

Supplementary Methods

Plant uptake of nitrogen adsorbed to biochars made from dairy manure

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Table SI 1 Composition of nutrient powder mixture used for the growth trial.

Reagent	Amount in mixture (g kg ⁻¹)
CaHPO ₄ ²⁻ ·H ₂ O	61.47
K ₂ CO ₃	120.24
MgO	54.0
ZnSO ₄ ·7H ₂ O	2.48
NaCl	54.15
CaCO ₃	688.46
K ₂ SO ₄	18.95

Table SI 2 Description of growth-trial amendment treatments and irrigation amounts. All amendments were added to 41.77 g of TH6 peat potting media and mixed thoroughly while dry. The bulk densities used for calculations are: (1) TH6 peat potting media = 0.14 g cm⁻³, (2) manure biochar = 0.32 g cm⁻³, (3) wood biochar = 0.13 g cm⁻³.

Amend.	N-form	Urea and biochar	Biochar (ton ha ⁻¹)	Nutrient powder (ton ha ⁻¹)	Urea-N (kg ha ⁻¹)	Urea (kg ha ⁻¹)	Initial irrigation (m ³ ha ⁻¹)
None	None	0.00	0.00	2.08	0.00	0.00	503.36
0.25x fert	Urea	0.25-fold of wood biochar N uptake (Table 1)	0.00	2.08	29.46	63.15	503.36
0.5x fert	Urea	0.5-fold of wood biochar N uptake	0.00	2.08	58.89	126.31	503.36
1x fert	Urea	1-fold (same amount) of wood biochar N uptake	0.00	2.08	117.79	252.65	503.36
1.5x fert	Urea	1.5-fold of wood biochar N uptake	0.00	2.08	176.68	378.96	503.36
Manure biochar NH ₃ +CO ₂	NH ₃ gas	Equivalent on C basis to wood biochar (Table 1)	24.16	0.00	0.00	0.00	516.78
Manure biochar+ slurry	Slurry	Equivalent on C basis to wood biochar	24.16	0.00	0.00	0.00	516.78
Manure biochar+1x fertilizer	Urea	Equivalent on C basis to wood biochar + urea-N 1-fold of wood biochar N uptake	24.16	0.00	117.79	252.65	516.78
Manure biochar	None	Equivalent on C basis to wood biochar	24.16	0.00	0.00	0.00	516.78
Wood biochar NH ₃ +CO ₂	NH ₃ gas	10% of pot volume	12.08	2.08	0.00	0.00	577.18
Wood biochar+ slurry	Slurry	10% of pot volume	12.08	2.08	0.00	0.00	577.18
Wood biochar+1x fertilizer	Urea	10% of pot volume + urea-N 1-fold of wood biochar N uptake	12.08	2.08	117.79	252.65	577.18
Wood biochar	None	10% of pot volume	12.08	2.08	0.00	0.00	577.18

Table SI 3 Description of urea-N additions (1x) in greenhouse trial based on six replicate measurements of N uptake of wood biochar after exposure to CO₂+NH₃.

Cycle of gas adsorption	Description	N (% w w ⁻¹)	ΔN wood biochar [CO ₂ +NH ₃ - wood biochar] (% w w ⁻¹)	Urea-N added to 3.6 g wood biochar [1x] (mg)	Urea-N addition in 1x treatment (g kg ⁻¹)
1	Wood biochar+NH ₃	2.16	0.98	35.10	4.90
2	Wood biochar+NH ₃ +CO ₂	1.48			
3	Wood biochar+NH ₃ +CO ₂ +NH ₃	1.65			
4	Wood biochar+NH ₃ +CO ₂ +NH ₃ +CO ₂	0.67			
5	Wood biochar+NH ₃ +CO ₂ +NH ₃ +CO ₂ +NH ₃	1.48			
6	Wood biochar+NH ₃ +CO ₂ +NH ₃ +CO ₂ +NH ₃ +CO ₂	1.41			
	Average n = 6	1.48			
	Unexposed wood biochar (control) average n = 5	0.50			

Table SI 4 Germination, mass of dry shoot and root biomass, and total carbon and nitrogen in shoot and root biomass of marigold, radish, and tomato plants. Letters not in brackets indicate significant differences between amendments within plant and biomass type while letters in brackets indicate significant differences between amendments and plant type within each biomass type ($p < 0.05$; $n = 4$).

Plant	Amendment	Germination (%)	Shoot biomass (dry) (g pot ⁻¹)	Shoot nitrogen (% w w ⁻¹)	Shoot carbon (% w w ⁻¹)	Root biomass (dry) (g pot ⁻¹)	Root nitrogen (% w w ⁻¹)	Root carbon (% w w ⁻¹)
Marigold	0x fert	80.04 ± 23.07 a	1.99 ± 0.26 ab	1.42 ± 0.38 ab	44.56 ± 1.04 a	0.82 ± 0.14 ab	0.99 ± 0.15 a	43.53 ± 0.78 a
Marigold	0.25x fert	55.03 ± 41.23 a	2.38 ± 0.36 ab	1.30 ± 0.24 ab	44.64 ± 1.26 a	1.01 ± 0.18 ab	0.94 ± 0.08 a	43.00 ± 1.01 a
Marigold	0.5x fert	75.01 ± 34.20 a	2.62 ± 0.41 a	1.14 ± 0.17 ab	45.32 ± 0.90 a	0.97 ± 0.17 ab	0.95 ± 0.11 a	43.90 ± 0.59 a
Marigold	1x fert	55.02 ± 34.22 a	2.65 ± 0.51 a	1.62 ± 0.51 ab	45.2 ± 1.02 a	0.98 ± 0.13 ab	1.07 ± 0.11 a	44.77 ± 0.48 a
Marigold	1.5x fert	55.04 ± 19.20 a	2.80 ± 0.39 a	1.86 ± 0.16 a	45.22 ± 0.31 a	0.86 ± 0.08 ab	1.10 ± 0.14 a	43.01 ± 3.31 a
Marigold	Manure biochar	80.01 ± 16.31 a	1.93 ± 0.13 ab	1.27 ± 0.26 ab	44.45 ± 0.18 a	0.76 ± 0.26 abc	1.00 ± 0.27 a	42.41 ± 0.80 a
Marigold	Manure biochar+ slurry	60.00 ± 43.21 a	1.96 ± 0.42 ab	1.39 ± 0.61 ab	44.01 ± 1.14 a	0.97 ± 0.14 ab	0.89 ± 0.08 a	42.81 ± 0.90 a
Marigold	Manure biochar CO ₂ +NH ₃	65.02 ± 47.30 a	1.24 ± 0.83 bc	1.59 ± 1.16 ab	33.47 ± 22.4 ab	0.59 ± 0.41 bc	0.86 ± 0.62 ab	31.93 ± 21.34 a
Marigold	Dairy manure biochar+1x	30.04 ± 20.03 a	0.60 ± 1.19 c	0.47 ± 0.94 b	11.42 ± 22.90 b	0.20 ± 0.41 c	0.22 ± 0.44 b	9.04 ± 18.08 b
Marigold	Wood biochar	65.02 ± 19.17 a	2.62 ± 0.13 a	0.94 ± 0.12 ab	45.09 ± 0.58 a	0.94 ± 0.25 ab	0.88 ± 0.29 a	42.51 ± 2.36 a
Marigold	Wood biochar+ slurry	35.01 ± 34.22 a	2.33 ± 0.29 ab	1.09 ± 0.08 ab	44.61 ± 0.54 a	0.81 ± 0.15 ab	0.96 ± 0.19 a	43.83 ± 0.50 a
Marigold	Wood biochar NH ₃ +CO ₂	60.04 ± 43.20 a	2.70 ± 0.33 a	1.39 ± 0.28 ab	45.80 ± 0.41 a	0.96 ± 0.14 ab	0.94 ± 0.16 a	43.72 ± 0.64 a
Marigold	Wood biochar+1x	60.04 ± 28.34 a	3.10 ± 0.17 a	1.37 ± 0.05 ab	46.01 ± 0.22 a	1.20 ± 0.17 a	0.91 ± 0.10 a	43.03 ± 2.53 a

