



Figure 1. Pot-based experiment with perennial ryegrass (*Lolium perenne* L.). Pots were filled with loamy sand with addition of straw and biochar produced from miscanthus (*Miscanthus × giganteus*) and winter wheat (*Triticum aestivum* L.). Pots were placed in a rainfall shelter with no walls and with transparent glass roof to exclude precipitation but to ensure natural light and ventilation.



Figure S2. Straw and biochar produced from miscanthus (*Miscanthus × giganteus*) and winter wheat (*Triticum aestivum* L.) used as soil amendment in a pot experiment; miscanthus straw biochar (a), wheat straw biochar (b), miscanthus straw (c), wheat straw (d).

Table S1. Analysis of variance (ANOVA) for biomass production of perennial ryegrass.

Factor	df	1 st cut 2017		2 nd cut 2017		3 rd cut 2017		1 st cut 2018		2 nd cut 2018		3 rd cut 2018	
		<i>F</i>	<i>p</i>	<i>F</i>	<i>p</i>	<i>F</i>	<i>p</i>	<i>F</i>	<i>p</i>	<i>F</i>	<i>p</i>	<i>F</i>	<i>p</i>
Amendment	1	429.74	<0.001	168.05	<0.001	32.91	<0.001	1052.78	<0.001	238.42	<0.001	3.68	0.070
Species	1	0.09	0.770	10.42	0.004	223.44	<0.001	15.81	<0.001	2.73	0.114	5.76	0.026
Rate	1	14.57	<0.001	3.79	0.066	2.99	0.099	39.49	<0.001	7.20	0.014	0.09	0.764
A×S	1	12.32	<0.001	10.82	0.004	67.90	<0.001	15.81	<0.001	14.40	<0.001	0.07	0.789
A×R	1	4.55	0.046	9.43	0.006	6.07	0.023	124.49	<0.001	15.06	<0.001	0.55	0.469
S×R	1	0.11	0.740	11.10	0.003	12.68	0.002	0.41	0.529	8.13	0.010	1.55	0.228
A×S×R	1	0.61	0.444	2.05	0.168	0.68	0.420	5.94	0.024	0.53	0.476	0.71	0.410

Table S2. Analysis of variance (ANOVA) for root morphometric parameters, root dry matter density (RDMD), root volume density (RVD), mean root diameter (MRD), specific root length (SRL), root surface area density (RSA), root:shoot ratio (RSR), root tissue density (RTD).

Factor	d f	RDMD		RVD		MRD		SRL		RSA		RSR		RTD	
		<i>F</i>	<i>p</i>	<i>F</i>	<i>p</i>	<i>F</i>	<i>p</i>	<i>F</i>	<i>p</i>	<i>F</i>	<i>p</i>	<i>F</i>	<i>p</i>	<i>F</i>	<i>p</i>
Amendme nt	1	4.8 2	0.04 4	6.2 4	0.01 5	0.0 5	0.81 5	0.0 8	0.76 9	6.8 4	0.01 1	21.4 0	0.00 0	0.61 4	0.43 5
Species	1	0.0 0	0.94 7	0.7 7	0.38 1	0.7 8	0.37 8	0.7 7	0.38 3	0.6 0	0.43 8	0.67 3	0.42 3	2.86 3	0.09 4
Rate	1	0.3 4	0.56 0	0.2 4	0.62 0	0.5 6	0.42 1	0.5 7	0.45 0	0.6 2	0.43 1	0.44 7	0.51 7	0.26 1	0.61 0
A×S	1	0.9 6	0.32 8	0.9 7	0.32 6	0.7 7	0.38 2	0.0 7	0.78 9	0.0 0	0.98 9	0.18 6	0.67 6	0.86 3	0.41 7
A×R	1	3.3 7	0.07 0	0.0 2	0.87 1	0.7 2	0.39 9	1.3 2	0.25 4	0.6 8	0.40 9	0.41 9	0.52 9	0.74 6	0.39 0
S×R	1	0.4 2	0.51 5	0.1 7	0.67 8	1.8 8	0.17 4	0.9 3	0.33 8	0.1 0	0.75 1	0.88 8	0.35 8	0.00 2	0.96 1
A×S×R	1	5.2 0	0.02 5	4.3 2	0.04 1	9.0 5	0.00 3	0.8 5	0.46 2	4.2 8	0.04 2	5.90 5	0.02 5	6.72 7	0.01 1

Table S3. Analysis of variance (ANOVA) for root length density (RLD) parameter.

