



Supplement of

Experimental drought and soil amendments affect grassland above- and belowground vegetation but not soil carbon stocks

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Supplements

Tables

Table S1. Climate, coordinates and soil texture for the study locations

General area:

- Mean annual precipitation 1991-2020: 500 mm
- Mean annual temperature 1991-2020: 6.5°C (Swedish Meteorological and Hydrological Institute, 2022)
- masl 50 m
- distance Ämtvik-Tovetorp: ~5 km
- distance high elevation site – low elevation site: 50 m, 6 m elevation difference
- distance to the forest edge: 6–20 m in Ämtvik, 50–90 m in Tovetorp

Location	Coordinates	Clay (%)	Silt (%)	Sand (%)
Tovetorp High	58.9458 N 17.1493 E	44,0	40,2	15,8
Tovetorp Low	58.9452 N 17.1494 E	28,3	41,7	30,0
Ämtvik High	58.9599 N 17.0939 E	26,3	58,7	15,0
Ämtvik Low	58.9587 N 17.0941 E	29,3	38,3	32,3

Table S2. Monthly precipitation data 2018-2022

Year	Month	Total precipitation (mm)	Year	Month	Total precipitation (mm)
2018	January	62.0	2020	July	37.0
2018	February	12.8	2020	August	11.6
2018	March	11.2	2020	September	41.6
2018	April	21.2	2020	October	90.4
2018	May	12.8	2020	November	22.8
2018	June	20.0	2020	December	89.8
2018	July	8.8	2021	January	46.0
2018	August	14.0	2021	February	4.4
2018	September	14.8	2021	March	15.8
2018	October	13.2	2021	April	12.4
2018	November	17.6	2021	May	106.8
2018	December	36.2	2021	June	28.4
2019	January	11.2	2021	July	34.8
2019	February	27.6	2021	August	67.8
2019	March	54.2	2021	September	23.0
2019	April	0.0	2021	October	28.6
2019	May	45.8	2021	November	30.4
2019	June	27.4	2021	December	23.4
2019	July	34.8	2022	January	33.6
2019	August	49.2	2022	February	51.6
2019	September	30.4	2022	March	0.0
2019	October	45.6	2022	April	24.2
2019	November	46.4	2022	May	30.8
2019	December	72.2	2022	June	10.8
2020	January	22.0	2022	July	50.8
2020	February	23.2	2022	August	39.2
2020	March	44.2	2022	September	29.4
2020	April	12.6	2022	October	32.2
2020	May	20.2	2022	November	37.2
2020	June	19.4	2022	December	21.8

Table S3. pH and nutrients (P, K, Mg, Ca) in the soil samples

plot	site	treatment	year	pH	P_AL (mg/100g)	K_AL (mg/100g)	Mg_AL (mg/100g)	Ca_AL (mg/100g)
1	Tovetorp high	control	2019	5,9	7,0	13,2	26,8	121,6
2	Tovetorp high	control	2019	5,9	7,8	15,1	23,2	116,5
3	Tovetorp high	control	2019	5,9	8,0	16,0	23,6	120,7
4	Tovetorp high	control	2019	5,9	6,5	15,8	21,7	109,8
5	Tovetorp high	control	2019	6,0	8,4	17,6	23,1	122,4
6	Tovetorp high	control	2019	5,8	7,7	16,2	20,0	117,4
7	Tovetorp high	control	2019	5,8	6,9	16,0	24,7	118,4
8	Tovetorp high	control	2019	6,0	7,0	17,7	24,8	121,5
9	Tovetorp high	control	2019	5,9	6,2	22,4	21,8	111,0
10	Tovetorp high	control	2019	5,8	6,8	20,8	19,6	104,5
11	Tovetorp high	control	2019	6,0	5,4	23,1	22,6	119,1
12	Tovetorp high	control	2019	5,9	5,8	23,1	16,9	103,1
13	Tovetorp low	control	2019	5,3	13,6	7,8	15,6	87,3
14	Tovetorp low	control	2019	5,5	10,4	9,5	16,8	90,6
15	Tovetorp low	control	2019	5,5	12,8	12,8	17,4	102,4
16	Tovetorp low	control	2019	5,6	14,4	12,0	17,8	109,5
17	Tovetorp low	control	2019	5,6	11,0	9,9	18,7	110,2
18	Tovetorp low	control	2019	5,5	10,9	10,1	18,7	111,5
19	Tovetorp low	control	2019	5,4	9,3	10,5	21,6	94,8
20	Tovetorp low	control	2019	5,5	11,3	8,7	18,9	100,0
21	Tovetorp low	control	2019	5,5	11,4	11,2	19,0	111,5
22	Tovetorp low	control	2019	5,5	11,5	11,8	21,2	117,7
23	Tovetorp low	control	2019	5,5	9,1	10,2	18,1	92,4
24	Tovetorp low	control	2019	5,6	14,2	6,8	19,1	115,8
25	Ämtvik high	control	2019	5,7	1,2	6,4	36,2	99,3
26	Ämtvik high	control	2019	5,6	1,4	7,0	27,6	83,3
27	Ämtvik high	control	2019	5,5	1,6	6,2	20,8	87,9
28	Ämtvik high	control	2019	5,6	1,0	4,8	13,6	61,6
29	Ämtvik high	control	2019	5,7	1,4	8,8	30,1	100,2
30	Ämtvik high	control	2019	5,4	1,6	7,5	23,4	84,5