Radish	0x fert	90.01 ± 11.63 a	0.77 ± 0.14 b	1.43 ± 0.40 abc	41.91 ± 1.22 ab	2.31 ± 0.27 c	0.81 ± 0.17 a	40.94 ± 4.18 a
Radish	0.25x fert	70.00 ± 11.60 a	1.05 ± 0.31 ab	1.80 ± 0.33 abc	42.90 ± 0.71 a	2.81 ± 0.47 bc	0.78 ± 0.25 a	41.12 ± 2.88 a
Radish	0.5x fert	80.04 ± 16.33 a	0.89 ± 0.12 ab	1.86 ± 0.55 abc	42.22 ± 1.22 ab	3.20 ± 0.29 abc	0.83 ± 0.15 a	41.71 ± 2.34 a
Radish	1x fert	65.04 ± 34.23 a	1.08 ± 0.17 ab	1.96 ± 0.28 abc	41.91 ± 2.12 ab	3.05 ± 0.61 abc	1.07 ± 0.26 a	43.11 ± 4.46 a
Radish	1.5x fert	85.00 ± 19.24 a	1.34 ± 0.34 a	2.05 ± 0.68 ab	43.40 ± 1.45 a	3.04 ± 0.90 abc	1.00 ± 0.26 a	39.61 ± 7.00 a
Radish	Manure biochar	90.02 ± 20.01 a	0.74 ± 0.15 b	1.34 ± 0.34 abc	40.38 ± 1.91 ab	2.91 ± 0.73 abc	0.72 ± 0.06 a	42.80 ± 1.52 a
Radish	Manure biochar+ slurry	90.01 ± 20.00 a	1.00 ± 0.13 ab	1.19 ± 0.29 bc	39.14 ± 3.50 b	2.92 ± 0.32 abc	0.68 ± 0.03 a	40.52 ± 4.31 a
Radish	Manure biochar CO ₂ +NH ₃	65.01 ± 10.02 a	0.98 ± 0.21 ab	2.12 ± 0.46 a	41.80 ± 1.31 ab	3.50 ± 0.36 abc	1.01 ± 0.22 a	40.61 ± 2.55 a
Radish	Manure biochar+1x	75.01 ± 19.20 a	0.94 ± 0.12 ab	1.51 ± 0.33 abc	41.11 ± 0.41 ab	4.10 ± 0.20 a	0.80 ± 0.06 a	42.69 ± 0.82 a
Radish	Wood biochar	90.04 ± 20.03 a	0.84 ± 0.12 ab	1.10 ± 0.12 c	42.75 ± 0.90 ab	3.13 ± 0.27 abc	0.72 ± 0.15 a	42.56 ± 1.54 a
Radish	Wood biochar+ slurry	90.04 ± 11.59 a	0.91 ± 0.26 ab	1.17 ± 0.20 bc	42.28 ± 0.47 ab	2.82 ± 0.24 bc	0.78 ± 0.07 a	42.33 ± 1.32 a
Radish	Wood biochar NH ₃ +CO ₂	80.01 ± 16.32 a	1.23 ± 0.26 ab	1.52 ± 0.19 abc	42.91 ± 0.71 a	3.81 ± 0.44 ab	0.83 ± 0.11 a	42.84 ± 1.01 a
Radish	Wood biochar+1x	90.03 ± 11.55 a	1.15 ± 0.11 ab	1.39 ± 0.19 abc	42.3 ± 1.11 ab	3.88 ± 0.61 ab	0.84 ± 0.08 a	43.61 ± 0.30 a
Tomato	0x fert	85.03 ± 19.21 a	3.04 ± 0.37 bcd	1.13 ± 0.12 c	42.11 ± 0.54 abcd	0.47 ± 0.09 bc	1.18 ± 0.08 c	42.44 ± 0.52 abcde
Tomato	0.25x fert	85.02 ± 19.22 a	3.37 ± 0.57 abcd	1.19 ± 0.17 bc	42.3 ± 0.70 abcd	0.56 ± 0.10 abc	1.26 ± 0.11 bc	42.82 ± 0.31 ab
Tomato	0.5x fert	55.04 ± 37.90 a	3.65 ± 0.27 abcd	1.27 ± 0.15 bc	42.6 ± 0.47 abcd	0.55 ± 0.13 bc	1.24 ± 0.16 bc	43.33 ± 0.60 a
Tomato	1x fert	65.01 ± 44.36 a	3.31 ± 0.67 abcd	1.68 ± 0.52 c	42.82 ± 0.72 abc	0.52 ± 0.11 bc	1.53 ± 0.30 ab	43.60 ± 0.43 a
Tomato	1.5x fert	100.21 ± 0.02 a	2.77 ± 0.51 d	2.41 ± 0.38 a	43.3 ± 0.71 ab	0.34 ± 0.13 c	1.76 ± 0.14 a	42.60 ± 0.65 abc
Tomato	Manure biochar	85.0 ± 19.15 a	2.84 ± 0.26 cd	1.01 ± 0.11 c	41.2 ± 0.32 d	0.52 ± 0.05 bc	1.09 ± 0.06 c	41.24 ± 0.42 e
Tomato	Manure biochar+ slurry	85.04 ± 30.02 a	3.06 ± 0.36 bcd	1.00 ± 0.13 c	41.1 ± 0.47 d	0.56 ± 0.09 abc	1.21 ± 0.11 c	41.27 ± 0.54 de

Tomato	Manure biochar CO ₂ +NH ₃	70.01 ± 25.78 a	3.99 ± 0.21 ab	1.12 ± 0.12 c	41.6 ± 0.17 cd	0.56 ± 0.03 bc	1.29 ± 0.07 bc	42.43 ± 0.87 abcde
Tomato	Manure biochar+1x	55.02 ± 37.94 a	3.77 ± 0.38 abc	1.14 ± 0.17 c	42.21 ± 0.60 abcd	0.63 ± 0.11 ab	1.13 ± 0.07 c	41.51 ± 0.80 cde
Tomato	Wood biochar	100.24 ± 0.00 a	3.09 ± 0.23 abcd	0.96 ± 0.06 c	42.01 ± 0.41 abcd	0.59 ± 0.08 ab	1.02 ± 0.07 c	42.52 ± 0.40 abcd
Tomato	Wood biochar+ slurry	90.01 ± 11.62 a	3.21 ± 0.34 abcd	1.07 ± 0.12 c	41.81 ± 0.92 bcd	0.56 ± 0.16 bc	1.09 ± 0.06 c	41.80 ± 0.34 bcde
Tomato	Wood biochar NH ₃ +CO ₂	90.01 ± 11.62 a	3.69 ± 0.26 abcd	1.21 ± 0.10 bc	43.38 ± 0.80 a	0.64 ± 0.07 ab	1.14 ± 0.04 c	43.11 ± 0.21 a
Tomato	Wood biochar+1x	85.00 ± 10.04 a	4.06 ± 0.42 a	1.18 ± 0.06 bc	43.54 ± 0.80 a	0.80 ± 0.03 a	1.18 ± 0.07 c	43.17 ± 0.12 a

