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Supplement of

Obtaining more benefits from crop residues as soil amendments by application as chemically heterogeneous mixtures

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S1. Supporting information for blocking structure

Based on the strong and consistent gradient we observed in %C content of the soils (Figure S1a) and a similar gradient for the %N content of the soils (Figure S1b), we applied a retrospective blocking structure to enable a more accurate assessment of nonadditive effects. The plots with the highest %C content for each treatment were grouped into one block, the plots with the second highest %C content for each treatment were grouped into another block, etc. (Figure S1c).

(a)

2.18	2.42	2.59	2.73	3.29	3.51	3.54	3.42
2.21	2.28	2.45	2.65	2.89	3.22	3.29	3.36
2.10	2.24	2.29	2.73	2.90	2.86	3.13	3.16

(b)

0.21	0.23	0.24	0.26	0.30	0.31	0.31	0.31
0.22	0.22	0.23	0.25	0.27	0.29	0.29	0.30
0.22	0.22	0.22	0.25	0.27	0.26	0.28	0.28

(c)

3	3	4	3	1	4	4	4
3	2	2	2	2	1	4	4
3	3	1	2	1	1	2	1

Figure S1: The gradient in (a) %C and (b) %N observed in the plots, and (c) the retrospective blocking structure we applied, where each box represents a plot, numbers = blocks; and colours = treatments (grey = Control, yellow = Straw, beige = Woodchip, purple = Compost, light brown = Straw-compost, chestnut brown = Woodchip-compost).

S2. Baseline soil data

Table S1: Baseline soil data for each treatment (SEM indicated in parentheses, n = 4).

	Soil LOI (%)	**Soil C:N**	**Soil pH**	**Clay content (%)**
Compost	7.94 (0.45)	10.77 (0.25)	8.30 (0.03)	23.3 (0.75)
Straw	6.84 (0.03)	10.45 (0.09)	8.30 (0.05)	23.8 (1.18)
Straw-compost	7.78 (0.51)	10.76 (0.20)	8.32 (0.04)	26.0 (1.08)
Woodchip	8.03 (0.51)	10.64 (0.39)	8.27 (0.03)	24.3 (0.75)
Woodchip-compost	8.29 (0.47)	10.95 (0.22)	8.32 (0.03)	26.5 (1.26)
Control	8.14 (0.32)	10.79 (0.13)	8.21 (0.02)	24.5 (1.50)

S3. Additional per-treatment results

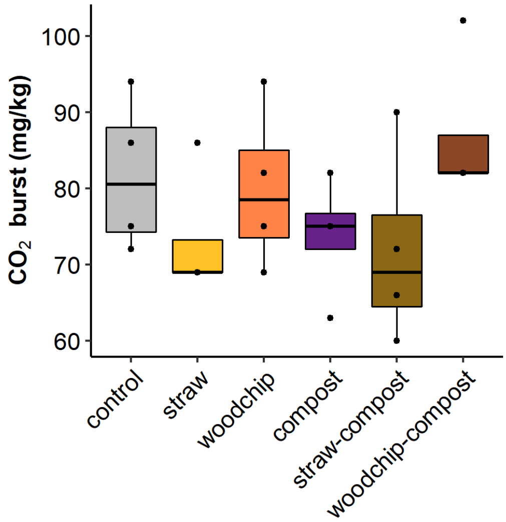

Figure S2: Soil respiration measured by the Solvita CO_2-burst method. Lower and upper hinges correspond to the 25th and 75th percentiles; black dots represent individual data points, which occasionally overlap (n = 4).

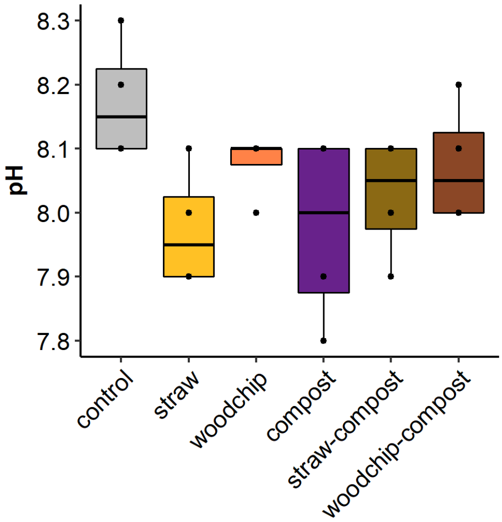

Figure S3: Soil pH after different treatments. Lower and upper hinges correspond to the 25th and 75th percentiles; black dots represent individual data points, which occasionally overlap (n = 4).

