Department of Geography and Environmental Science

Mixtures of crop residue soil amendments provide non-additive benefits in arable cropping soil

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Introduction

Crop residues are valuable resources produced in arable cropping systems in terms of the calories, carbon and other nutrients they contain, but *in situ* decomposition of residue amendments does not always lead to improved soil structure, nutrient availability, or fertility. Previous studies in forest and grassland systems have demonstrated enhanced decomposition rates with chemically heterogeneous litter mixtures (i.e. a blend of high- and low-quality litters), attributed to (a) a transfer of nutrients between different litters[1,2]; (b) litter compounds directly affecting decomposer community[3]; or (c) more diverse microenvironmental conditions[3]. This study aims to identify if these mechanism could be exploited to obtain greater benefits from crop residues as soil amendments in an arable cropping soil. Higher decomposition is hypothesised if mixtures rather than individual soil amendments are used, such that (H1) N is temporarily locked up as labile N is decomposed (Box 1); and (H2) more SOM is added to the soil.

Experimental set-up

Field site

Individual and mixtures of soil amendments (wheat straw, woodchips and vegetable waste compost) were incorporated into 6 m × 2 m plots in a full factorial randomised block design before planting with a crop of gem lettuce (Table 1).

Table 1. Experimental design with two factors and six treatments, n=4 (*C/N*)

RESIDUE → *COMPOST ↓*	Straw	Woodchip	None
Compost	straw-comp *(30)*	wood-comp *(41)*	compost *(13)*
No compost	straw *(41)*	woodchip *(64)*	control *(n/a)*

Assessment of benefits

- Effects of organic amendments on soil properties indicative of soil structure and nutrient cycling:
    - Lettuce crop yield, soil respiration, soil aggregate stability, bulk density, soil C, available and potentially mineralisable N, and available P, K and Mg.
- Calculation of non-additive effects:
    - Synergism = mix > sum of parts
    - Antagonism = mix < sum of parts