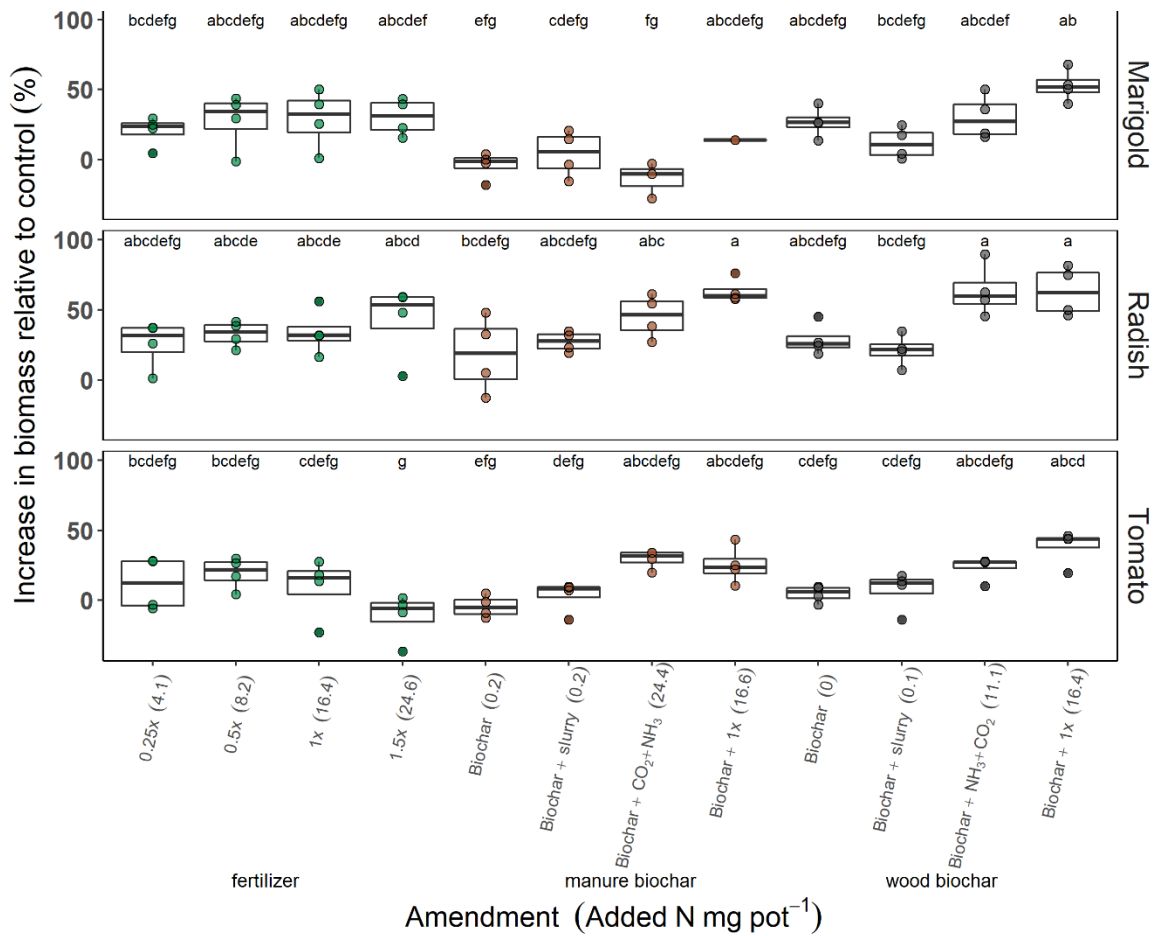


Figure SI 1. Increase in plant biomass (sum of root and shoot biomass) grown with urea fertilizer (green points), manure biochar (brown points) or wood biochar (gray points) amendments relative to unamended plants (0x). The amount of plant-available N in each type of amendment is listed in parentheses. Letters above the bars indicate significant differences between amendments and plant type as calculated from a two-way ANOVA ($p < 0.05$; $n = 4$; whiskers indicate standard errors).

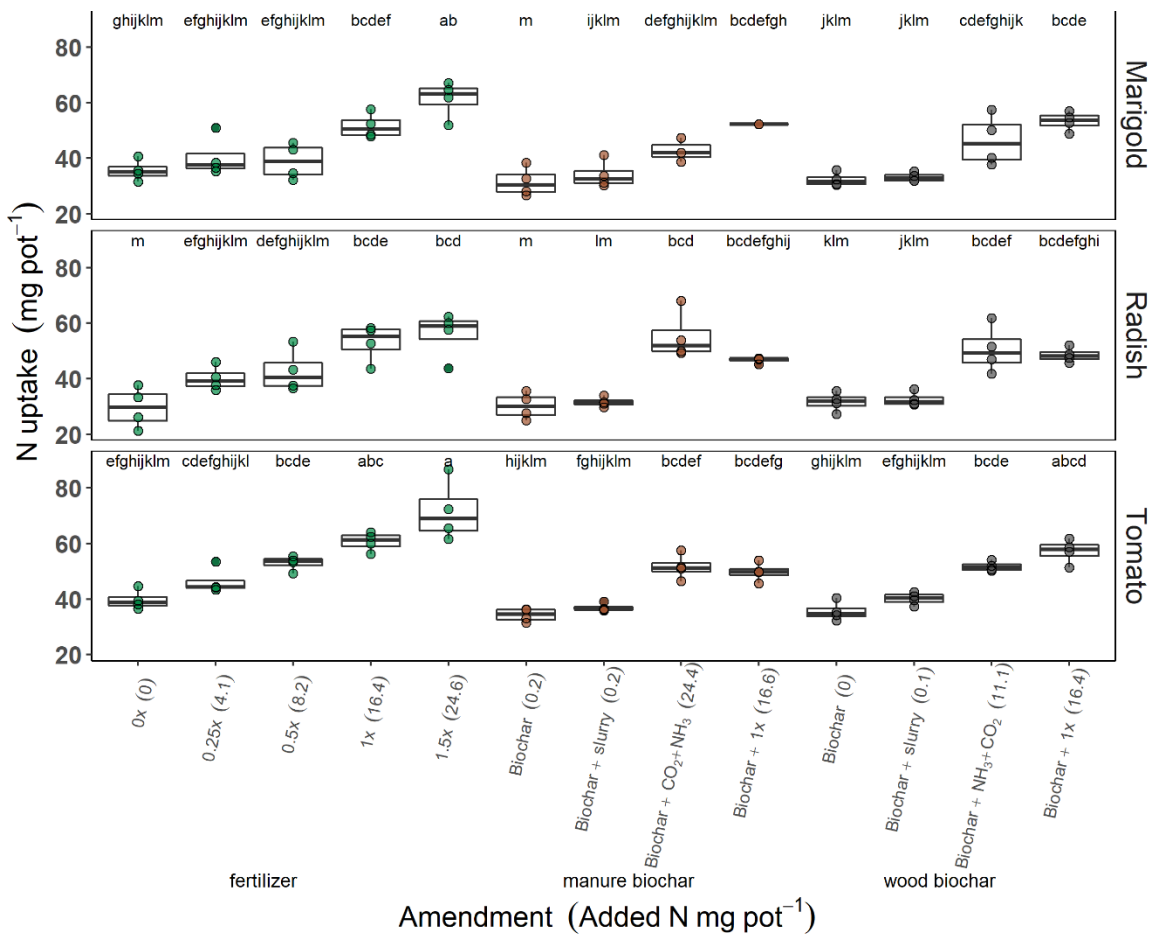


Figure SI 2. Total nitrogen uptake in shoot and root biomass of plants grown with urea fertilizer (green dots), manure biochar (brown dots), or wood biochar (grey dots) amendments or no amendments (0x). Letters above the bars indicate significant differences between amendments and plant type as calculated from a two-way anova ($p < 0.05$; $n = 4$).