31	Ämtvik high	control	2019	5,5	1,3	9,3	23,6	82,2
32	Ämtvik high	control	2019	5,6	1,7	12,9	28,6	89,3
33	Ämtvik high	control	2019	5,5	1,5	8,7	24,8	86,6
34	Ämtvik high	control	2019	5,6	1,4	11,3	26,9	85,8
35	Ämtvik high	control	2019	5,7	1,4	13,6	23,2	76,8
36	Ämtvik high	control	2019	5,5	1,2	8,2	16,9	64,3
37	Ämtvik low	control	2019	5,7	1,2	20,8	19,9	63,8
38	Ämtvik low	control	2019	5,8	1,5	17,8	22,8	80,3
39	Ämtvik low	control	2019	5,9	1,1	10,6	17,8	73,8
40	Ämtvik low	control	2019	5,7	1,3	9,3	17,8	64,9
41	Ämtvik low	control	2019	5,6	1,1	10,1	31,7	84,1
42	Ämtvik low	control	2019	6,0	1,1	12,2	17,8	70,3
43	Ämtvik low	control	2019	5,7	1,2	6,8	16,3	62,0
44	Ämtvik low	control	2019	5,6	1,6	10,2	19,7	75,2
45	Ämtvik low	control	2019	5,6	1,4	10,0	19,4	78,9
46	Ämtvik low	control	2019	5,8	1,0	7,4	13,5	51,3
47	Ämtvik low	control	2019	6,0	11,9	43,3	28,1	144,0
48	Ämtvik low	control	2019	5,7	1,0	5,3	14,0	55,6
1	Tovetorp high	drought	2022	6,1	6,7	16,0	28,0	136,2
2	Tovetorp high	drought x compost	2022	6,2	8,5	16,0	26,4	131,4
3	Tovetorp high	control	2022	6,0	6,5	14,9	21,5	113,4
4	Tovetorp high	compost	2022	6,2	7,2	17,3	26,4	127,6
5	Tovetorp high	drought	2022	6,0	7,6	14,9	22,1	121,3
6	Tovetorp high	drought x compost	2022	6,0	4,2	11,9	17,0	105,7
7	Tovetorp high	control	2022	6,0	9,4	14,9	26,5	128,2
8	Tovetorp high	compost	2022	6,0	7,0	14,6	24,5	124,4
9	Tovetorp high	drought	2022	5,9	6,4	15,4	20,6	114,6
10	Tovetorp high	drought x compost	2022	6,0	4,9	16,0	22,1	117,5
11	Tovetorp high	control	2022	6,1	6,0	15,4	22,6	120,3
12	Tovetorp high	compost	2022	6,1	6,1	17,2	17,2	105,3
13	Tovetorp low	drought	2022	5,8	9,5	6,7	14,4	80,8
14	Tovetorp low	drought x compost	2022	5,7	12,0	7,4	13,2	77,0
15	Tovetorp low	drought x compost	2022	5,8	12,9	9,8	16,1	97,6