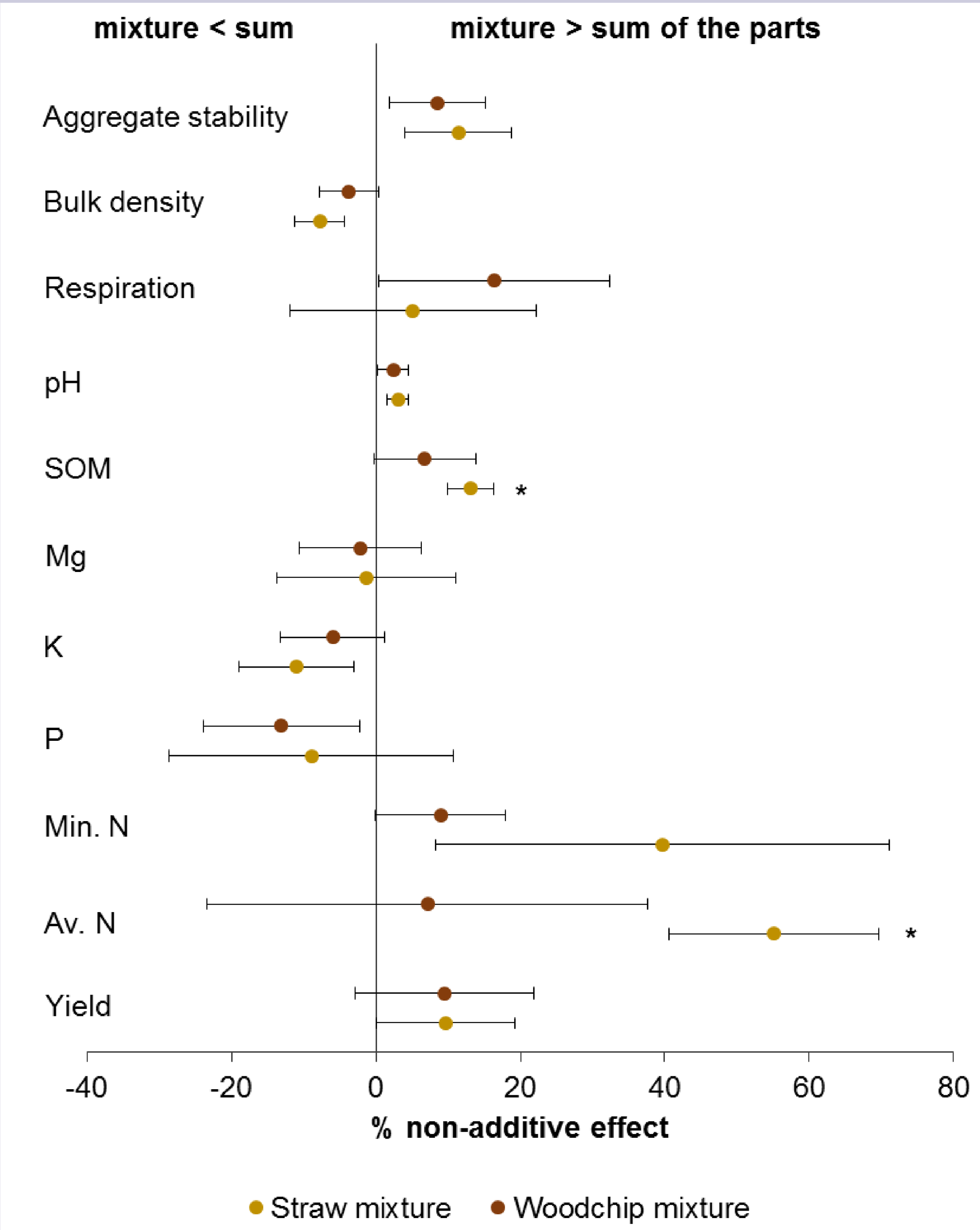

Figure 1. Average % deviation from additivity. Yield is total biomass, Av. N is available N, Min. N is potentially mineralisable N, soil P, K, and Mg are soil available nutrients, SOM measured as LOI, soil respiration assessed by CO_2 burst. Error bars = SEM (n=4). * = sig. diff. from zero (i.e. no benefit) (T-test, P<0.05).