Table SI 5 The average \pm standard deviation of the pH of potting mix and amendments after 40 days, total plant biomass (shoot and root combined) and relative increase in plant biomass relative to unamended plants (0x), total N plant uptake (shoot and root combined), and relative increase in biomass N uptake in comparison to unamended plants. Letters not in brackets indicate significant differences from a one-way anova between amendments within plant type while letters within square brackets indicate significant differences from a two-way anova between amendments and plant type ($p < 0.05$; $n = 4$).

Plant	Amendment	pH after 40 days	Plant N uptake (mg pot ⁻¹)	Relative increase in plant N uptake (% w w ⁻¹)	Plant biomass (g pot ⁻¹)	Relative increase in plant biomass (% w w ⁻¹)
Marigold	0x fert	6.35 \pm 0.13 cd [ghij]	35.63 \pm 3.87 de [ghijklm]	NA	2.81 \pm 0.36 bc [hij]	NA
Marigold	0.25x fert	6.28 \pm 0.14 cd [hij]	40.37 \pm 7.21 bcde [efghijklm]	13.28 \pm 20.25 bcde [ghijklm]	3.38 \pm 0.31 abc [defghij]	20.27 \pm 10.89 abc [bcdefg]
Marigold	0.5x fert	6.30 \pm 0.04 cd [hij]	38.97 \pm 6.45 cde [efghijklm]	9.36 \pm 18.10 cde [ghijklm]	3.59 \pm 0.57 ab [cdefghij]	27.73 \pm 20.15 ab [abcdefg]
Marigold	1x fert	6.15 \pm 0.14 d [j]	51.63 \pm 4.49 abc [bcdef]	44.89 \pm 12.61 abc [bcdefghi]	3.63 \pm 0.60 ab [cdefghij]	28.98 \pm 21.20 ab [abcdefg]
Marigold	1.5x fert	6.25 \pm 0.11 cd [hij]	61.36 \pm 6.64 a [ab]	72.20 \pm 18.65 a [abcd]	3.66 \pm 0.37 ab [cdefghij]	30.22 \pm 13.25 ab [abcdef]
Marigold	Manure biochar	7.46 \pm 0.16 a [a]	31.50 \pm 5.24 e [m]	-11.60 \pm 14.71 e [lm]	2.69 \pm 0.27 bc [ij]	-4.27 \pm 9.67 bc [efg]
Marigold	Manure biochar+slurry	7.35 \pm 0.43 a [ab]	34.10 \pm 4.93 de [ijklm]	-4.30 \pm 13.83 de [jklm]	2.93 \pm 0.46 bc [ghij]	4.00 \pm 16.51 bc [cdefg]
Marigold	Manure biochar CO ₂ +NH ₃	7.41 \pm 0.24 a [abc]	42.74 \pm 4.38 bcde [defghijklm]	19.95 \pm 12.29 bcde [efghijklm]	2.43 \pm 0.36 c [j]	-13.72 \pm 12.77 c [fg]
Marigold	Manure biochar+1x	7.35 \pm 0.04 a [abc]	52.28 \pm 0.00 abc [bcdefgh]	46.71 \pm 0.00 abc [abcdefghij]	3.20 \pm 0.00 abc [defghij]	13.78 \pm 0.00 abc [abcdefg]
Marigold	Wood biochar	6.53 \pm 0.19 cd [defghij]	32.40 \pm 2.46 e [ijklm]	-9.08 \pm 6.92 e [klm]	3.56 \pm 0.31 ab [defghij]	26.58 \pm 10.89 ab [abcdefg]

Marigold	Wood biochar+slurry	7.03 ± 0.18 ab [abcdef]	33.20 ± 1.63 de [jklm]	-6.84 ± 4.56 de [jklm]	3.14 ± 0.31 bc [efghij]	11.64 ± 11.16 bc [bcdefg]
Marigold	Wood biochar NH ₃ +CO ₂	6.62 ± 0.13 bc [defghij]	46.44 ± 9.15 bcd [cdefghijk]	30.33 ± 25.67 bcd [defghijkl]	3.66 ± 0.44 ab [cdefghij]	30.22 ± 15.82 ab [abcdef]
Marigold	Wood biochar+1x	6.51 ± 0.15 cd [defghij]	53.33 ± 3.45 ab [bcde]	49.66 ± 9.67 ab [abcdefgh]	4.30 ± 0.33 a [abcdef]	52.80 ± 11.58 a [ab]
Radish	0x fert	6.48 ± 0.12 cd [efghij]	29.60 ± 7.33 d [m]	NA	3.08 ± 0.27 c [fghij]	NA
Radish	0.25x fert	6.51 ± 0.16 cd [defghij]	40.06 ± 4.41 bcd [efghijklm]	35.33 ± 14.89 bcd [cdefghij]	3.87 ± 0.52 abc [abcdefghi]	25.39 ± 16.91 ab [abcdefg]
Radish	0.5x fert	6.34 ± 0.14 d [ghij]	42.74 ± 7.71 abcd [defghijklm]	44.37 ± 26.04 abcd [bcdefghi]	4.09 ± 0.28 abc [abcdefgh]	32.69 ± 9.13 ab [abcde]
Radish	1x fert	6.35 ± 0.15 d [ghij]	53.04 ± 6.73 ab [bcde]	79.17 ± 22.74 ab [abc]	4.13 ± 0.50 abc [abcdefg]	34.06 ± 16.35 ab [abcde]
Radish	1.5x fert	6.37 ± 0.14 d [ghij]	55.94 ± 8.38 a [bcd]	88.96 ± 28.30 a [a]	4.39 ± 0.83 ab [abcde]	42.25 ± 26.80 ab [abcd]
Radish	Manure biochar	7.22 ± 0.10 ab [abc]	30.19 ± 4.82 d [m]	1.99 ± 16.27 d [ijklm]	3.65 ± 0.84 bc [cdefghij]	18.25 ± 27.22 b [bcdefg]
Radish	Manure biochar+slurry	7.31 ± 0.12 a [abc]	31.60 ± 1.78 d [lm]	6.74 ± 6.00 d [hijklm]	3.93 ± 0.22 abc [abcdefghi]	27.33 ± 7.19 ab [abcdefg]
Radish	Manure biochar CO ₂ +NH ₃	7.25 ± 0.13 a [abc]	55.28 ± 8.68 a [bcd]	86.75 ± 29.34 a [ab]	4.48 ± 0.48 ab [abcd]	45.26 ± 15.45 ab [abc]
Radish	Manure biochar+1x	7.02 ± 0.56 ab [abcdef]	46.72 ± 1.03 abc [bcdefghij]	57.82 ± 3.49 abc [abcdef]	5.04 ± 0.27 a [a]	63.42 ± 8.62 a [a]
Radish	Wood biochar	6.74 ± 0.04 bcd [cdefghi]	31.68 ± 3.45 d [klm]	7.01 ± 11.64 d [hijklm]	3.97 ± 0.35 abc [abcdefghi]	28.79 ± 11.34 ab [abcdefg]
Radish	Wood biochar+slurry	6.90 ± 0.16 abc [abcdefg]	32.58 ± 2.55 cd [jklm]	10.05 ± 8.61 cd [ghijklm]	3.74 ± 0.35 bc [bcdefghij]	21.17 ± 11.28 b [bcdefg]
Radish	Wood biochar NH ₃ +CO ₂	6.45 ± 0.06 cd [fghij]	50.52 ± 8.56 ab [bcdef]	70.65 ± 28.92 ab [abcd]	5.05 ± 0.58 a [a]	63.67 ± 18.83 a [a]
Radish	Wood biochar+1x	6.48 ± 0.14 cd [efghij]	48.51 ± 2.66 ab [bcdefghi]	63.88 ± 8.97 ab [abcde]	5.03 ± 0.55 a [ab]	63.10 ± 17.80 a [a]
Tomato	0x fert	6.11 ± 0.07 d [j]	39.70 ± 3.52 def [efghijklm]	NA	3.52 ± 0.43 bcd [defghij]	NA
Tomato	0.25x fert	6.15 ± 0.18 d [j]	46.36 ± 4.73 cde [cdefghijkl]	16.79 ± 11.92 cde [fghijklm]	3.93 ± 0.66 abcd [abcdefghi]	11.81 ± 18.76 abcd [bcdefg]

