

Supplement of Biogeosciences, 16, 3333–3349, 2019  
<https://doi.org/10.5194/bg-16-3333-2019-supplement>  
© Author(s) 2019. This work is distributed under  
the Creative Commons Attribution 4.0 License.



*Supplement of*

## **Plant functional traits determine latitudinal variations in soil microbial function: evidence from forests in China**

**Zhiwei Xu et al.**

*Correspondence to:* Guirui Yu ([yugr@igsnr.ac.cn](mailto:yugr@igsnr.ac.cn)) and Qiufeng Wang ([qfwang@igsnr.ac.cn](mailto:qfwang@igsnr.ac.cn))

The copyright of individual parts of the supplement might differ from the CC BY 4.0 License.

Table S1 Average values of forest soil enzyme activity and different group of PLFAs along the NSTEC.

Sampling	Enzyme activities					PLFAs						
	site	BG	NAG	LAP	AP	tPLFA	Bacteria	Fungi	Acti-	F/B	G <sup>+</sup>	G <sup>-</sup>
HZ	244±8.6	111±5.5	41±0.8	459±5.0	17.7±1.2	9.4 ±0.4	0.9±0.1	0.4±0.2	0.09 ±0.01	4.5±0.4	4.23±0.2	1.4±0.1
LS	203±12.0	68±6.6	60±0.8	3297±17.5	16.8±1.2	7.9±0.4	0.6±0.1	0.5±0.4	0.06±0.01	4.5±0.4	2.88±0.1	1.6±0.1
CB	520±52.3	115±2.4	545±15.5	1213±90.6	22.2±1.9	12.3± 1.0	0.4±0.1	0.8±0.1	0.05±0.02	7.3± 0.4	3.21±0.9	1.6±0.1
DL	266±2.5	122±12.9	101±10.9	407±6.9	13.5±0.9	5.4±0.7	2.4±0.3	0.3±0.3	0.36±0.02	3.52±0.3	1.92±0.1	2.1±0.1
TY	267±21.9	189±2.4	367±11.1	356±41.0	8.0±0.3	3.7±0.1	0.3±0.1	0.2±0.1	0.07±0.01	1.85±0.1	1.53±0.1	1.2±0.1
SN	163±10.7	70±3.6	111±1.3	239±8.6	12.2±0.5	6.2±0.3	0.3±0.1	0.3±0.1	0.05±0.01	3.02±0.1	2.76±0.2	1.1±0.1
JL	67±4.3	35±0.5	83±2.9	845±33.2	9.8±0.8	4.2±0.2	0.7±0.3	0.3±0.1	0.15±0.04	3.17±0.2	1.18±0.4	3.1±1.0
DH	71±0.4	20±1.2	81±0.4	1075±13.6	10.0±0.5	5.6±0.2	0.9±0.1	0.3±0.1	0.16±0.01	3.75±0.2	1.46±0.1	2.5±0.6
JF	37±3.4	14±3.1	77±1.4	656±40.5	7.9±1.2	4.4±0.5	0.6± 0.3	0.3±0.1	0.11±0.05	3.16±0.4	1.68±0.1	2.2±0.1

All values are presented as means±SE (n=4). The enzyme activity (nmol·h<sup>-1</sup> g<sup>-1</sup> dry soil) and PLFAs (nmol·g<sup>-1</sup> dry soil). C acquisition is represented by β-1,4-glucosidase (BG); N acquisition is measured by the potential activities of β-1,4-N-acetylglucosaminidase (NAG) and leucine aminopeptidase (LAP); P acquisition is measured as acid (alkaline) phosphatase (AP) activity. tPLFA, total PLFAs, Acti-, actinomycetes, F/B, fungi/bacteria; G<sup>+</sup>/G<sup>-</sup>, Gram-positive bacteria/ Gram-negative bacteria. The abbreviations of the sampling sites were showed in table 1.

