

2 **Biochar effects on soil nitrogen retention, leaching and yield of**
3 **perennial citron daylily under three irrigation regimes**

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5 Xiaolei Sun^{a,b,c,1}, Xiaosong Yang^{a,1}, Zhengyi Hu^{a*}, Fulai Liu^d, Zijian Xie^a, Songyan
6 Li^{a,d}, Guoxi Wang^a, Meng Li^e, Zheng Sun^{f,g}, Roland Bol^{b,h}

7
8 ^a *College of Resources and Environment, Sino-Danish College, University of Chinese*
9 *Academy of Sciences, Beijing 100049, China*

10 ^b *Institute of Bio- and Geosciences, Agrosphere (IBG-3), Forschungszentrum Jülich,*
11 *52425, Jülich, Germany*

12 ^c *Institute for Environmental Research, Biology 5, RWTH Aachen University,*
13 *Worringerweg 1, 52074 Aachen, Germany*

14 ^d *Department of Plant and Environmental Sciences, Crop Science Section, University*
15 *of Copenhagen, Højbakkegaard Allé 13, DK-2630 Taastrup, Denmark*

16 ^e *Institute of Wetland Research, Chinese Academy of Forestry, Beijing 100091, China*

17 ^f *Sorbonne Universités, UPMC Univ Paris 06, CNRS, EPHE, UMR 7619 METIS, 4*
18 *place Jussieu, 75252 Paris cedex 05, France*

19 ^g *IFP Energies Nouvelles, Geosciences Division, 1 et 4 Avenue de Bois-Préau, 92852*
20 *Rueil-Malmaison Cedex, France*

21 ^h *School of Natural Sciences, Environment Centre Wales, Bangor University, Bangor,*
22 *United Kingdom*

23

24 **Correspondence:**

25 Prof. Dr. Zhengyi Hu at *College of Resources and Environment, Sino-Danish Center*
26 *for Education and Research, Beijing 100190, China*, E-mail: zhyhu@ucas.ac.cn

27 ¹ These authors contributed equally.

28 **Table S1** Effects of biochar application on soil pH, TC (g kg⁻¹), and C/N under three irrigation regimes during citron daylily growing season in 2017 and 2018

Irrigation regimes	Biochar application	Depth of profile(cm)	2017			2018		
			pH	TC	C/N	pH	TC	C/N
CDI [§]	-B	0-20	7.91±0.12a [‡]	9.44±0.51a	8.00±0.56a	7.73±0.18b	6.92±0.10a	10.57±0.39a
CDI	+B		7.94±0.15a	12.56±1.23a	10.26±0.59a	8.88±0.30a	22.23±0.45a	21.65±1.07a
WSDI	-B		7.77±0.22a	7.73±0.66a	7.98±0.21a	7.96±0.14b	6.27±0.29a	9.75±0.19a
WSDI	+B		7.94±0.11a	11.71±0.91a	10.34±0.51a	8.73±0.16ab	26.37±3.49a	24.45±3.25a
APRDI	-B		7.98±0.22a	9.79±3.77a	8.70±2.29a	8.19±0.06b	6.66±0.93a	12.28±1.51a
APRDI	+B		7.94±0.03a	11.43±2.82a	9.91±1.45a	8.86±0.25a	23.51±1.98a	23.66±1.34a

CDI	-B	20-50	8.07±0.18a	5.75±0.67a	7.08±0.40a	7.96±0.22b	4.52±0.56a	11.57±0.42a
CDI	+B		8.03±0.17a	4.94±0.32a	7.36±0.68a	8.48±0.16ab	6.86±0.50b	15.51±0.84b
WSDI	-B		7.97±0.17a	4.27±0.35a	8.02±1.03a	8.12±0.16b	4.09±0.16a	11.88±0.61a
WSDI	+B		8.06±0.19a	4.79±0.72a	7.50±0.71a	8.61±0.11a	11.44±3.26a	20.63±2.85a

APRDI	-B		8.22±0.22a	5.05±0.91a	8.36±0.48a	8.15±0.06b	4.09±0.23a	10.88±0.14a
APRDI	+B		8.03±0.07a	5.30±0.50a	7.34±0.53a	8.34±0.12ab	6.89±0.35b	15.49±1.29b