Tomato	0.5x fert	6.33 ± 0.55 cd [ghij]	52.98 ± 2.68 bc [bcde]	33.46 ± 6.74 bc [defghijk]	4.20 ± 0.40 abcd [abcdefg]	19.49 ± 11.37 abcd [bcdefg]
Tomato	1x fert	6.17 ± 0.02 d [ij]	60.72 ± 3.40 ab [abc]	52.95 ± 8.58 ab [abcdefg]	3.84 ± 0.78 abcd [abcdefghi]	9.10 ± 22.11 abcd [cdefg]
Tomato	1.5x fert	6.36 ± 0.30 cd [ghij]	71.55 ± 11.10 a [a]	80.23 ± 27.97 a [ab]	3.11 ± 0.60 d [efghij]	-11.59 ± 16.98 d [g]
Tomato	Manure biochar	7.08 ± 0.12 a [abcd]	34.26 ± 2.42 f [hijklm]	-13.69 ± 6.09 f [m]	3.36 ± 0.28 cd [defghij]	-4.48 ± 7.89 cd [efg]
Tomato	Manure biochar+slurry	7.07 ± 0.13 a [abcd]	36.95 ± 1.50 ef [fghijklm]	-6.91 ± 3.78 ef [jklm]	3.63 ± 0.40 bcd [cdefghij]	3.13 ± 11.34 bcd [defg]
Tomato	Manure biochar CO ₂ +NH ₃	6.83 ± 0.46 abc [bcdefgh]	51.64 ± 4.60 bc [bcdef]	30.09 ± 11.58 bc [defghijklm]	4.55 ± 0.24 ab [abcd]	29.30 ± 6.71 ab [abcdefg]
Tomato	Manure biochar+1x	7.05 ± 0.03 ab [abcde]	49.75 ± 3.39 bcd [bcdefg]	25.32 ± 8.55 bcd [efghijklm]	4.40 ± 0.48 abc [abcde]	25.18 ± 13.67 abc [abcdefg]
Tomato	Wood biochar	6.30 ± 0.14 cd [hij]	35.60 ± 3.47 ef [ghijklm]	-10.33 ± 8.74 ef [klm]	3.68 ± 0.21 bcd [cdefghij]	4.62 ± 5.89 bcd [cdefg]
Tomato	Wood biochar+slurry	6.47 ± 0.12 bcd [fghij]	40.16 ± 2.27 def [efghijklm]	1.16 ± 5.73 def [ijklm]	3.77 ± 0.50 abcd [abcdefghij]	7.18 ± 14.22 abcd [cdefg]
Tomato	Wood biochar NH ₃ +CO ₂	6.32 ± 0.11 cd [hij]	51.79 ± 1.76 bc [bcde]	30.45 ± 4.42 bc [defghijkl]	4.33 ± 0.31 abc [abcdef]	23.19 ± 8.73 abc [abcdefg]
Tomato	Wood biochar+1x	6.25 ± 0.05 cd [ij]	57.20 ± 4.41 bc [abcd]	44.10 ± 11.11 bc [bcdefghi]	4.86 ± 0.44 a [abc]	38.26 ± 12.56 a [abcd]

Table SI 6 Total aluminum (Al), sodium (Na), macronutrients (Ca, K, Mg, P, S), micronutrients (Micronutrients: B, Cu, Mn, Mo, Zn), and heavy metals (Cd, Cr, Pb) in plant shoots. Letters indicate significant differences between amendments within plant and biomass type ($p < 0.05$; $n = 4$).

Plant	Amendment	Al	Ca	K	Mg	Na	P	S	Micro-nutrients	Heavy metals
Shoot		(g kg ⁻¹)	(g kg ⁻¹)	(g kg ⁻¹)	(g kg ⁻¹)	(g kg ⁻¹)	(g kg ⁻¹)	(g kg ⁻¹)	(g kg ⁻¹)	(mg kg ⁻¹)
Marigold	0x fert	4.67 ± 1.25 a	8.36 ± 0.68 a	8.07 ± 0.85 a	5.17 ± 0.47 a	0.60 ± 0.29 a	4.44 ± 0.92 a	3.17 ± 0.63 a	0.23 ± 0.03 a	0.45 ± 0.28 a
Marigold	0.25x fert	4.66 ± 2.07 a	8.22 ± 0.37 a	6.84 ± 0.97 a	5.19 ± 0.45 a	0.62 ± 0.12 a	3.85 ± 0.66 a	2.71 ± 0.55 a	0.21 ± 0.03 a	0.28 ± 0.09 a
Marigold	0.5x fert	4.49 ± 1.17 a	7.83 ± 0.88 a	6.37 ± 0.4 a	5.07 ± 0.83 a	0.36 ± 0.26 a	3.28 ± 0.75 a	2.41 ± 0.45 a	0.20 ± 0.03 a	0.40 ± 0.22 a
Marigold	1x fert	5.47 ± 1.55 a	8.39 ± 2.08 a	6.38 ± 0.82 a	5.64 ± 1.73 a	0.43 ± 0.34 a	3.67 ± 0.86 a	2.53 ± 0.44 a	0.23 ± 0.04 a	0.26 ± 0.06 a
Marigold	1.5x fert	5.61 ± 1.29 a	7.33 ± 1.12 a	6.63 ± 0.45 a	4.80 ± 0.72 a	0.49 ± 0.26 a	3.49 ± 0.41 a	2.62 ± 0.32 a	0.21 ± 0.03 a	0.59 ± 0.59 a
Marigold	Manure biochar	4.66 ± 2.53 a	9.24 ± 1.15 a	7.64 ± 1.12 a	5.07 ± 0.58 a	0.27 ± 0.22 a	4.40 ± 0.56 a	3.07 ± 0.24 a	0.20 ± 0.03 a	0.26 ± 0.02 a
Marigold	Manure biochar+ slurry	6.63 ± 2.54 a	8.78 ± 2.03 a	9.65 ± 2.76 a	4.95 ± 1.46 a	0.64 ± 0.38 a	4.93 ± 1.75 a	3.50 ± 1.58 a	0.19 ± 0.04 a	0.32 ± 0.11 a
Marigold	Manure biochar CO ₂ +NH ₃	2.57 ± 2.3 a	6.65 ± 4.56 a	6.96 ± 4.77 a	3.96 ± 2.80 a	0.60 ± 0.48 a	4.06 ± 2.96 a	2.87 ± 2.06 a	0.16 ± 0.12 a	0.20 ± 0.15 a
Marigold	Manure biochar+ 1x	5.65 ± 0.00 a	7.12 ± 0.00 a	10.3 ± 0.00 a	4.13 ± 0.00 a	0.97 ± 0.00 a	4.35 ± 0.00 a	3.16 ± 0.00 a	0.18 ± 0.00 a	0.20 ± 0.00 a
Marigold	Wood biochar	3.75 ± 0.75 a	7.24 ± 0.52 a	7.56 ± 0.34 a	3.88 ± 0.21 a	0.16 ± 0.02 a	3.19 ± 0.15 a	2.15 ± 0.08 a	0.21 ± 0.02 a	0.17 ± 0.04 a
Marigold	Wood biochar+ slurry	5.10 ± 0.33 a	6.94 ± 1.11 a	8.76 ± 1.12 a	3.95 ± 0.59 a	0.48 ± 0.24 a	4.16 ± 0.53 a	2.67 ± 0.43 a	0.21 ± 0.03 a	0.24 ± 0.11 a
Marigold	Wood biochar NH ₃ +CO ₂	6.54 ± 3.73 a	7.61 ± 0.86 a	7.96 ± 2.31 a	4.30 ± 0.44 a	0.28 ± 0.28 a	3.44 ± 0.64 a	2.52 ± 0.68 a	0.22 ± 0.04 a	0.42 ± 0.33 a
Marigold	Wood biochar+ 1x	4.69 ± 2.01 a	7.96 ± 0.84 a	7.28 ± 0.68 a	4.68 ± 0.49 a	0.52 ± 0.24 a	3.01 ± 0.37 a	2.23 ± 0.26 a	0.19 ± 0.05 a	0.33 ± 0.17 a
Radish	0x fert	43.04 ± 60.93 a	23.7 ± 3.85 a	17.83 ± 4.28 a	8.78 ± 1.54 a	7.01 ± 2.19 ab	2.41 ± 0.30 a	2.47 ± 0.52 a	0.44 ± 0.10 a	0.58 ± 0.12 a