**Table S2** The plant diversity and community weighted means of plant functional traits

Sites	H'	LDMC (mg g <sup>-1</sup> )	SLA (m <sup>2</sup> kg <sup>-1</sup> )	Leaf C (g kg <sup>-1</sup> )	Leaf N (g kg <sup>-1</sup> )
HZ	0.53	365.6	8.5	487.5	19.4
LS	2.05	345.5	12.1	441.6	18.5
CB	2.14	287.8	18.5	108.7	6.12
DL	2.74	408.1	11.3	447.6	25.1
TY	1.01	421.6	9.5	494.0	19.5
SN	2.61	289.8	8.7	332.7	13.5
JL	2.73	359.3	6.2	392.6	14.2
DH	2.09	412.2	6.4	463.1	16.2
JF	4.08	nd	nd	nd	nd

H': the diversity of the tree species; LDMC: the oven-dried mass of a leaf divided by its water-saturated fresh mass, SLA: the one-sided area of a fresh leaf divided by its oven-dried mass; Leaf C: Leaf carbon concentration; Leaf N: Leaf nitrogen concentration. nd: none detected. The abbreviations of the sampling sites were showed in table 1.

**Table S3** The soil organic matter (SOM) decomposition rates during the 28 days of incubation time (Mean±SE) ( $\mu\text{gC}\cdot\text{g}^{-1}\text{d}^{-1}$ )

Sites	1d	7d	14d	21d	28d	Average
HZ	3.23±0.24c	4.69±0.27a	3.40±0.17b	3.64±0.03a	2.19±0.13b	3.43±0.09b
LS	6.17±0.19a	4.60±0.44a	4.97±0.17a	3.83±0.17a	3.47±0.02a	4.61±0.14a
CB	3.74±0.13b	4.27±0.23b	3.36±0.13b	4.11±0.09a	3.41±0.43a	3.78±0.14b
DL	2.82±0.13d	2.66±0.08c	1.96±0.04c	2.38±0.02c	2.10±0.12b	2.38±0.05d
TY	3.92±0.27b	3.87±0.20b	3.75±0.36b	3.77±0.04a	3.50±0.06a	3.76±0.04b
SN	6.36±0.19a	5.36±0.24a	3.87±0.08b	3.19±0.16b	2.56±0.14b	4.27±0.10a
JL	2.88±0.08d	2.29±0.09c	2.40±0.08c	2.70±0.08c	1.82±0.03c	2.42±0.04d
DH	0.74±0.05e	0.58±0.06d	0.33±0.01d	1.03±0.12d	0.53±0.07e	0.64±0.04f
JF	2.21±0.06d	1.71±0.20c	1.72±0.29c	3.14±0.09b	1.30±0.03d	2.02±0.11e

Data labeled with different letters indicated soil organic matter (SOM) decomposition rates were significantly different at  $P < 0.01$ . The abbreviations of the sampling sites were given in the Table 1.

**Table S4** Path analysis of environmental variables to soil microbial use of carbohydrates source

Variables	Direct effect	Indirect effect											
		MAT	MAP	ST	SMC	Silt	SOC	TN	TP	LDMC	SLA	Leaf N	Leaf C
MAT	2.95		-0.82	<b>-1.82</b>	-0.09	-0.12	-0.01	<b>-0.86</b>	<b>1.04</b>	-0.04	-0.02	-0.18	-0.09
MAP	-0.88	2.77		<b>-1.66</b>	-0.07	0.26	-0.01	<b>-0.73</b>	<b>0.92</b>	0.00	-0.02	-0.45	0.01
ST	-1.94	2.77	-0.76		-0.08	-0.01	-0.01	<b>-0.66</b>	<b>0.93</b>	-0.02	-0.01	-0.24	0.01
SMC	0.28	-1.02	0.22	0.55		0.83	0.01	<b>1.13</b>	<b>-1.40</b>	0.10	-0.03	<b>-1.16</b>	<b>1.04</b>
Silt	1.49	-1.76	0.50	1.37	0.01		0.00	0.34	-0.57	0.01	0.01	0.41	-0.02
SOC	0.02	-0.23	-0.16	0.02	0.15	1.49		0.53	-0.63	0.10	0.00	<b>-1.15</b>	<b>0.57</b>
TN	1.36	-1.95	0.54	1.05	0.20	0.49	0.02		-1.21	0.07	0.03	<b>-0.59</b>	<b>0.65</b>
TP	-1.57	-1.85	0.47	0.93	0.23	0.58	0.02	1.36		0.10	0.03	<b>-0.75</b>	<b>0.86</b>
LDMC	-0.14	-1.95	0.52	1.15	0.25	0.59	0.02	<b>1.18</b>	<b>-1.57</b>		0.03	-0.86	0.91
SLA	0.03	0.82	0.01	-0.32	-0.20	-1.02	-0.01	<b>-0.97</b>	<b>1.09</b>	-0.14		1.01	-0.86
Leaf N	1.41	-1.58	0.51	0.84	-0.22	0.19	0.02	<b>1.19</b>	<b>-1.29</b>	0.07	0.03		0.81
Leaf C	-1.12	-0.38	0.28	0.33	-0.23	-1.21	-0.01	<b>-0.72</b>	<b>0.96</b>	-0.10	-0.01	1.41	