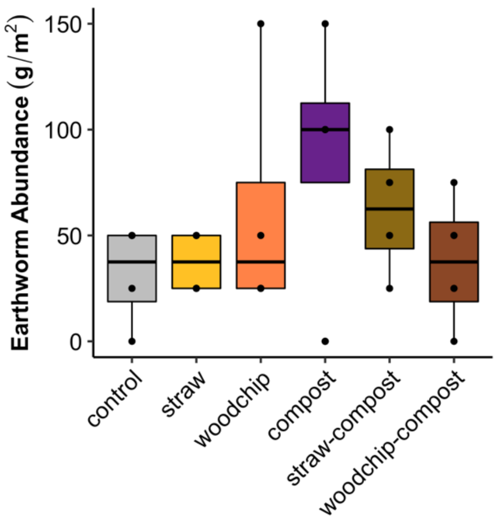

Figure S4: Earthworm abundance per plot after different treatments. Lower and upper hinges correspond to the 25th and 75th percentiles; black dots represent individual data points, which occasionally overlap (n = 4).

Table S2: Qualitative assessment of lettuce plants as the % of lettuce heads per plot affected by each condition. "Overall" quality impairment is the % of lettuce head per plot affected by one or more conditions. Mean values per treatment (n = 4; SEM in parentheses).

Treatment	**Chlorosis**		**Tip burn**	**Rot**	**Overall**
	(All)	(Tips only)			
Control	49.1 (16.1)	47.3 (16.9)	15.5 (4.9)	1.7 (1.1)	77.8 (12.3)
Straw	31.5 (11.7)	21.7 (7.49)	1.9 (1.3)	0.0 (0.0)	43.1 (15.6)
Woodchip	39.3 (9.3)	33.4 (8.5)	12.2 (4.5)	4.3 (2.0)	80.4 (11.6)
Compost	40.4 (7.7)	34.3 (6.6)	14.5 (9.0)	0.6 (0.6)	69.4 (10.7)
Straw-compost	58.3 (14.9)	56.1 (15.2)	16.9 (8.6)	0.7 (0.7)	93.0 (7.0)
Woodchip-compost	61.7 (14.0)	54.1 (16.7)	18.0 (8.7)	0.0 (0.0)	82.2 (11.0)

S4. Calculation of the amount of nutrients added to the soil via residue mixtures

First the mass of nutrients applied per plot was calculated, using the application rate of each residue (kg residue/plot) and the amount of each nutrient in the residues (mg nutrient/kg residue):

$$Nutrients\ applied\ (mg\ plot^{-1}) = Reisude\ applied\ to\ each\ plot\ (kg\ plot^{-1}) \times nutrient\ content\ of\ reisdues\ (mg\ kg^{-1})$$

Then, using the plot volume to 20 cm depth 0.2 m × 6 m × 2 m = 2.4 m^3/plot) and the bulk density (g/m^3), assuming the bulk density is representative of the top 20 cm and assuming nutrients from the residues applied remained in the top 20 cm of the soil (the sampling depth), we calculated the amount of nutrients added per g of soil via the residues (mg nutrients/g soil) as:

$$Nutrient\ application\ rate\ (mg\ g^{-1}) = \frac{Nutrients\ applied\ (mg\ plot^{-1})}{Area\ of\ the\ plot\ (m^3)} / Bulk\ density\ (g\ m^{-3})$$

Then the difference between the amount of nutrients measured in each plot and the average amount of nutrients measured in the control plots was calculated as:

$$Nutrient\ increase\ (mg\ g^{-1}) = Nutrients\ in\ treatment\ plot\ (mg\ g^{-1}) - nutreints\ in\ control\ plot\ (mg\ g^{-1})$$

Then we determined the increase in available nutrients (relative to control) as a proportion of the amount of nutrients added to the soil via residue amendments:

$$Increase\ in\ available\ soil\ nutrients\ (\%) = \frac{Nutrient\ increase\ (mg\ g^{-1})}{Nutrient\ application\ rate\ (mg\ g^{-1})} \times 100\%$$

Table S3: Increase in available nutrients in the soil (relative to control treatment) as a proportion (%) of the quantity of nutrients added to the soil (assuming nutrients added via residues remained in the top 20 cm of the soil that was sampled). Numbers in bold are significantly different ($p < 0.05$) from 0 (SEM indicated in parentheses).