Radish	0.25x fert	10.62 ± 3.91 a	22.56 ± 5.53 a	17.33 ± 5.34 a	7.52 ± 1.99 a	7.28 ± 1.70 ab	2.59 ± 0.77 a	2.69 ± 0.63 a	0.41 ± 0.08 a	0.29 ± 0.12 a
Radish	0.5x fert	13.12 ± 6.42 a	22.46 ± 6.00 a	18.28 ± 4.72 a	8.62 ± 1.93 a	9.49 ± 1.20 a	2.35 ± 0.40 a	2.58 ± 0.62 a	0.45 ± 0.04 a	0.44 ± 0.19 a
Radish	1x fert	11.49 ± 4.27 a	24.7 ± 4.50 a	18.04 ± 4.23 a	8.77 ± 1.41 a	9.50 ± 1.88 a	2.59 ± 0.22 a	2.29 ± 0.31 a	0.45 ± 0.03 a	0.33 ± 0.10 a
Radish	1.5x fert	20.07 ± 24.15 a	22.90 ± 5.33 a	17.61 ± 6.76 a	7.83 ± 1.57 a	7.93 ± 2.27 ab	2.80 ± 1.18 a	2.96 ± 1.90 a	0.51 ± 0.17 a	4.46 ± 7.41 a
Radish	Manure biochar	7.08 ± 1.60 a	25.53 ± 6.28 a	20.17 ± 5.05 a	7.69 ± 1.73 a	3.72 ± 1.92 b	2.84 ± 0.68 a	3.07 ± 1.18 a	0.46 ± 0.08 a	0.20 ± 0.05 a
Radish	Manure biochar+ slurry	7.53 ± 2.79 a	26.7 ± 9.82 a	19.6x ± 4.77 a	7.56 ± 2.08 a	3.77 ± 1.18 b	2.76 ± 0.34 a	2.75 ± 0.45 a	0.45 ± 0.11 a	0.33 ± 0.12 a
Radish	Manure biochar CO ₂ +NH ₃	10.86 ± 3.06 a	26.04 ± 4.87 a	18.46 ± 2.30 a	8.63 ± 1.57 a	7.41 ± 4.38 ab	2.89 ± 0.40 a	2.58 ± 0.30 a	0.51 ± 0.08 a	0.67 ± 0.64 a
Radish	Manure biochar+ 1x	10.47 ± 2.45 a	26.84 ± 4.56 a	17.4x ± 3.31 a	8.67 ± 1.22 a	6.89 ± 2.04 ab	2.56 ± 0.47 a	2.06 ± 0.25 a	0.48 ± 0.03 a	0.33 ± 0.12 a
Radish	Wood biochar	8.50 ± 4.75 a	21.29 ± 6.27 a	16.3x ± 4.21 a	6.27 ± 1.86 a	4.46 ± 2.54 ab	2.38 ± 0.45 a	2.46 ± 0.40 a	0.41 ± 0.08 a	0.40 ± 0.32 a
Radish	Wood biochar+ slurry	7.89 ± 4.00 a	18.21 ± 1.38 a	19.0x ± 3.42 a	5.90 ± 0.81 a	5.09 ± 3.02 ab	2.37 ± 0.57 a	2.59 ± 0.68 a	0.40 ± 0.03 a	0.25 ± 0.16 a
Radish	Wood biochar NH ₃ +CO ₂	20.57 ± 24.53 a	20.60 ± 2.61 a	18.17 ± 3.05 a	6.29 ± 1.23 a	4.76 ± 0.94 ab	2.10 ± 0.39 a	1.90 ± 0.45 a	0.43 ± 0.04 a	0.41 ± 0.18 a
Radish	Wood biochar+1x	13.32 ± 6.78 a	23.71 ± 2.80 a	20.22 ± 6.06 a	7.59 ± 0.88 a	6.40 ± 2.15 ab	2.40 ± 0.56 a	2.18 ± 0.49 a	0.44 ± 0.06 a	0.59 ± 0.35 a
Tomato	0x fert	4.53 ± 1.52 a	12.77 ± 1.27 bc	12.48 ± 0.49 a	5.06 ± 0.47 a	2.48 ± 0.52 ab	3.39 ± 0.57 abcd	3.81 ± 0.89 ab	0.19 ± 0.02 a	0.10 ± 0.02 a
Tomato	0.25x fert	4.90 ± 0.37 a	12.31 ± 0.48 bc	12.88 ± 0.99 a	5.08 ± 0.52 a	2.53 ± 0.33 ab	3.04 ± 0.22 cd	3.10 ± 0.35 abc	0.18 ± 0.01 a	0.08 ± 0.01 a
Tomato	0.5x fert	4.78 ± 1.94 a	10.65 ± 0.87 c	12.51 ± 1.39 a	4.42 ± 0.20 a	2.51 ± 0.49 ab	2.87 ± 0.28 cd	3.02 ± 0.47 abc	0.17 ± 0.02 a	0.08 ± 0.02 a
Tomato	1x fert	5.00 ± 0.70 a	10.2 ± 0.86 c	12.16 ± 0.08 a	4.54 ± 0.15 a	3.08 ± 0.73 ab	3.11 ± 0.55 cd	3.58 ± 0.59 abc	0.16 ± 0.01 a	0.11 ± 0.04 a
Tomato	1.5x fert	4.90 ± 2.31 a	10.15 ± 1.16 c	12.75 ± 0.49 a	4.69 ± 0.50 a	4.33 ± 1.10 a	3.76 ± 0.71 abc	3.91 ± 0.92 ab	0.18 ± 0.02 a	0.16 ± 0.05 a
Tomato	Manure biochar	6.53 ± 1.42 a	16.81 ± 1.77 a	13.29 ± 0.55 a	5.08 ± 0.50 a	2.44 ± 0.88 b	4.36 ± 0.33 a	4.12 ± 0.52 a	0.22 ± 0.04 a	0.14 ± 0.03 a
Tomato	Manure biochar+ slurry	5.90 ± 2.33 a	14.90 ± 1.60 ab	13.93 ± 1.23 a	4.51 ± 0.37 a	3.41 ± 1.90 ab	4.22 ± 0.36 ab	3.95 ± 0.51 a	0.41 ± 0.46 a	1.99 ± 3.79 a
Tomato	Manure biochar CO ₂ +NH ₃	5.15 ± 1.33 a	12.20 ± 0.60 bc	13.63 ± 0.74 a	4.27 ± 0.23 a	2.67 ± 0.31 ab	3.75 ± 0.51 abc	3.24 ± 0.33 abc	0.16 ± 0.01 a	0.09 ± 0.01 a