Note: MAT= mean annual temperature; MAP=mean annual precipitation. ST=temperature of 0–10 cm soil; SMC=soil moisture content; Silt=soil silt content; SOC=soil organic carbon; TN=soil total nitrogen; TP=soil total phosphorus. The vegetation data: LDMC=leaf dry matter weight; Leaf C=leaf carbon content; Leaf N=leaf nitrogen content; SLA=specific leaf area.

**Table S5** Path analysis of relevant environmental variables to soil microbial use of carboxylic acids source

Variables	Direct effect	Indirect effect											
		MAT	MAP	ST	SMC	Silt	SOC	TN	TP	LDMC	SLA	Leaf N	Leaf C
MAT	1.86		-0.26	<b>-1.24</b>	-0.06	-0.09	0.08	<b>-0.64</b>	<b>0.70</b>	-0.02	-0.07	-0.08	-0.04
MAP	-0.28	1.74		<b>-1.14</b>	-0.05	0.20	0.07	<b>-0.55</b>	<b>0.62</b>	0.00	-0.07	-0.19	0.00
ST	-1.32	-0.26	-0.24		-0.05	-0.01	0.06	<b>-0.49</b>	<b>0.63</b>	-0.01	-0.05	-0.10	0.00
SMC	0.18	0.46	0.07	0.37		0.63	-0.08	<b>0.85</b>	<b>-0.94</b>	0.06	-0.10	-0.49	0.44
Silt	1.13	-0.11	0.16	0.94	0.01		-0.02	0.26	-0.38	0.01	0.04	0.18	-0.01
SOC	-0.11	-0.09	-0.05	0.01	0.10	1.13		0.40	-0.42	0.06	0.02	<b>-0.49</b>	<b>0.24</b>
TN	1.02	0.08	0.17	0.71	0.13	0.38	-0.11		-0.82	0.04	0.11	<b>-0.25</b>	<b>0.28</b>
TP	-1.06	-0.64	0.15	0.64	0.15	0.44	-0.10	1.02		0.06	0.11	<b>-0.32</b>	<b>0.36</b>
LDMC	-0.09	0.70	0.16	0.78	0.16	0.45	-0.09	<b>0.89</b>	<b>-1.06</b>		0.10	-0.36	0.39
SLA	0.13	-0.02	0.00	-0.22	-0.13	-0.78	0.05	<b>-0.73</b>	<b>0.74</b>	-0.09		0.43	-0.36
Leaf N	0.60	-0.07	0.16	0.57	-0.14	0.14	-0.10	<b>0.89</b>	<b>-0.87</b>	0.04	0.13		0.34
Leaf C	-0.48	-0.08	0.09	0.23	-0.15	-0.92	0.05	<b>-0.54</b>	<b>0.64</b>	-0.06	-0.05	0.60	

Note: MAT= mean annual temperature; MAP=mean annual precipitation. ST=temperature of 0–10 cm soil; SMC=soil moisture content; Silt=soil silt content; SOC=soil organic carbon; TN=soil total nitrogen; TP=soil total phosphorus. The vegetation data: LDMC=leaf dry matter weight; Leaf C=leaf carbon content; Leaf N=leaf nitrogen content; SLA=specific leaf area.