CDI	-B	50-100	8.01±0.05a	4.86±0.26b	8.36±0.49a	8.02±0.11a	3.36±0.18a	10.58±0.36a
CDI	+B		7.83±0.13a	4.88±0.16b	8.04±0.28a	7.99±0.03a	3.57±0.14a	10.67±0.96a
WSDI	-B		7.84±0.13a	4.09±0.41b	7.67±0.18a	7.90±0.11a	3.17±0.22a	11.12±0.54a
WSDI	+B		7.85±0.28a	4.37±0.49b	7.69±0.49a	8.05±0.12a	4.38±0.84a	14.65±3.26a
APRDI	-B		8.10±0.17a	4.63±0.21b	8.15±0.83a	7.98±0.08a	3.15±0.12a	10.18±0.23a
APRDI	+B		7.95±0.05a	5.24±0.58a	6.91±0.41b	7.87±0.04a	3.77±0.38a	11.01±0.51a

Analysis of the difference of biochar application under the same irrigation regime

0-20	Irrigation regimes (I)	0.531	0.555	0.964	0.165	0.227	0.185
	Biochar application (B)	0.469	0.011**	0.004**	<0.001***	<0.001***	<0.001***
	I×B	0.509	0.617	0.654	0.134	0.080	0.147

20-50	Irrigation regimes (I)	0.550	0.091	0.253	0.228	0.026*	0.004**

	Biochar application (B)	0.539	0.970	0.208	<0.001***	<0.001***	<0.001***
	I×B	0.404	0.177	0.279	0.132	0.015*	0.02*

50–100	Irrigation regimes (I)	0.175	0.014**	0.082	0.295	0.330	0.026*
	Biochar application (B)	0.172	0.123	0.046*	0.917	0.004**	0.049*
	I×B	0.542	0.436	0.113	0.076	0.135	0.134

29 [§]CDI-Conventional drip irrigation, WSDI-water-saving drip irrigation (80% of conventional drip irrigation), APRDI-alternative partial root-zone drip irrigation (80%
30 of conventional drip irrigation). Rates of biochar application in 0-20cm soil: 0, and 30 t ha⁻¹. [‡]The value was given as mean ± SD. Different letters indicates
31 significant difference ($p < 0.05$) of treatments. *indicates significant at $p < 0.05$, **indicates significant at $p < 0.01$, ***indicates significant at $p < 0.001$

32 **Table S2** Effects of biochar application on organic N (ON, g kg⁻¹), inorganic N (IN, mg kg⁻¹) concentrations in soils and NO₃⁻-N/ NH₄⁺-N under three irrigation
 33 regimes during citron daylily growing season in 2017 and 2018

Irrigation regimes	Biochar application	Depth of profile(cm)	2017			2018		
			ON	IN	NO ₃ ⁻ / NH ₄ ⁺	ON	IN	NO ₃ ⁻ / NH ₄ ⁺
CDI [§]	-B	0-20	1.12±0.08a	61±3b	58±5c	0.64±0.02b	19±1ab	55±29a
CDI	+B		1.14±0.06a	79±4a	56±7c	1.02±0.06a	13±1b	47±3a
WSDI	-B		0.90±0.11a	68±3ab	111±14a	0.62±0.02b	21±2a	59±44a
WSDI	+B		1.07±0.03a	62±1b	88±16b	1.07±0.10a	14±2b	46±5a
APRDI	-B		1.06±0.18a	52±5b	49±8cd	0.53±0.04b	16±4ab	31±9a
APRDI	+B		1.08±0.18a	61±6b	38±2d	0.98±0.09a	13±2b	23±3a
CDI	-B	20-50	0.73±0.03a	64±2a	138±30a	0.38±0.05b	6±2ab	128±70a
CDI	+B		0.65±0.04a	58±6a	91±12b	0.44±0.03ab	4±2b	92±73a
WSDI	-B		0.54±0.07a	45±4b	72±18b	0.34±0.02b	4±0b	86±24a

WSDI	+B		0.58±0.15a	45±2b	96±11b	0.56±0.19a	4±1b	136±66a
APRDI	-B		0.60±0.10a	56±5ab	94±22b	0.37±0.02b	5±2ab	146±37a
APRDI	+B		0.62±0.06a	55±2ab	70±6b	0.44±0.03ab	9±3a	122±180a

CDI	-B	50-100	0.57±0.03ab	60±6ab	143±14b	0.31±0.03a	12±0a	21±6a
CDI	+B		0.57±0.01ab	49±3b	116±2c	0.32±0.02a	11±3a	23±23a
WSDI	-B		0.47±0.07b	63±8a	203±23a	0.27±0.01a	11±4a	35±51a
WSDI	+B		0.55±0.09ab	42±1b	73±5d	0.29±0.04a	10±1a	16±8a
APRDI	-B		0.63±0.05a	52±5ab	72±20d	0.30±0.01a	9±1a	6±5a
APRDI	+B		0.68±0.04a	52±2ab	71±11d	0.33±0.03a	10±0a	16±16a