Tomato	Manure biochar+1x	4.67 ± 1.33 a	12.82 ± 1.60 bc	12.91 ± 0.97 a	4.23 ± 0.68 a	1.95 ± 0.50 b	3.57 ± 0.47 abcd	3.18 ± 0.58 abc	0.15 ± 0.02 a	0.11 ± 0.02 a
Tomato	Wood biochar	5.85 ± 1.67 a	12.1 ± 1.04 bc	13.8x ± 0.55 a	4.22 ± 0.10 a	2.14 ± 0.22 b	3.17 ± 0.06 bcd	3.04 ± 0.38 abc	0.22 ± 0.01 a	0.08 ± 0.00 a
Tomato	Wood biochar+ slurry	5.47 ± 2.59 a	12.03 ± 2.14 bc	14.04 ± 0.61 a	4.32 ± 0.60 a	2.84 ± 0.26 ab	3.69 ± 0.32 abc	3.56 ± 0.55 abc	0.22 ± 0.03 a	0.23 ± 0.32 a
Tomato	Wood biochar NH ₃ +CO ₂	5.88 ± 2.44 a	10.6 ± 0.58 c	12.12 ± 1.42 a	4.21 ± 0.50 a	2.29 ± 0.44 b	2.82 ± 0.31 cd	2.60 ± 0.06 bc	0.19 ± 0.01 a	0.11 ± 0.06 a
Tomato	Wood biochar+1x	5.45 ± 0.59 a	11.27 ± 1.34 c	12.59 ± 0.44 a	4.24 ± 0.50 a	1.92 ± 0.23 b	2.59 ± 0.40 d	2.36 ± 0.24 c	0.19 ± 0.02 a	0.08 ± 0.01 a

Table SI 7 Total aluminum (Al), sodium (Na), macronutrients (Ca, K, Mg, P, S), micronutrients (Micronutrients: B, Cu, Mn, Mo, Zn), and heavy metals (H. metal; Cd, Cr, Pb) in plant roots. Letters indicate significant differences between amendments within plant and biomass type ($p < 0.05$; $n = 4$).

Plant	Amendment	Al	Ca	K	Mg	Na	P	S	Micro-nutrients	Heavy metal
Root		(g kg ⁻¹)	(g kg ⁻¹)	(g kg ⁻¹)	(g kg ⁻¹)	(g kg ⁻¹)	(g kg ⁻¹)	(g kg ⁻¹)	(g kg ⁻¹)	(mg kg ⁻¹)
Marigold	0x fert	101.07 ± 125.37 a	4.21 ± 0.43 a	13.91 ± 3.30 abcd	2.97 ± 0.63 ab	22.72 ± 6.44 a	1.85 ± 0.35 ab	3.01 ± 0.87 ab	0.39 ± 0.16 a	1.66 ± 0.56 a
Marigold	0.25x fert	59.37 ± 52.51 a	3.75 ± 0.20 a	11.08 ± 3.43 abcd	3.05 ± 1.22 ab	18.89 ± 3.40 a	1.43 ± 0.31 abcde	2.31 ± 0.28 b	0.30 ± 0.07 a	1.27 ± 0.33 a
Marigold	0.5x fert	34.93 ± 16.46 a	4.01 ± 0.38 a	9.04 ± 1.83 cd	3.14 ± 0.57 ab	17.87 ± 1.77 a	1.18 ± 0.20 de	2.04 ± 0.35 b	0.25 ± 0.05 a	1.03 ± 0.16 a
Marigold	1x fert	71.64 ± 75.75 a	3.97 ± 0.78 a	8.19 ± 2.82 d	3.41 ± 1.25 a	19.93 ± 8.44 a	1.27 ± 0.30 bcde	2.10 ± 0.46 b	0.32 ± 0.16 a	1.53 ± 1.10 a
Marigold	1.5x fert	33.85 ± 14.99 a	3.83 ± 0.22 a	9.40 ± 1.02 bcd	2.81 ± 0.47 ab	19.23 ± 3.41 a	1.30 ± 0.15 abcde	2.16 ± 0.14 b	0.27 ± 0.06 a	1.11 ± 0.24 a
Marigold	Manure biochar	31.23 ± 14.91 a	3.96 ± 0.22 a	17.21 ± 2.44 a	2.28 ± 0.44 ab	19.22 ± 4.64 a	1.76 ± 0.37 abcd	3.25 ± 0.64 ab	0.20 ± 0.03 a	0.59 ± 0.48 a
Marigold	Manure biochar+ slurry	26.78 ± 13.29 a	3.45 ± 0.38 a	15.36 ± 3.01 ab	1.71 ± 0.44 ab	14.80 ± 3.04 a	1.48 ± 0.15 abcde	2.31 ± 0.44 b	0.19 ± 0.07 a	0.57 ± 0.41 a
Marigold	Manure biochar CO ₂ +NH ₃	38.5 ± 13.8 a	3.98 ± 0.44 a	15.62 ± 2.44 abc	2.44 ± 0.16 ab	18.54 ± 1.98 a	1.93 ± 0.27 a	3.25 ± 0.65 ab	0.24 ± 0.07 a	0.69 ± 0.53 a
Marigold	Manure biochar+1x	28.3 ± 0.00 a	4.81 ± 0.00 a	18.22 ± 0.04 a	2.86 ± 0.00 ab	26.09 ± 0.02 a	1.94 ± 0.00 abc	3.95 ± 0.00 a	0.28 ± 0.00 a	0.07 ± 0.00 a
Marigold	Wood biochar	19.17 ± 3.12 a	3.51 ± 0.70 a	15.08 ± 2.36 abc	1.72 ± 0.44 ab	14.90 ± 4.22 a	1.44 ± 0.16 abcde	2.26 ± 0.48 b	0.34 ± 0.31 a	0.55 ± 0.20 a
Marigold	Wood biochar+ slurry	31.81 ± 15.54 a	3.63 ± 0.23 a	16.40 ± 2.47 a	1.45 ± 0.47 b	14.03 ± 2.14 a	1.75 ± 0.06 abcd	2.68 ± 0.43 ab	0.21 ± 0.04 a	0.54 ± 0.40 a
Marigold	Wood biochar NH ₃ +CO ₂	53.47 ± 44.32 a	3.65 ± 0.57 a	13.82 ± 3.03 abcd	2.22 ± 0.94 ab	17.44 ± 4.90 a	1.22 ± 0.24 cde	2.49 ± 0.64 ab	0.26 ± 0.11 a	0.83 ± 0.81 a
Marigold	Wood biochar+1x	34.17 ± 13.82 a	4.10 ± 0.56 a	11.22 ± 1.37 abcd	2.85 ± 0.54 ab	18.38 ± 2.51 a	1.12 ± 0.15 e	2.04 ± 0.42 b	0.24 ± 0.04 a	0.65 ± 0.43 a
Radish	0x fert	26.67± 8.19 a	4.95 ± 0.79 a	8.94 ± 2.20 bcd	4.16 ± 0.43 abcd	17.17 ± 1.80 a	2.53 ± 0.29 abcde	1.46 ± 0.07 ab	0.20 ± 0.02 a	0.00 ± 0.00 a