16	Tovetorp low	drought	2022	5,6	9,3	6,1	15,1	98,0
17	Tovetorp low	compost	2022	5,7	14,7	10,8	17,1	106,5
18	Tovetorp low	control	2022	5,6	11,0	9,8	17,8	108,2
19	Tovetorp low	control	2022	5,5	9,1	15,3	25,2	131,8
20	Tovetorp low	compost	2022	5,6	8,6	9,8	18,4	92,8
21	Tovetorp low	drought	2022	5,6	9,9	7,5	16,3	94,3
22	Tovetorp low	drought x compost	2022	5,6	12,1	8,3	19,0	108,1
23	Tovetorp low	control	2022	5,9	11,9	7,2	16,4	101,8
24	Tovetorp low	compost	2022	5,6	10,0	6,5	16,5	106,2
25	Ämtvik high	drought x compost	2022	6,0	1,1	8,0	32,3	114,9
26	Ämtvik high	drought	2022	6,0	1,5	9,9	20,9	61,3
27	Ämtvik high	drought x compost	2022	5,8	1,3	5,0	12,7	57,6
28	Ämtvik high	drought	2022	5,7	1,2	4,9	12,6	57,2
29	Ämtvik high	control	2022	5,8	1,1	6,7	20,5	75,8
30	Ämtvik high	compost	2022	5,9	1,5	17,7	26,9	81,8
31	Ämtvik high	control	2022	5,9	1,0	5,6	30,0	72,3
32	Ämtvik high	compost	2022	5,7	1,3	6,3	16,4	62,7
33	Ämtvik high	drought	2022	5,9	0,9	5,9	28,8	88,4
34	Ämtvik high	drought x compost	2022	6,0	1,1	11,1	25,5	73,4
35	Ämtvik high	compost	2022	5,8	1,3	7,1	24,6	77,8
36	Ämtvik high	control	2022	6,0	0,5	5,7	15,3	43,0
37	Ämtvik low	control	2022	5,9	1,0	6,5	26,1	59,3
38	Ämtvik low	compost	2022	5,8	1,0	6,5	18,5	62,0
39	Ämtvik low	drought	2022	5,6	1,3	9,4	14,1	58,9
40	Ämtvik low	drought x compost	2022	5,6	1,3	6,2	16,6	54,5
41	Ämtvik low	compost	2022	5,9	1,8	8,3	16,0	61,4
42	Ämtvik low	control	2022	6,1	1,3	11,4	20,4	70,9
43	Ämtvik low	drought x compost	2022	5,7	1,6	8,1	32,0	84,7
44	Ämtvik low	drought	2022	5,5	1,2	9,6	14,8	56,2
45	Ämtvik low	compost	2022	5,8	3,0	6,9	14,7	61,7
46	Ämtvik low	control	2022	5,7	1,6	6,3	15,3	58,1
47	Ämtvik low	drought	2022	5,7	1,3	4,5	16,6	57,6
48	Ämtvik low	drought x compost	2022	5,8	1,1	5,2	12,7	50,1

Table S4. Relative abundance of grasses, forbs and legumes in 2019 (as percentage of total dry weight of live plant biomass excluding mosses, average values per site, n = 6):

Site	% grasses (n = 6)	% forbs (n = 6)	% legumes (n = 6)	Average biomass increase (g m ²) 2019- 2022 (compost-treated plots, n = 3)
Tovetorp - High elevation	66,4	23,9	9,7	420,3
Tovetorp - Low elevation	88,4	10,6	1,0	581,7
Ämtvik - High elevation	66,0	26,2	7,8	234,7
Ämtvik - Low elevation	54,8	34,6	10,5	193,7

Table S5. Details of the sampling design

	2019	2022
Soil bulk density	3 cores per site (12 cores in total)	1 core per plot (48 cores in total)
Total C and N and $\delta^{13}\text{C}$	6 cores per site (24 cores in total)	1 core per plot (48 cores in total)
pH	0-10 cm, 10-20 cm, 20-30 cm and 40-50 cm. All plots (n = 48)	0-10 cm, 10-20 cm, 20-30 cm and 40-50 cm. All plots (n = 48)
P, Ca, Mg, K	0-30 cm. All plots (n = 48)	10-20 cm. All plots (n = 48)
Soil moisture	All plots (n = 48)	All plots (n = 48)
Root biomass	All plots (n = 48)	All plots (n = 48)
Aboveground biomass	All plots (n = 48)	All plots (n = 48)

Table S6. Effect sizes (Cohen's d) of the differences between sites, years and treatments for each soil depth. Effect sizes can be regarded as small (absolute value <0.2), medium (0.2-0.8) or large (> 0.8, bold).

