
	E- Bi	412.58±3.34	380.70±4.99	8.66±0.08	6.12±0.19	0.33±0.05	0.28±0.03
Early-	M	354.30±9.31*	335.94±4.86***	7.16±0.73	6.40±0.05***	0.81±0.03***	0.27±0.09
	M- Sv	322.45±5.60	217.71±6.22	6.98±0.34	2.14±0.14	0.20±0.03	0.28±0.01
Mid-	M	369.63±1.93***	321.94±2.74	7.71±0.10**	8.37±0.38*	1.04±0.04***	0.43±0.09
	M- Sb	346.60±2.11	315.68±6.21	7.24±0.09	6.74±0.37	0.51±0.06	0.47±0.01
Late-	M	379.30±2.73**	374.70±3.84**	6.93±0.30	6.29±0.32	0.83±0.05***	0.46±0.01
	M- Bi	451.49±9.69	400.77±5.62	7.52±0.25	6.82±0.12	0.41±0.02	0.44±0.07
Early-	L	387.10±5.72*	349.84±4.97**	8.23±0.11**	8.06±0.12***	0.72±0.03***	0.38±0.05*
	L-Sv	363.49±5.98	323.63±2.69	7.01±0.21	2.85±0.12	0.37±0.00	0.24±0.01
Mid-	L	391.45±0.85***	299.47±9.03	7.69±0.11**	7.88±0.20	0.98±0.11*	0.45±0.05
	L-Sb	371.95±3.04	292.19±1.57	10.98±0.74	8.72±0.30	0.66±0.08	0.50±0.02
Late-	L	400.02±4.19***	392.36±3.79	8.69±0.09*	7.66±0.41*	0.79±0.02***	0.57±0.04**
	L-Bi	453.77±3.02	393.68±7.34	9.45±0.21	8.67±0.12	0.46±0.03	0.29±0.01

Notes: E, early- species soil. M, mid- species soil. L, late- species soil. L-Bi, L-Sb, and L-Sv were soils created after late- species *Bothriochloa ischaemum* (Bi), mid- species *Stipa bungeana* (Sb), and early- species *Setaria viridis* (Sv) were grown in the soil of late-species (L). M-Bi, M-Sb, and M-Sv were soils that were created after Bi, Sb, and Sv were grown in the soil of mid late- species (M). E-Bi, E-Sb, and E-Sv were soils that were created after Bi, Sb, and Sv were grown in the soil of early late- species (E). Different letters indicate significant differences among groups based on Duncan's post hoc test ($P < 0.05$).