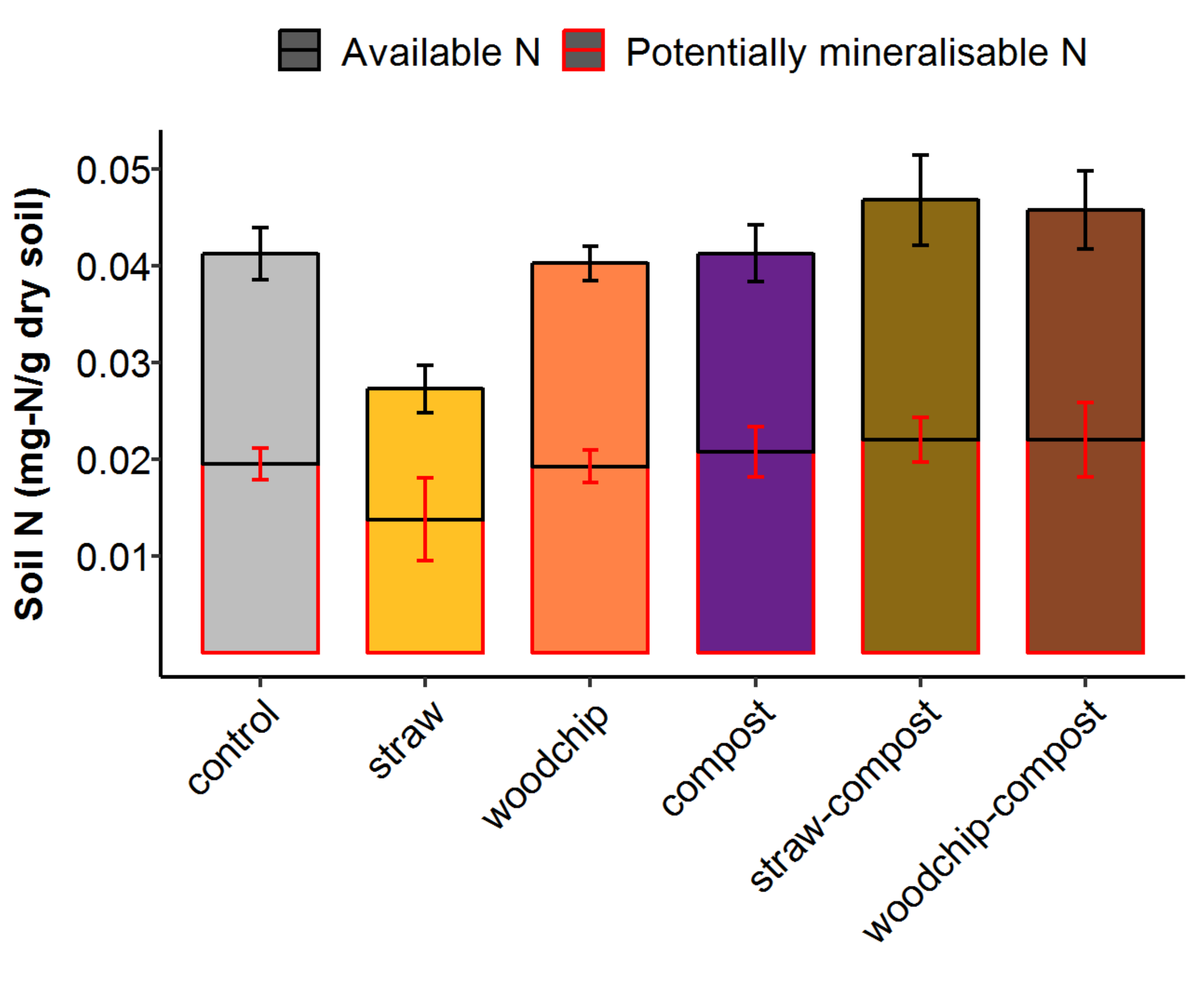

Figure 2. Soil mineral N. Error bars = SEM of each variable (n=4).

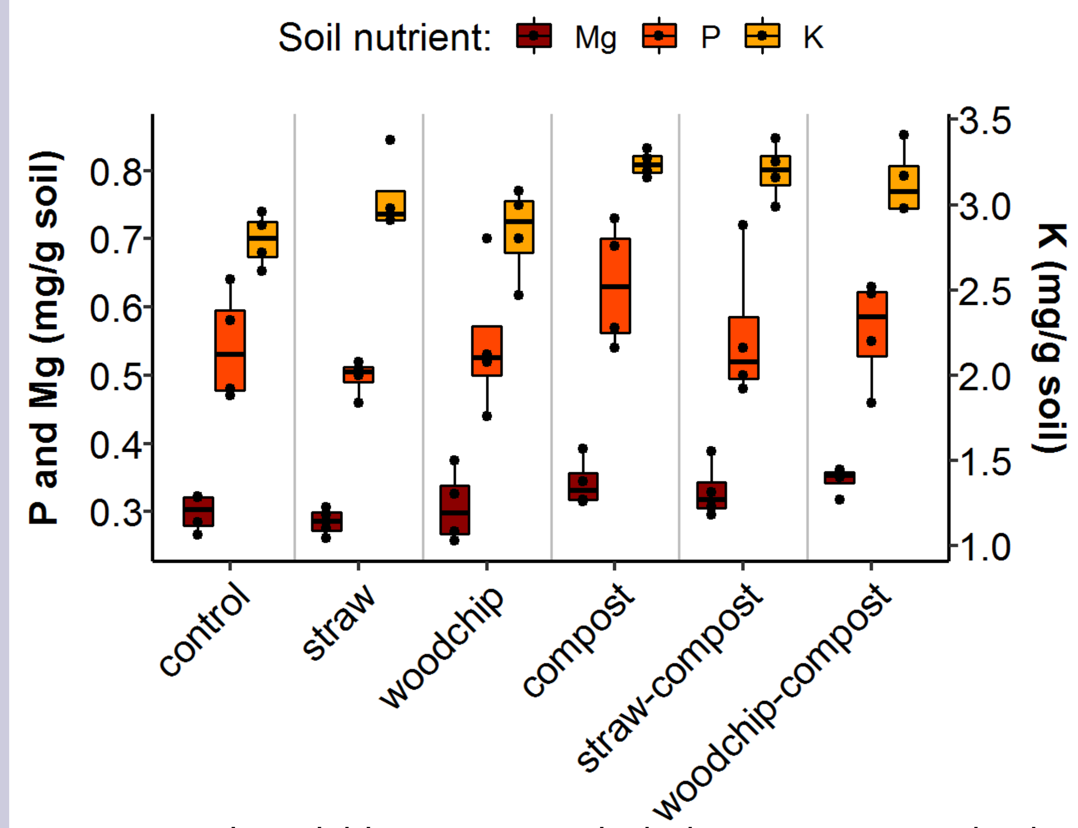

Figure 3. Soil available nutrients. Black dots represent individual datapoints, occasionally overlapping (n=4).