depth	factor	Tot C	C stock	Bulk density	Root biomass	Aboveground biomass
0–5 cm		0.21	0.10	-0.40	-0.32	
0–15 cm	grassland	0.64	0.58	-0.36	-0.24	-0.17
15–30 cm		-0.67	-0.89	-0.01	1.00	
30–45 cm		-0.53	-0.51	0.53	0.28	
0–5 cm		-1.03	-1.12	-0.06	-0.44	
0–15 cm	catenary position	-0.61	-0.47	1.09	-0.86	
15–30 cm		-0.48	-0.46	-0.68	-0.64	0.14
30–45 cm		-0.96	-0.99	0.62	0.27	
0–5 cm		0.34	-0.08	-0.81	0.07	
0–15 cm	year	0.96	1.25	0.06	1.27	-1.62
15–30 cm		0.21	0.23	-0.19	0.49	
30–45 cm		0.30	0.13	-1.41	0.87	
0–5 cm		0.52	0.26	-0.79	-0.08	
0–15 cm	compost	-0.02	0.26	0.40	0.14	1.13
15–30 cm		-0.13	-0.18	0.50	-0.33	
30–45 cm		-0.49	-0.33	1.25	1.82	
0–5 cm		-0.07	0.01	0.09	-0.20	
0–15 cm	drought	-0.29	-0.22	-0.12	0.95	-0.19
15–30 cm		-0.33	0.09	0.93	-0.49	
30–45 cm		-0.39	-0.63	-1.03	0.24	

Table S7. Effect of the treatments, F and P values from the mixed linear model

variable		coefficient	F-value	P-value
Tot C%	Compost (control)	-0.505312	3.92	0.04
	Drought (drought)	0.012977	0.11	0.74
	depth	-0.330701	381.34	< 0.001
	compost*drought	-0.085369	0.09	0.75
	compost*depth	0.076318	4.71	0.03
	drought*depth	-0.002850	0.07	0.78
	compost*drought*depth	0.001698	0.18	0.67
	Soil C stock	Compost (control)	-1.711e-01	2.55
Drought (drought)		1.367e-02	0.02	0.88
depth		-1.581e-01	318.82	< 0.001
compost*drought		-1.664e-03	0.45	0.49
compost*depth		2.477e-02	1.58	0.21
drought*depth		-9.951e-03	0.75	0.38
compost*drought*depth		-3.883e-04	0.14	0.70
Bulk Density		Compost (control)	0.103812	4.43
	Drought (drought)	0.004631	0.53	0.46
	depth	0.065142	133.90	< 0.001
	compost*drought	0.038799	0.01	0.91
	compost*depth	-0.023496	3.42	0.06
	drought*depth	-0.017299	2.60	0.10
	compost*drought*depth	0.011497	1.24	0.26
	Root biomass	Compost (control)	0.205588	0.01
Drought (drought)		0.022839	0.26	0.60
depth		-0.607117	742.50	< 0.001
compost*drought		-0.178543	0.28	0.59
compost*depth		-0.069662	0.03	0.84
drought*depth		-0.002867	0.01	0.97
compost*drought*depth		0.024838	0.51	0.47
Root:shoot		Compost (control)	0.343372	0.26
	Drought (drought)	0.212338	1.44	0.23
	depth	-0.616760	730.55	< 0.001
	compost*drought	-0.262769	0.54	0.46
	compost*depth	-0.053439	0.04	0.84
	drought*depth	0.006602	0.01	0.93
	compost*drought*depth	-0.001445	0.20	0.65
	Aboveground biomass	Compost (control)	-146.010	43.47
Drought (drought)		-160.656	61.29	< 0.001
compost*drought		135.720	32.77	< 0.001