**Table S6** Path analysis of relevant environmental variables to soil microbial use of amino acids source

Variables	Direct	Indirect effect											
	effect	MAT	MAP	ST	SMC	Silt	SOC	TN	TP	LDMC	SLA	Leaf N	Leaf C
MAT	3.18		-0.91	<b>-2.20</b>	0.15	-0.14	0.00	<b>-0.68</b>	<b>0.72</b>	0.04	0.02	-0.11	-0.09
MAP	-0.98	2.98		<b>-2.02</b>	0.11	0.32	0.00	<b>-0.58</b>	<b>0.64</b>	0.00	0.02	-0.29	0.01
ST	-2.35	2.98	-0.84		0.12	-0.02	0.00	<b>-0.52</b>	<b>0.64</b>	0.03	0.02	-0.15	0.01
SMC	-0.43	-1.09	0.25	0.66		1.00	0.01	<b>0.90</b>	<b>-0.97</b>	-0.11	0.03	<b>-0.74</b>	<b>1.04</b>
Silt	1.80	-1.89	0.56	1.67	-0.02		0.00	0.27	-0.39	-0.02	-0.01	0.26	-0.02
SOC	0.01	-0.25	-0.17	0.02	-0.24	1.80		0.42	-0.43	-0.11	-0.01	<b>-0.73</b>	<b>0.57</b>
TN	1.08	-2.09	0.60	1.27	-0.32	0.60	0.01		-0.84	-0.08	-0.03	<b>-0.37</b>	<b>0.65</b>
TP	-1.09	-1.99	0.52	1.13	-0.36	0.70	0.01	1.08		-0.11	-0.03	<b>-0.48</b>	<b>0.86</b>
LDMC	0.16	-2.10	0.57	1.39	-0.39	0.72	0.01	<b>0.94</b>	<b>-1.09</b>		-0.03	-0.55	0.91
SLA	-0.04	0.88	0.01	-0.38	0.31	-1.24	0.00	<b>-0.77</b>	<b>0.75</b>	0.16		0.65	-0.87
Leaf N	0.90	-1.70	0.57	1.02	0.35	0.23	0.01	<b>0.94</b>	<b>-0.89</b>	-0.08	-0.04		0.81
Leaf C	-1.13	-0.40	0.31	0.40	0.36	-1.46	0.00	<b>-0.57</b>	<b>0.66</b>	0.12	0.02	0.90	

Note: MAT= mean annual temperature; MAP=mean annual precipitation. ST=temperature of 0–10 cm soil; SMC=soil moisture content; Silt=soil silt content; SOC=soil organic carbon; TN=soil total nitrogen; TP=soil total phosphorus. The vegetation data: LDMC=leaf dry matter weight; Leaf C=leaf carbon content; Leaf N=leaf nitrogen content; SLA=specific leaf area.

**Table S7** Path analysis of relevant environmental variables to soil microbial use of polymers source

Variables	Direct effect	Indirect effect											
		MAT	MAP	ST	SMC	Silt	SOC	TN	TP	LDMC	SLA	Leaf N	Leaf C
MAT	3.34		-0.44	<b>-2.70</b>	0.05	-0.13	0.24	<b>-1.15</b>	<b>1.37</b>	-0.02	-0.03	-0.18	-0.12
MAP	-0.47	3.13		<b>-2.47</b>	0.04	0.29	0.22	<b>-0.98</b>	<b>1.21</b>	0.00	-0.03	-0.46	0.01
ST	-2.88	3.13	-0.40		0.04	-0.01	0.19	<b>-0.88</b>	<b>1.22</b>	-0.01	-0.02	-0.25	0.01
SMC	-0.16	-1.15	0.12	0.81		<b>0.91</b>	-0.26	<b>1.51</b>	<b>-1.84</b>	0.04	-0.04	<b>-1.19</b>	<b>1.34</b>
Silt	1.63	-1.99	0.27	2.04	-0.01		-0.06	0.46	-0.74	0.01	0.02	0.43	-0.03
SOC	-0.36	-0.26	-0.08	0.03	-0.09	1.63		0.71	-0.83	0.04	0.01	<b>-1.18</b>	<b>0.73</b>
TN	1.83	-2.20	0.29	1.55	-0.12	0.54	-0.36		-1.60	0.03	0.05	<b>-0.60</b>	<b>0.84</b>
TP	-2.07	-2.09	0.25	1.39	-0.13	0.63	-0.33	1.83		0.04	0.05	<b>-0.77</b>	<b>1.11</b>
LDMC	-0.06	-2.21	0.27	1.70	-0.14	0.65	-0.28	<b>1.59</b>	<b>-2.07</b>		0.04	-0.88	1.17
SLA	0.05	0.92	0.01	-0.47	0.11	-1.12	0.17	<b>-1.30</b>	<b>1.44</b>	-0.06		1.04	-1.11
Leaf N	1.45	-1.79	0.27	1.25	0.13	0.20	-0.30	<b>1.59</b>	<b>-1.69</b>	0.03	0.05		1.04
Leaf C	-1.45	-0.42	0.15	0.49	0.13	-1.32	0.15	<b>-0.97</b>	<b>1.26</b>	-0.04	-0.02	1.45	