Analysis of the difference of biochar application under the same irrigation regime

0-20	Irrigation regimes (I)	0.140	<0.001***	<0.001***	0.070	0.148	0.123
	Biochar application (B)	0.224	0.003**	0.022*	<0.001***	<0.001***	0.343
	I×B	0.495	0.001***	0.231	0.544	0.287	0.975

20–50	Irrigation regimes (I)	0.066	<0.001***	0.015*	0.599	0.019*	0.877
	Biochar application (B)	0.879	0.205	0.099	0.013*	0.753	0.937
	I×B	0.448	0.502	0.017*	0.2	0.037*	0.682
50–100	Irrigation regimes (I)	0.002**	0.689	<0.001***	0.072	0.189	0.574
	Biochar application (B)	0.139	0.001***	<0.001***	0.082	0.510	0.851
	I×B	0.521	0.014**	<0.001***	0.876	0.560	0.551

34 §CDI-Conventional drip irrigation, WSDI-water-saving drip irrigation (80% of conventional drip irrigation), APRDI-alternative partial root-zone drip irrigation (80%
35 of conventional drip irrigation). Rates of biochar application in 0-20cm soil: 0, and 30 t ha⁻¹. ‡The value was given as mean ± SD. Different letters indicates
36 significant difference ($p < 0.05$) of treatments. *indicates significant at $p < 0.05$, **indicates significant at $p < 0.01$, ***indicates significant at $p < 0.001$

37 **Table S3** Analysis of variance (P values) for soil pH, TC, C/N, organic N (ON), inorganic N (IN)
 38 in soils, $\text{NO}_3^-/\text{NH}_4^+$ and TN concentration in soil solution as affected by planting year

Depth of soil profile(cm)	Index	Year (Y)
0–20	pH	<0.001***
	TC	0.036*
	C/N	<0.001***
	ON	<0.001***
	IN	<0.001***
	$\text{NO}_3^-/\text{NH}_4^+$	0.009**
	TN concentration in solution	<0.001***
20–50	pH	0.006**
	TC	0.073
	C/N	<0.001***
	ON	<0.001***
	IN	<0.001***
	$\text{NO}_3^-/\text{NH}_4^+$	0.219
	TN concentration in solution	<0.001***
50–100	pH	0.374
	TC	<0.001***
	C/N	<0.001***
	ON	<0.001***
	IN	<0.001***

NO₃⁻/NH₄⁺ <0.001***

TN concentration in solution <0.001***

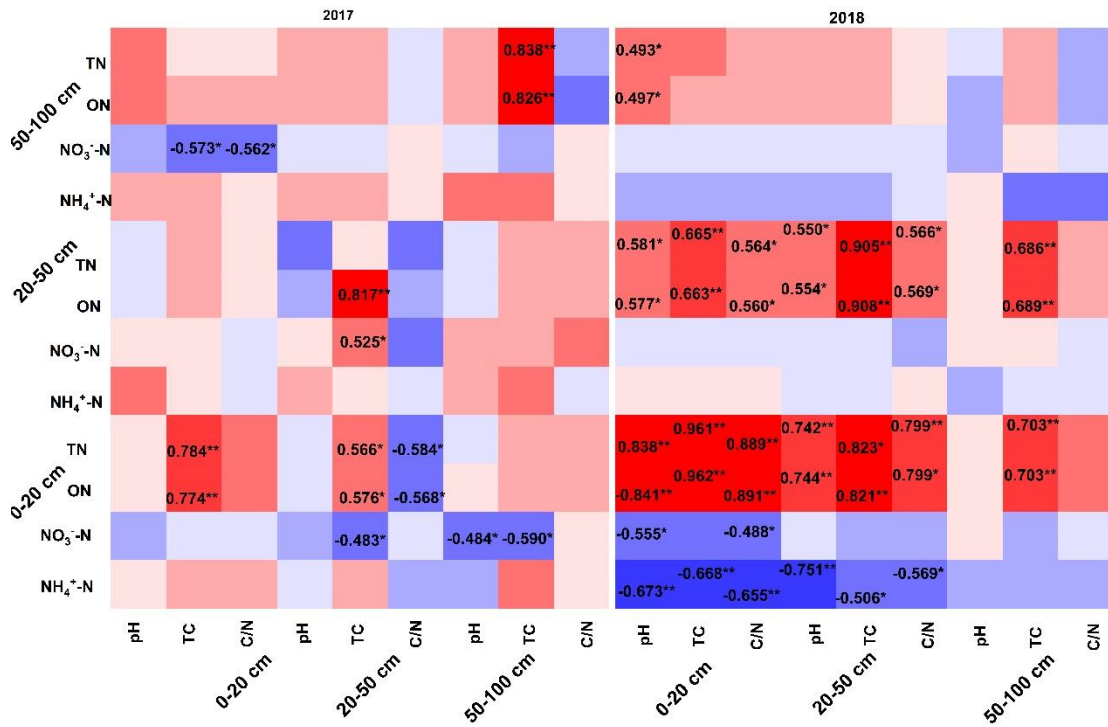
39 * indicates significant at p < 0.05, **indicates significant at p < 0.01, ***indicates significant at p
40 <0.001.