	Straw	Woodchip	Compost	Straw-compost	Woodchip-compost
P	**-95 (4)**	15(65)	12 (15)	-2 (10)	1 (7)
K	10 (37)	57 (68)	**53 (12)**	**31 (3)**	**49 (13)**
Mg	**-242 (42)**	38 (74)	25 (30)	15 (25)	**35 (10)**
N	**-19 (5)**	-3 (5)	-2 (4)	2 (3)	1 (3)

S5. Statistical outputs

Table S4: Statistical outputs of baseline soil properties. Significance indicated as **p < 0.05** and p < 0.1.

Variable	**two-way ANOVA** (per *factor*) (*residue*; *compost*; *residue*compost*)		**Levene**		**Shapiro-Wilk of residuals**	
	F	p	F	p	W	p
SOM (LOI)	2.433; 0.914; 0.938	0.116; 0.352; 0.410	2.092	0.114	0.966	0.578
Soil moisture	0.843; 2.425; 0.315	0.447; 0.137; 0.733	2.911	0.043	0.965	0.536
pH	1.142; 3.241; 0.345	0.341; 0.089; 0.713	0.881	0.513	0.932	0.108
C:N	0.427; 1.094; 0.328	0.659; 0.310; 0.725	0.809	0.558	0.948	0.244
Variable	**one-way ANOVA** (per treatment)		**Levene**		**Shapiro-Wilk of residuals**	
	F	p	F	p	W	p
SOM (LOI)	1.206	0.350	1.727	0.175	0.966	0.574
Soil moisture	1.067	0.420	1.598	0.208	0.947	0.228
pH	1.382	0.278	0.735	0.628	0.950	0.275
C:N	0.410	0.862	0.692	0.659	0.948	0.242

Table S5: Statistical outputs of per-treatment results. Significance indicated as **p < 0.05** and p < 0.1.

Variable	**two-way ANOVA** (per *factor*) (*residues*; *compost*; *residues*compost*)		**Levene**		**Shapiro-Wilk of residuals**	
	F	p	F	p	W	p
Available N	0.509; 2.566; 1.930	0.609; 0.127; 0.174	1.871	0.150	0.950	0.273
Mineralisable N	0.504; 2.936; 0.797	0.612; 0.104; 0.466	1.508	0.237	0.981	0.909
Mineralisable:Available	0.372; 0.597; 0.204	0.695; 0.450; 0.818	0.656	0.661	0.973	0.759
Available+Mineralisable	0.680; 3.877; 1.895	0.519; 0.065; 0.179	1.313	0.303	0.958	0.391
Total biomass	1.625; 1.306; 0.303	0.225; 0.268; 0.742	0.883	0.513	0.971	0.697
CO_2 Burst	2.289; 0.033; 1.091	0.130; 0.859; 0.357	0.323	0.893	0.906	0.029
Earthworm abundance	0.136; 1.221; 1.945	0.874; 0.284; 0.172	0.449	0.809	0.956	0.361
P (mg/g soil)	1.547; 1.214; 0.440	0.240; 0.285; 0.651	1.300	0.308	0.967	0.586
K (mg/g soil)	0.291; 7.761; 0.009	0.751; **0.012**; 0.991	2.369	0.081	0.987	0.918
Mg (mg/g soil)	2.067; 4.953; 0.450	0.156; **0.039**; 0.645	2.573	0.063	0.960	0.437
SOM (LOI)	1.219; 0.574; 0.945	0.319; 0.458; 0.407	1.434	0.260	0.954	0.331
pH	1.459; 1.459; 3.405	0.259; 0.243; 0.056	1.600	0.211	0.902	0.024
Bulk density	3.283; 1.269; 0.994	0.062; 0.276; 0.391	1.214	0.345	0.966	0.589
Aggregate stability	0.836; 0.022; 0.646	0.449; 0.883; 0.536	0.685	0.641	0.955	0.342
Quality impairment	0.653; 2.294; 3.568	0.532; 0.147; **0.050**	0.466	0.796	0.946	0.233