Note: MAT= mean annual temperature; MAP=mean annual precipitation. ST=temperature of 0–10 cm soil; SMC=soil moisture content; Silt=soil silt content; SOC=soil organic carbon; TN=soil total nitrogen; TP=soil total phosphorus. The vegetation data: LDMC=leaf dry matter weight; Leaf C=leaf carbon content; Leaf N=leaf nitrogen content; SLA=specific leaf area.



**Table S8** Path analysis of relevant environmental variables to soil microbial use of amines source

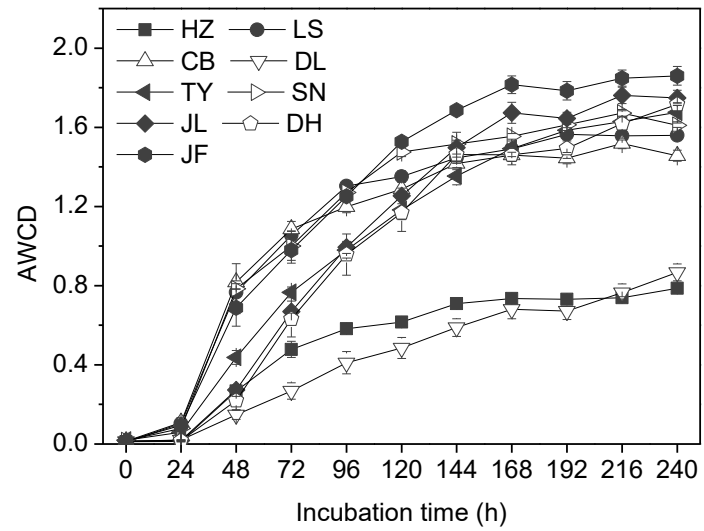
Variables	Direct effect	Indirect effect											
		MAT	MAP	ST	SMC	Silt	SOC	TN	TP	LDMC	SLA	Leaf N	Leaf C
MAT	4.29		-2.13	<b>-2.22</b>	0.14	-0.15	0.30	<b>-1.01</b>	<b>1.01</b>	0.02	0.08	-0.06	-0.08
MAP	-2.27	4.02		<b>-2.03</b>	0.10	0.34	0.28	<b>-0.86</b>	<b>0.89</b>	0.00	0.08	-0.16	0.00
ST	-2.37	4.02	-1.95		0.12	-0.02	0.25	<b>-0.77</b>	<b>0.90</b>	0.01	0.06	-0.08	0.01
SMC	-0.41	-1.48	0.58	0.67		<b>1.07</b>	-0.34	<b>1.33</b>	<b>-1.36</b>	-0.05	0.12	-0.41	<b>0.90</b>
Silt	1.92	-2.56	1.30	1.68	-0.01		-0.08	0.40	-0.55	-0.01	-0.04	0.14	-0.02
SOC	-0.46	-0.34	-0.40	0.02	-0.23	1.92		0.62	-0.61	-0.05	-0.02	-0.40	<b>0.49</b>
TN	1.61	-2.83	1.40	1.28	-0.30	0.64	-0.46		-1.17	-0.03	-0.12	-0.21	<b>0.57</b>
TP	-1.52	-2.69	1.21	1.14	-0.34	0.74	-0.42	1.61		-0.05	-0.13	-0.26	<b>0.75</b>
LDMC	0.07	-2.84	1.33	1.40	-0.36	0.76	-0.35	<b>1.39</b>	<b>-1.52</b>		-0.12	-0.30	0.79
SLA	-0.15	1.18	0.03	-0.39	0.29	-1.32	0.22	<b>-1.14</b>	<b>1.06</b>	0.07		0.35	-0.75
Leaf N	0.49	-2.30	1.32	1.03	0.33	0.24	-0.38	<b>1.40</b>	<b>-1.25</b>	-0.04	-0.15		0.70
Leaf C	-0.97	-0.54	0.72	0.40	0.34	-1.56	0.19	<b>-0.85</b>	<b>0.93</b>	0.05	0.06	0.49	