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42 **Table S4** Analysis of variance (P values) for citron daylily yield, accumulated amount and
43 concentration of N in flower of citron daylily as affected by planting year

Index	Year (Y)
Yield	<0.001***
N concentration	<0.001***
N accumulation	<0.001***

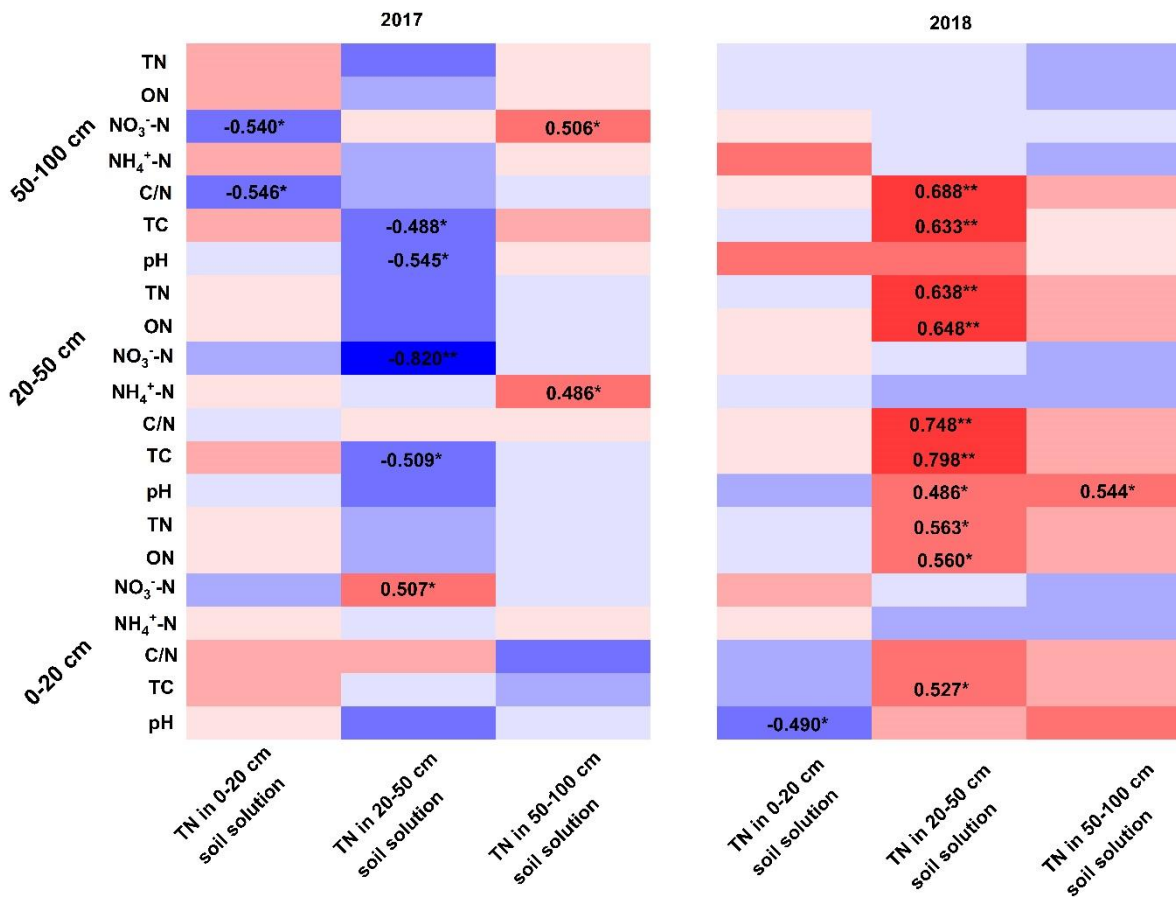
44 * indicates significant at p < 0.05, **indicates significant at p < 0.01, ***indicates significant at p
45 <0.001.