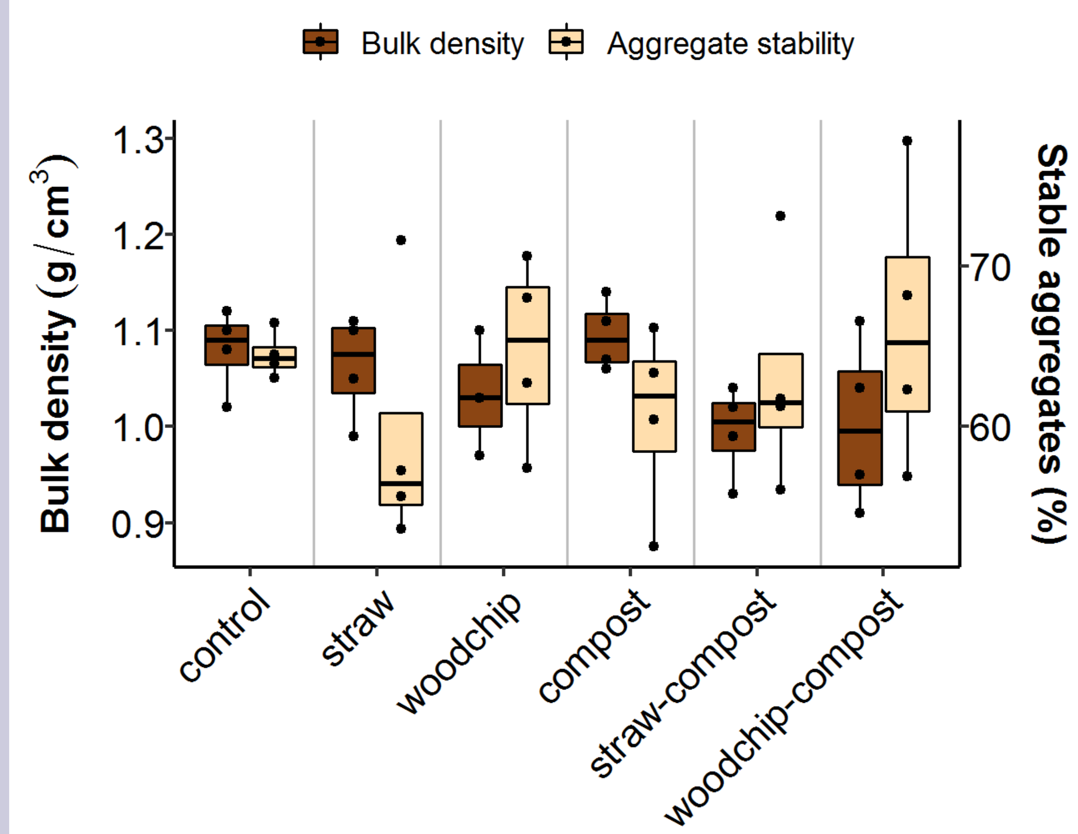

Figure 4. Soil physical properties. Black dots represent individual datapoints (n=4).