Table S8. Spatial variability, F and P values from the mixed linear model

variable		coefficient	F-value	P-value
Tot C%	Grassland (Tovetorp)	-0.74720	6.12	0.01
	catenary position (Low)	-0.04495	88.07	< 0.01
	depth	-0.34268	1031.73	< 0.01
	grass*cat pos	1.26078	43.19	< 0.01
	grass*depth	0.12659	42.61	< 0.01
	cat pos*depth	0.04961	2.44	0.12
	grass*cat pos*depth	-0.08199	3.85	0.04
	Soil C stock	Grassland (Tovetorp)	-0.15975	3.80
catenary position (Low)		0.16169	59.62	< 0.01
depth		-0.16568	697.73	< 0.01
grass*cat pos		0.28128	9.98	< 0.01
grass*depth		0.04597	44.45	< 0.01
cat pos*depth		0.01387	0.28	0.59
grass*cat pos*depth		0.01279	0.75	0.38
Bulk Density		Grassland (Tovetorp)	0.253719	5.82
	catenary position (Low)	0.166079	16.51	< 0.01
	depth	0.061534	261.30	< 0.01
	grass*cat pos	-0.393454	44.24	< 0.01
	grass*depth	-0.026164	4.00	0.04
	cat pos*depth	-0.018662	4.60	0.03
	grass*cat pos*depth	0.034814	10.94	< 0.01
	Root biomass	Grassland (Tovetorp)	97.60	0.72
catenary position (Low)		107.19	3.89	0.04
depth		-50.41	581.87	< 0.01
grass*cat pos		213.00	5.61	0.02
grass*depth		-16.30	1.83	0.17
cat pos*depth		-12.29	12.94	< 0.01
grass*cat pos*depth		-34.77	0.04	0.83
Root:shoot		Grassland (Tovetorp)	0.02614	0.42
	catenary position (Low)	0.09763	3.96	0.04
	depth	-0.70420	748.09	< 0.01
	grass*cat pos	0.01363	1.26	0.26
	grass*depth	-0.05263	2.60	0.11
	cat pos*depth	0.22429	12.17	< 0.01
	grass*cat pos*depth	-0.01548	0.49	0.48
	Aboveground biomass	Grassland (Tovetorp)	-79.730	9.58
catenary position (Low)		-147.158	0.24	0.62
grass*cat pos		319.817	38.14	< 0.01

Table S9. Temporal variability, F and P values from the mixed linear model

variable		coefficient	F-value	P-value
Tot C%	Year (2022)	0.03766	12.22	< 0.01
	depth	-0.25696	969.92	< 0.01
	year*depth	-0.03626	0.79	0.37
Soil C stock	Year (2022)	0.138012	5.00	0.02
	depth	-0.114506	659.01	< 0.01
	year*depth	-0.036145	0.001	0.96
Bulk Density	Year (2022)	7.962e-02	6.83	< 0.01
	depth	4.808e-02	254.08	< 0.01
	year*depth	-5.085e-04	0.27	0.59
Root biomass	Year (2022)	0.33963	7.27	< 0.01
	depth	-0.60590	581.70	< 0.01
	year*depth	-0.03090	9.13	< 0.01
Root:shoot	Year (2022)	-0.16514	22.62	< 0.01
	depth	-0.61237	575.76	< 0.01
	year*depth	-0.02721	8.99	< 0.01
Aboveground biomass	Year (2022)	258.223	102.75	< 0.01

Figures

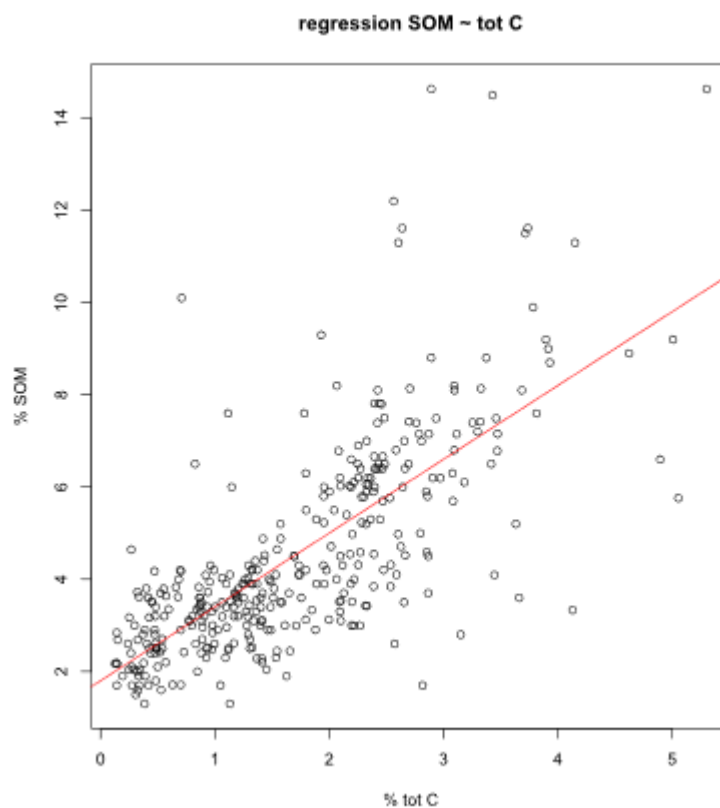


Fig S1. Regression plot SOM ~ tot C in the study system.