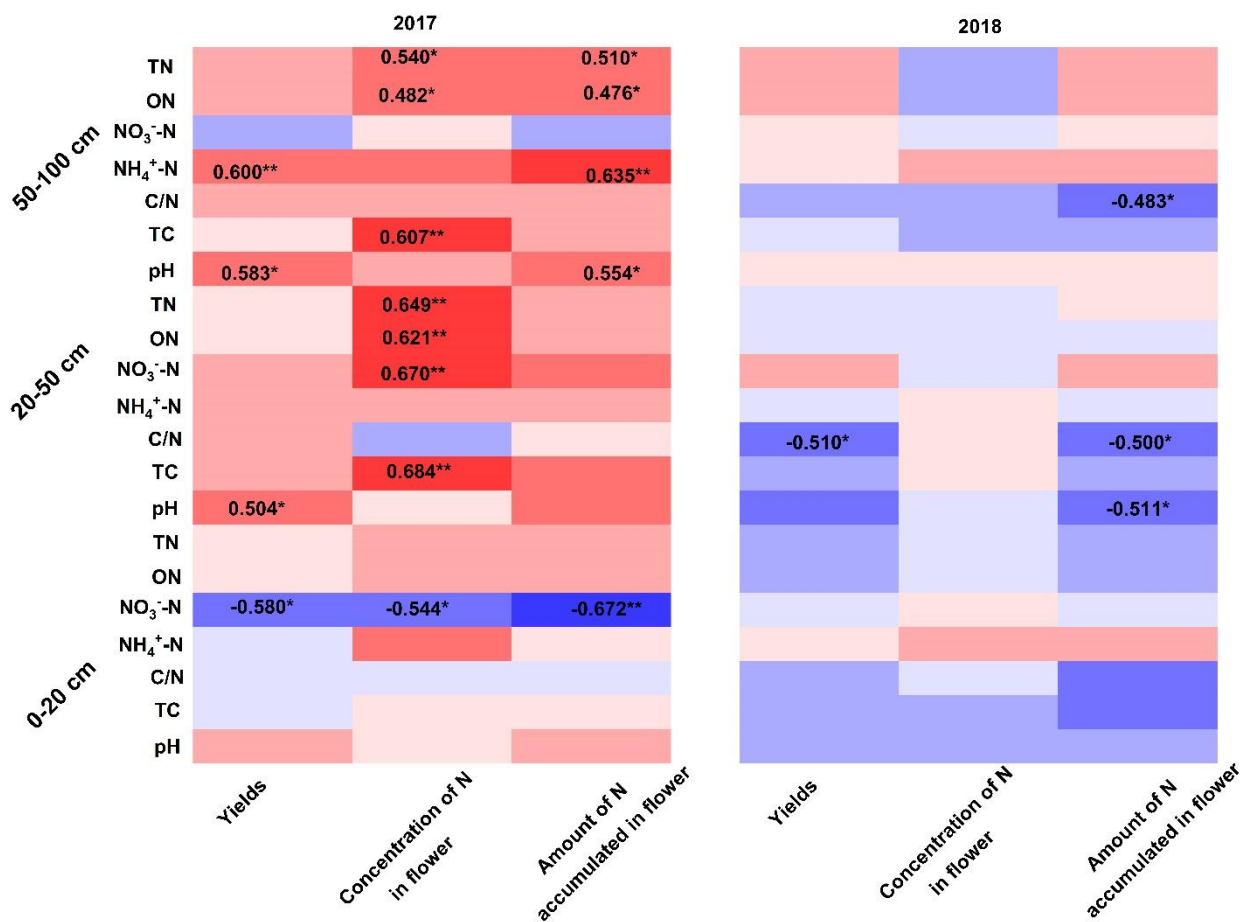
46 **Figures**

47 **Figure S1.** Heatmaps demonstrating the correlation between soil properties (X-coordinate: pH, TC,

48 C/N), and concentration of soil N (Y-coordinate: NH₄⁺-N, NO₃⁻-N, organic N, total N).



49 **Figure S2.** Heatmaps demonstrating the correlation between soil solution TN concentration
 50 (X-coordinate) with soil properties and concentration of soil N (Y-coordinate: pH, TC, C/N,
 51 NH₄⁺-N, NO₃⁻-N, organic N, total N).



52 **Figure S3.** Heatmaps demonstrating the correlation between flower characteristics (X-coordinate:
 53 yield, accumulated amount of N, and concentration of N in flower buds of citron daylily) with soil
 54 properties and concentration of soil N (Y-coordinate: pH, TC, C/N, NH₄⁺-N, NO₃⁻-N, organic N,
 55 total N).
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 57