Factor	df	RLD	
		<i>F</i>	<i>p</i>
Amendment	1	4.29	0.042
Species	1	0.48	0.489
Rate	1	2.62	0.110
Diameter	7	338.87	<0.001
A×S	1	2.85	0.091
A×R	1	3.54	0.060
S×R	1	1.22	0.268
A×D	7	2.51	0.015
S×D	7	1.94	0.060
R×D	7	1.58	0.137
A×S×R	1	1.49	0.134
A×S×D	7	1.61	0.128
A×R×D	7	1.26	0.265
S×R×D	7	0.71	0.661
A×S×R×D	7	1.22	0.288

Table S4. Root morphometric characteristics, root length density (RLD), root dry matter density (RDMD), root volume density (RVD), mean root diameter (MRD), specific root length (SRL), root surface area (RSA), root:shoot ratio (RSR), root tissue density (RTD).

Treatment	RLD (cm cm ⁻³)	RDMD (mg cm ⁻³)	RVD (cm ³ cm ⁻³)	MRD (mm)	SRL (m g ⁻¹)	RSA (cm ² cm ⁻³)	RSR (g g ⁻¹)	RTD (mg cm ⁻³)
1%MBM	90.40 ^{ab}	2.19 ^{ab}	0.00456 ^b	0.0527 ^{bc}	427.6	1.486 ^b	0.90 ^b	0.479 ^b
2%MBM	75.45 ^b	2.34 ^a	0.00409 ^b	0.0588 ^{ab}	325.7	1.356 ^b	0.87 ^b	0.489 ^b
1%MBW	80.98 ^b	1.99 ^{ab}	0.00543 ^{ab}	0.0597 ^a	411.2	1.515 ^{ab}	0.80 ^b	0.367 ^c
2%MBW	94.40 ^a	2.84 ^a	0.00653 ^a	0.0618 ^a	378.6	1.805 ^a	1.05 ^b	0.435 ^{bc}
1%MSM	74.75 ^b	1.75 ^{bc}	0.00371 ^{bc}	0.0537 ^{bc}	424.2	1.246 ^b	1.11 ^{ab}	0.472 ^b
2%MSM	61.90 ^{bc}	1.90 ^b	0.00505 ^{ab}	0.0551 ^b	328.2	1.262 ^b	1.38 ^a	0.376 ^c
1%MSW	71.23 ^{bc}	1.85 ^{bc}	0.00482 ^b	0.0561 ^b	368.5	1.380 ^b	1.02 ^b	0.384 ^{bc}
2%MSW	77.06 ^{ab}	1.90 ^b	0.00458 ^b	0.0570 ^{ab}	403.4	1.364 ^b	1.21 ^{ab}	0.415 ^{bc}
MCTR	83.69 ^{ab}	1.71 ^{bc}	0.00331 ^{bc}	0.0494 ^c	514.6	1.302 ^b	0.86 ^b	0.515 ^{ab}
CTR	53.49 ^c	1.25 ^c	0.00216 ^c	0.0489 ^c	432.6	0.815 ^c	1.04 ^b	0.576 ^a
Means for amendments rate								
1%	79.34	1.94	0.00463	0.0555	407.9	1.407	0.96	0.420
2%	77.21	2.24	0.00506	0.0582	359.0	1.447	1.13	0.429
Means for feedstock species								
Miscanthus	75.63	2.04	0.00435	0.0576	376.4	1.338	1.07	0.451
Wheat	80.92	2.15	0.00534	0.0586	390.4	1.516	1.02	0.402
Means for amendment material								
Biochar	85.31 ^a	2.34 ^a	0.00515 ^a	0.0583	385.8	1.541 ^a	0.91 ^b	0.439
Straw	71.24 ^b	1.85 ^b	0.00454 ^b	0.0580	381.1	1.313 ^b	1.18 ^a	0.407

For each column, mean values with different letters are significantly different ($P<0.05$); Bonferroni post hoc test; superscripts used only for significant differences according to ANOVA (see Table S2 in Supplementary Materials).

Table S5. Pearson's correlation coefficients (r) between root morphometric parameters, root dry matter density (RDMD), root surface area density (RSA), root volume density (RVD), root length density (RLD) and annual aboveground biomass productivity of perennial ryegrass.

Root morphometric parameter	Annual yield
RDMD	0.537**
RSA	0.544**
RVD	0.447*
RLD	0.497**
MRD	0.253
SRL	-0.111
RTD	-0.038

r is statistically significant at * $P < 0.05$, ** $P < 0.01$