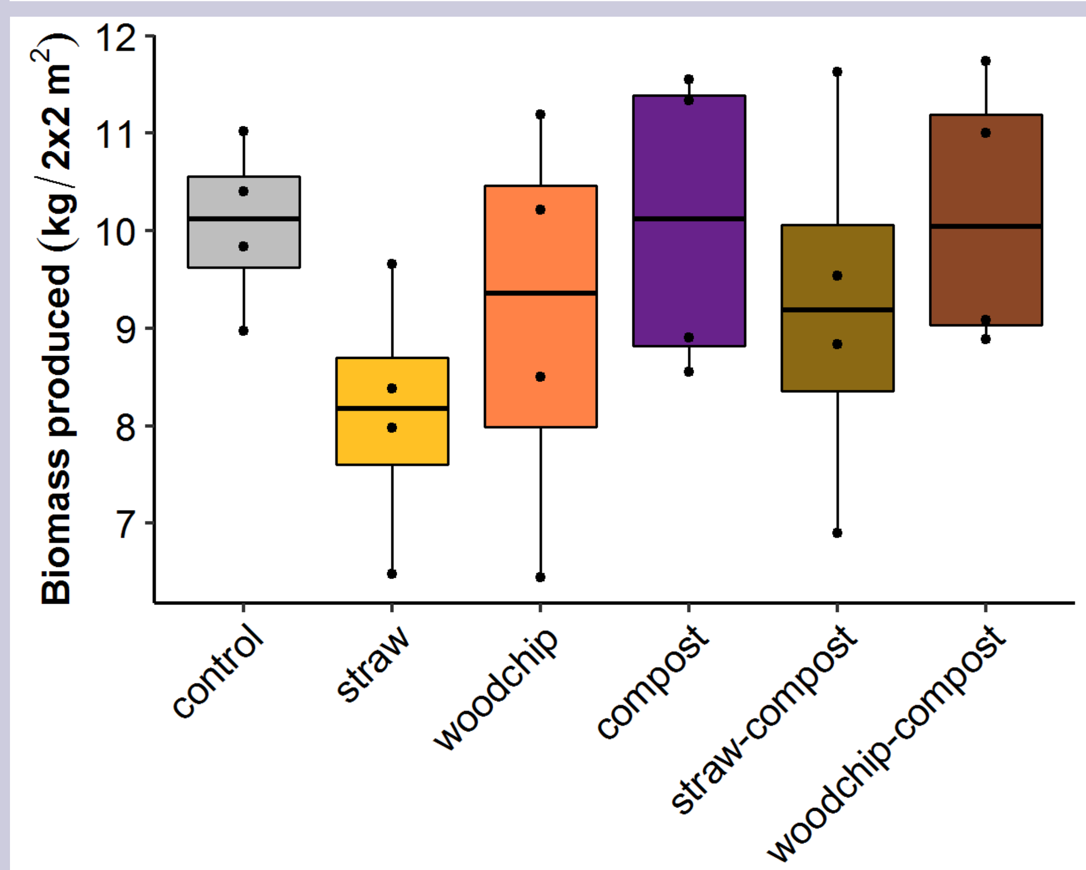

Figure 5. Gem lettuce yield as total biomass produced per 2×2 m^2 plot sampled. Black dots represent individual datapoints (n=4).

Results

Synergies

- Significant non-additive increases in SOM and mineral N (resp. p = 0.028; 0.032) from straw-compost mix (**Fig. 1**).
- Mostly similar trends from both amendment mixes, but none are significant. Probably due to slower decomposition and release of nutrients of woodchip-compost mix (**Fig. 1**).

Soil nutrients

- Compost in mix or individually increased soil mineral N and K and Mg levels (resp. p = 0.065; 0.001; 0.008) (**Figs. 2, 3**).

Soil physical properties and crop yield

- Bulk density seems lower when low-quality residues were incorporated in the soil amendment (p = 0.062) (**Fig. 4**).
- No observable impact on aggregate stability or yield, which is not surprising considering the duration of the experiment (44 days) (**Figs. 4, 5**).

Box 1: decomposition and soil C and N dynamics

Theory: Initial N demand is high when labile C is mineralised → temporary lockup of available N → decrease in microbial N demand as more recalcitrant C is decomposed → return of mineral N to the soil[4].
This experiment: Synergies from straw-compost mixture (N and SOM) + N levels from straw-compost mix exceeding control treatment → suggests that labile C in the mix was decomposed and assimilated in the SOM fraction.

Conclusions

- N lockup not observed in mixtures (H2); non-additive SOM increase seen for the straw-compost mixture only (H1).
- Mixing crop residues can improve soil non-additively.
- Greater benefits could be obtained from crop residue amendments by removing, mixing and re-applying than by simply returning them to the soils *in situ*.

References

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