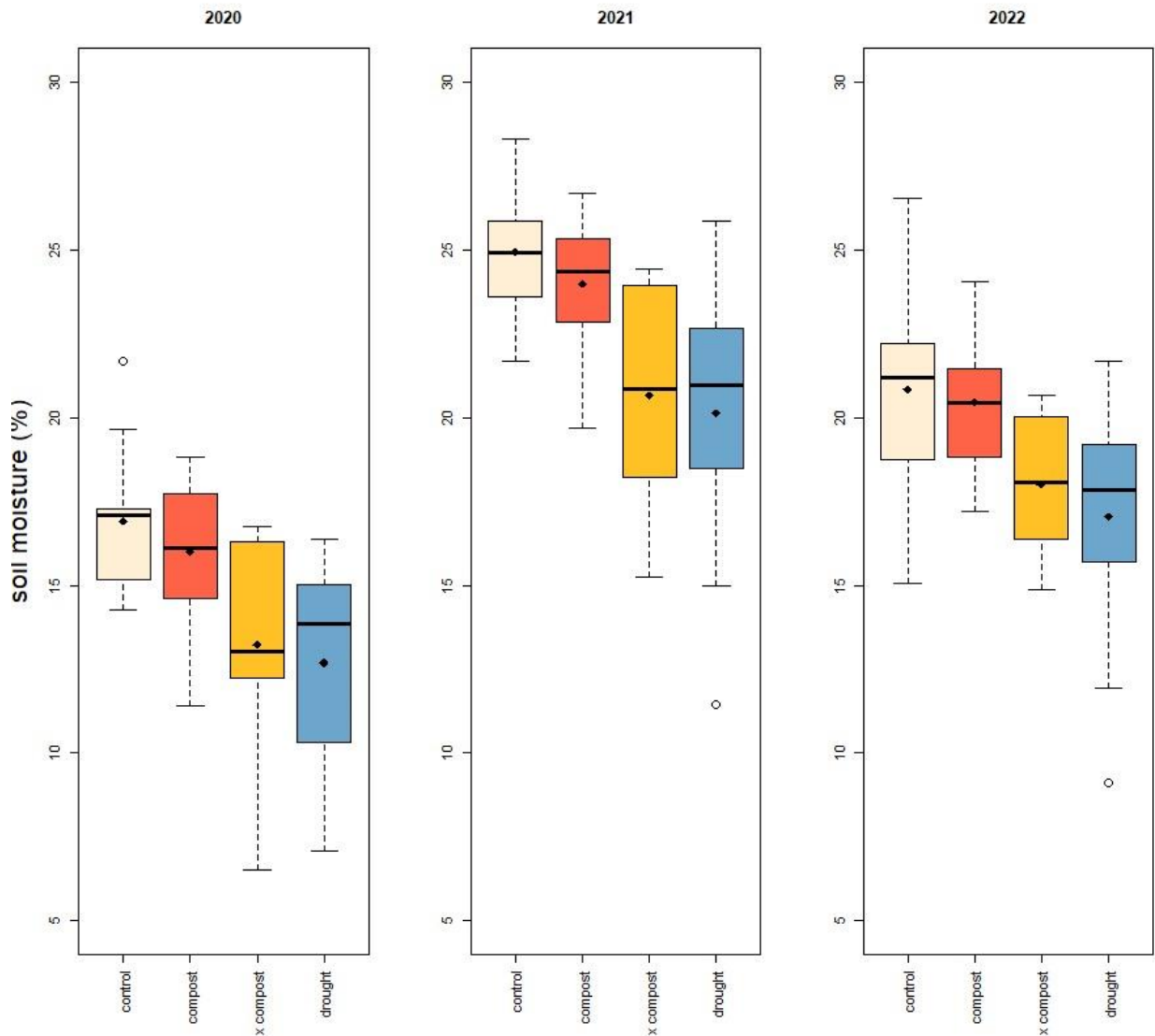


Fig. S2. Growing season (April through August) average values of volumetric soil moisture (%) in the 0-30 cm soil depth for each treatment (colored boxes), for 2020, 2021 and 2022. Values are means for all sites ($n = 12$). White = control, red = compost, yellow = compost \times drought, blue = drought. Boxes show mean (dot inside the box), median (horizontal line) and interquartile range (IQR, colored box); whiskers extend to $1.5 \times \text{IQR}$; empty dots in the graph are outliers.