Radish	0.25x fert	36.78 ± 4.11 a	4.47 ± 0.29 a	6.56 ± 1.44 cd	3.75 ± 0.33 bcde	14.94 ± 1.55 a	1.96 ± 0.19 de	1.41 ± 0.16 ab	0.23 ± 0.01 a	0.00 ± 0.00 a
Radish	0.5x fert	38.10 ± 15.13 a	4.64 ± 0.46 a	7.85 ± 2.10 bcd	3.68 ± 0.32 bcde	14.89 ± 2.74 a	1.90 ± 0.41 de	1.46 ± 0.29 ab	0.23 ± 0.03 a	0.00 ± 0.00 a
Radish	1x fert	50.18 ± 8.43 a	4.51 ± 0.57 a	6.05 ± 0.90 d	3.62 ± 0.56 bcde	16.23 ± 1.28 a	1.75 ± 0.46 de	1.75 ± 0.26 ab	0.24 ± 0.03 a	0.00 ± 0.00 a
Radish	1.5x fert	47.67 ± 29.21 a	4.43 ± 0.51 a	9.64 ± 3.56 bcd	3.70 ± 0.78 bcde	17.81 ± 3.88 a	2.46 ± 0.42 bcde	2.08 ± 0.67 a	0.25 ± 0.08 a	0.00 ± 0.00 a
Radish	Manure biochar	32.83 ± 6.62 a	5.61 ± 0.82 a	13.82 ± 1.01 abc	4.86 ± 0.90 ab	14.21 ± 1.80 a	3.59 ± 0.36 a	1.47 ± 0.09 ab	0.20 ± 0.02 a	0.00 ± 0.00 a
Radish	Manure biochar+ slurry	30.43 ± 6.97 a	5.12 ± 0.23 a	15.01 ± 4.60 ab	4.62 ± 0.62 abc	15.72 ± 2.99 a	3.46 ± 0.45 ab	1.69 ± 0.35 ab	0.18 ± 0.01 a	0.00 ± 0.00 a
Radish	Manure biochar CO ₂ +NH ₃	37.20 ± 11.12 a	4.98 ± 0.46 a	9.01 ± 1.71 bcd	3.95 ± 0.76 abcde	16.04 ± 3.78 a	2.35 ± 0.42 cde	1.30 ± 0.15 b	0.20 ± 0.01 a	0.00 ± 0.00 a
Radish	Manure biochar+1x	39.56 ± 19.03 a	5.75 ± 1.02 a	10.47 ± 5.72 abcd	5.24 ± 0.81 a	17.52 ± 2.19 a	3.32 ± 0.91 abc	1.74 ± 0.48 ab	0.21 ± 0.05 a	0.00 ± 0.00 a
Radish	Wood biochar	46.10 ± 22.42 a	5.24 ± 1.05 a	13.16 ± 3.39 abcd	3.19 ± 0.51 cde	13.17 ± 2.41 a	2.15 ± 0.39 de	1.33 ± 0.26 b	0.27 ± 0.09 a	1.36 ± 2.73 a
Radish	Wood biochar+ slurry	27.82 ± 14.99 a	4.64 ± 0.63 a	17.56 ± 3.60 a	3.03 ± 0.55 de	13.36 ± 3.82 a	2.84 ± 0.43 abcd	1.51 ± 0.23 ab	0.19 ± 0.04 a	0.00 ± 0.00 a
Radish	Wood biochar NH ₃ +CO ₂	37.32 ± 8.80 a	4.59 ± 0.82 a	8.22 ± 0.48 bcd	2.91 ± 0.49 de	16.21 ± 4.47 a	1.74 ± 0.10 e	1.25 ± 0.19 b	0.22 ± 0.03 a	0.00 ± 0.00 a
Radish	Wood biochar+1x	29.10 ± 9.31 a	4.69 ± 0.45 a	7.88 ± 2.52 bcd	2.49 ± 0.19 e	12.91 ± 3.02 a	1.60 ± 0.05 e	1.15 ± 0.17 b	0.20 ± 0.04 a	0.00 ± 0.00 a
Tomato	0x fert	26.74 ± 8.17 a	4.95 ± 0.79 a	8.88 ± 2.24 bcd	4.16 ± 0.43 abcd	17.21 ± 1.78 a	2.53 ± 0.29 abcde	1.46 ± 0.07 ab	0.20 ± 0.02 a	0.00 ± 0.00 a
Tomato	0.25x fert	36.78 ± 4.11 a	4.47 ± 0.29 a	6.60 ± 1.43 cd	3.75 ± 0.33 bcde	14.87 ± 1.59 a	1.96 ± 0.19 de	1.41 ± 0.16 ab	0.23 ± 0.01 a	0.00 ± 0.00 a
Tomato	0.5x fert	38.07 ± 15.10 a	4.64 ± 0.46 a	7.92 ± 2.10 bcd	3.68 ± 0.32 bcde	14.91 ± 2.67 a	1.90 ± 0.41 de	1.46 ± 0.29 ab	0.23 ± 0.03 a	0.00 ± 0.00 a
Tomato	1x fert	50.24 ± 8.39 a	4.51 ± 0.57 a	6.08 ± 0.91 d	3.62 ± 0.56 bcde	16.17 ± 1.29 a	1.75 ± 0.46 e	1.75 ± 0.26 ab	0.24 ± 0.03 a	0.00 ± 0.00 a
Tomato	1.5x fert	47.70 ± 29.22 a	4.43 ± 0.51 a	9.58 ± 3.64 bcd	3.70 ± 0.78 bcde	17.80 ± 3.88 a	2.46 ± 0.42 bcde	2.08 ± 0.67 a	0.25 ± 0.08 a	0.00 ± 0.02 a
Tomato	Manure biochar	32.76 ± 6.61 a	5.61 ± 0.82 a	13.84 ± 1.07 abc	4.86 ± 0.90 ab	14.22 ± 1.76 a	3.59 ± 0.36 a	1.47 ± 0.09 ab	0.21 ± 0.02 a	0.00 ± 0.00 a
Tomato	Manure biochar+ slurry	30.42 ± 7.00 a	5.12 ± 0.23 a	145.35 ± 4.62 ab	4.62 ± 0.62 abc	15.70 ± 3.04 a	3.46 ± 0.45 ab	1.69 ± 0.35 ab	0.18 ± 0.01 a	0.00 ± 0.00 a
Tomato	Manure biochar CO ₂ +NH ₃	37.19 ± 11.14 a	4.98 ± 0.46 a	8.97 ± 1.74 bcd	3.95 ± 0.76 abcde	16.01 ± 3.77 a	2.35 ± 0.42 cde	1.30 ± 0.15 b	0.20 ± 0.01 a	0.00 ± 0.00 a

Tomato	Manure biochar+1x	39.62 ± 18.89 a	5.75 ± 1.02 a	10.54 ± 5.73 abcd	5.24 ± 0.81 a	17.52 ± 2.23 a	3.32 ± 0.91 abc	1.74 ± 0.48 ab	0.21 ± 0.05 a	0.00 ± 0.00 a
Tomato	Wood biochar	46.10 ± 22.41 a	5.24 ± 1.05 a	13.18 ± 3.39 abcd	3.19 ± 0.51 cde	13.22 ± 2.35 a	2.15 ± 0.39 de	1.33 ± 0.26 b	0.27 ± 0.09 a	1.36 ± 2.73 a
Tomato	Wood biochar+ slurry	27.77 ± 15.02 a	4.64 ± 0.63 a	17.61 ± 3.62 a	3.03 ± 0.55 de	13.43 ± 3.76 a	2.84 ± 0.43 abcd	1.51 ± 0.23 ab	0.19 ± 0.04 a	0.00 ± 0.00 a
Tomato	Wood biochar NH ₃ +CO ₂	37.30 ± 8.81 a	4.59 ± 0.82 a	8.19 ± 0.53 bcd	2.91 ± 0.49 de	16.24 ± 4.48 a	1.74 ± 0.10 e	1.25 ± 0.19 b	0.22 ± 0.03 a	0.00 ± 0.00 a
Tomato	Wood biochar+1x	29.12 ± 9.31 a	4.69 ± 0.45 a	7.88 ± 2.47 bcd	2.49 ± 0.19 e	12.89 ± 2.99 a	1.60 ± 0.05 e	1.15 ± 0.17 b	0.20 ± 0.04 a	0.00 ± 0.00 a