Note: MAT= mean annual temperature; MAP=mean annual precipitation. ST=temperature of 0–10 cm soil; SMC=soil moisture content; Silt=soil silt content; SOC=soil organic carbon; TN=soil total nitrogen; TP=soil total phosphorus. The vegetation data: LDMC=leaf dry matter weight; Leaf C=leaf carbon content; Leaf N=leaf nitrogen content; SLA=specific leaf area.

**Table S9** Path analysis of relevant environmental variables to soil microbial use of miscellaneous source

Variables	Direct effect	Indirect effect											
		MAT	MAP	ST	SMC	Silt	SOC	TN	TP	LDMC	SLA	Leaf N	Leaf C
MAT	3.84		-1.46	<b>-1.92</b>	-0.34	-0.12	0.19	<b>-0.95</b>	<b>1.19</b>	-0.04	0.08	-0.15	-0.05
MAP	-1.56	3.60		<b>-1.76</b>	-0.25	0.28	0.18	<b>-0.81</b>	<b>1.05</b>	0.00	0.08	-0.38	0.00
ST	-2.05	3.60	-1.34		-0.28	-0.01	0.15	<b>-0.73</b>	<b>1.06</b>	-0.03	0.06	-0.21	0.01
SMC	1.00	-1.32	0.40	0.58		0.87	-0.21	<b>1.25</b>	<b>-1.60</b>	0.11	0.12	<b>-1.00</b>	<b>0.59</b>
Silt	1.57	-2.29	0.89	1.46	0.04		-0.05	0.38	<b>-0.65</b>	0.01	-0.04	0.35	-0.01
SOC	-0.29	-0.30	-0.28	0.02	0.55	1.57		<b>0.59</b>	<b>-0.72</b>	0.11	-0.02	<b>-0.98</b>	0.32
TN	1.51	-2.53	0.96	1.11	0.74	0.52	-0.29		-1.39	0.07	-0.12	<b>-0.50</b>	0.37
TP	-1.80	-2.41	0.83	0.99	0.82	0.61	-0.26	1.51		0.11	-0.13	<b>-0.64</b>	0.49
LDMC	-0.16	-2.54	0.91	1.21	0.89	0.62	-0.22	<b>1.31</b>	<b>-1.80</b>		-0.12	-0.74	0.51
SLA	-0.15	1.06	0.02	-0.33	-0.71	-1.08	0.14	<b>-1.08</b>	<b>1.25</b>	-0.16		0.87	-0.49
Leaf N	1.21	-2.06	0.90	0.89	-0.80	0.20	-0.24	<b>1.32</b>	<b>-1.47</b>	0.08	-0.15		0.45
Leaf C	-0.63	-0.49	0.49	0.35	-0.82	-1.27	0.12	<b>-0.80</b>	<b>1.09</b>	-0.11	0.06	1.21	

Note: MAT= mean annual temperature; MAP=mean annual precipitation. ST=temperature of 0–10 cm soil; SMC=soil moisture content; Silt=soil silt content; SOC=soil organic carbon; TN=soil total nitrogen; TP=soil total phosphorus. The vegetation data: LDMC=leaf dry matter weight; Leaf C=leaf carbon content; Leaf N=leaf nitrogen content; SLA=specific leaf area.