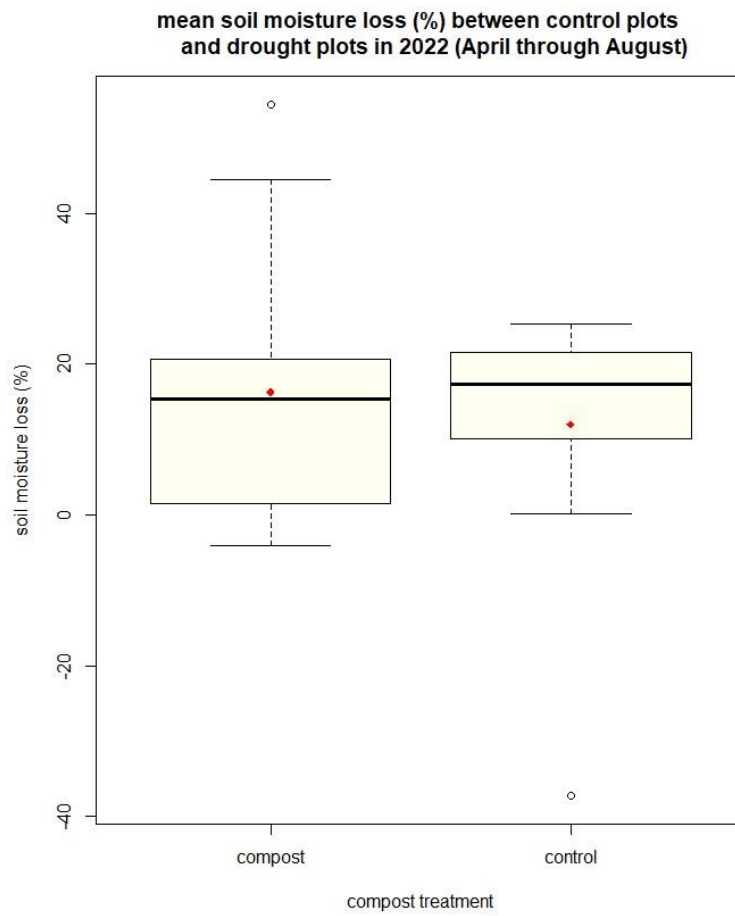


Fig. S3. Growing season (April through August) average values of volumetric soil moisture loss (%) (difference between drought plots and control plots) in the 0-30 cm soil depth in compost-treated plots and untreated plots. Values are means for all sites ($n = 12$). Boxes show mean (red dot inside the box), median (horizontal line) and interquartile range (IQR, colored box); whiskers extend to $1.5 \times IQR$; empty dots in the graph are outliers.

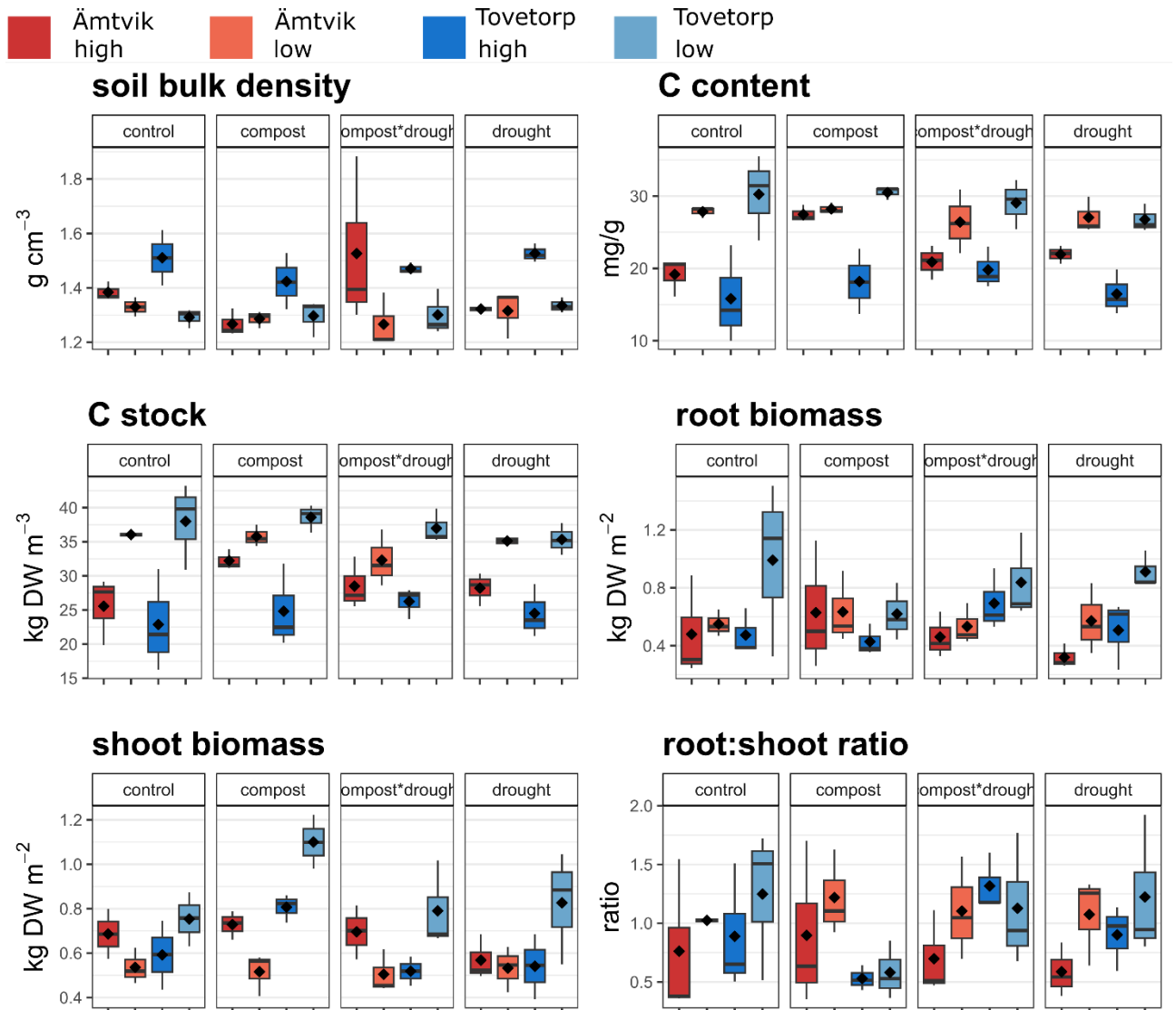


Fig. S4. Values of soil bulk density, soil carbon (C) content, soil C stocks, root biomass, shoot biomass and root-shoot ratio, at 0-15 cm depth at each site (colors) and for each treatment (control, compost, compost x drought, drought) in 2022 ($n = 3$). Red = Ämtvik High elevation, orange = Ämtvik Low elevation, blue = Tovetorp High elevation, light blue = Tovetorp Low elevation. Boxes show mean (diamond inside the box), median (horizontal line) and interquartile range (IQR, colored box); whiskers extend to $1.5 \times IQR$; dots outside of the boxes are outliers.

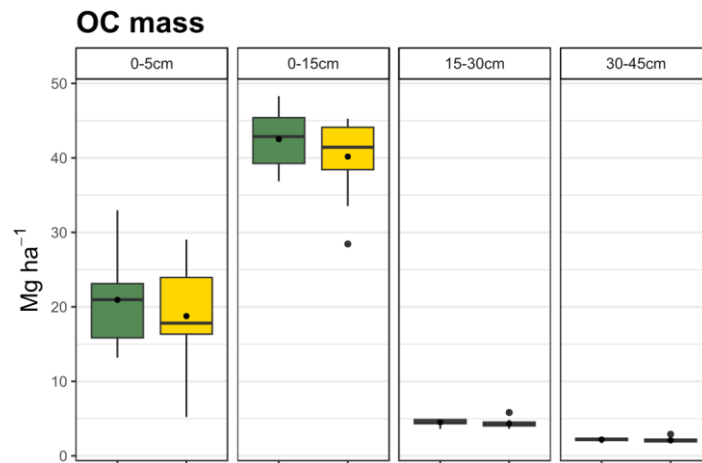


Fig. S5. Values organic carbon (OC) mass at different sampling depths in 2019 and 2022 (control plots, $n = 12$). Values are means for all plots. Green = 2019, yellow = 2022. The calculation was based on equivalent soil mass method. Boxes show mean (dot inside the box), median (horizontal line) and interquartile range (IQR, colored box); whiskers extend to $1.5 \times \text{IQR}$; dots in the graph are outliers.