**Fig.S1** Variation of the average well color development (AWCD) values during a 240-h incubation for the nine forests. The abbreviations of the sampling sites were showed in table 1.

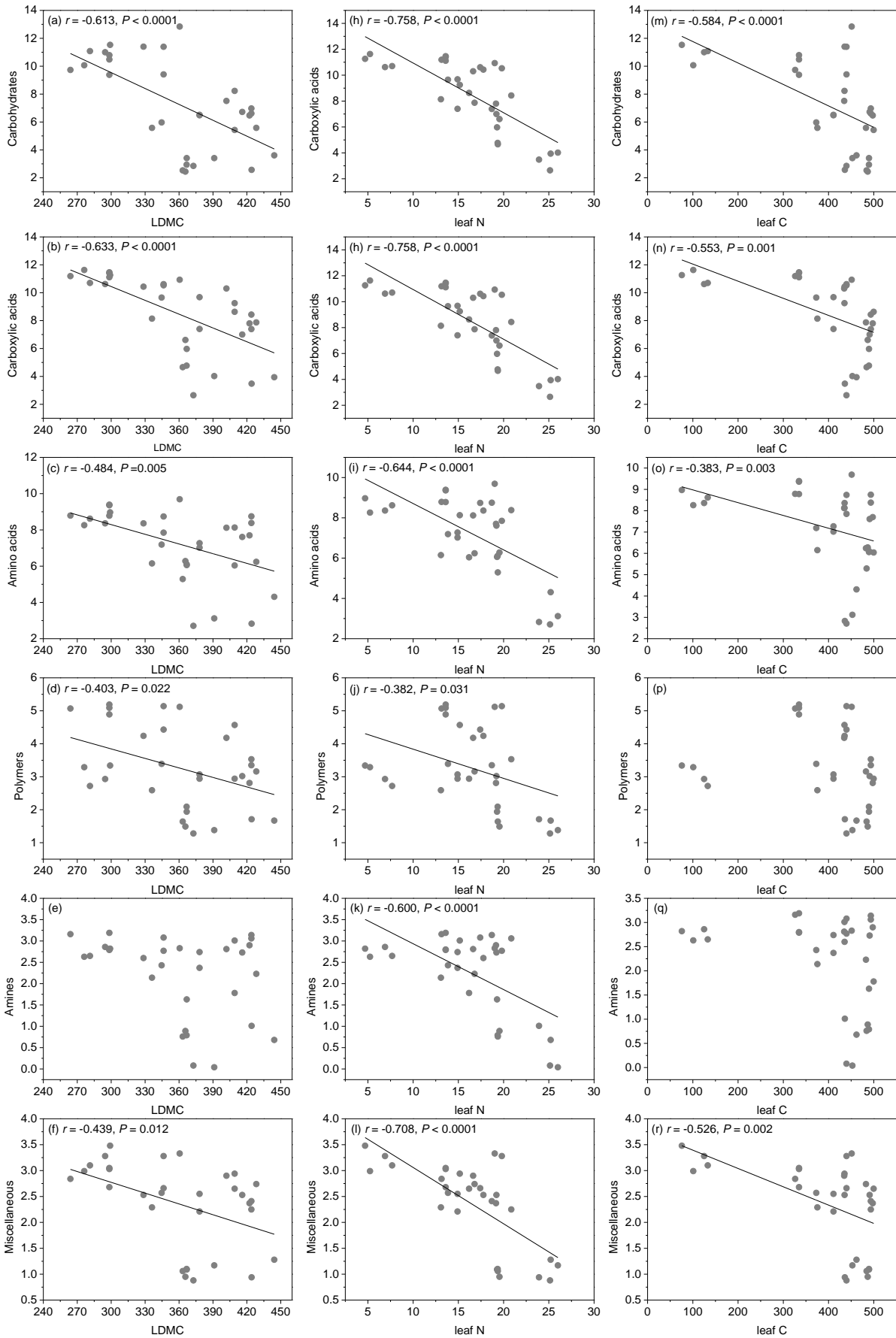


Fig.S2 The Pearson's correlation coefficients between the use of individual substrates and plant functional traits.