DYNAMICS OF PLANT RESIDUE DECOMPOSITION AND NUTRIENT RELEASE

By

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Declaration

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Abstract

Proper management of soil organic matter (SOM) contributes to increasing plant productivity and reducing dependency on mineral fertilizers. Organic matter is widely regarded as a vital component of a healthy soil as it plays an important role in soil physical, chemical and biological fertility. Plant residues are the primary source of SOM. Therefore, proper SOM management requires a better understanding of plant residue decomposition kinetics in order to synchronize nutrient release during decomposition and plant uptake and prevent nutrient losses. In natural and managed ecosystems, residues are added frequently to soil, in the form of dead roots and litter fall of plant species with different C/N ratios. However, in most studies on residue decomposition, residues with different C/N ratios are added once and the effect of the presence of plants on residue decomposition is rarely investigated. In this project, four experiments were carried out with different objectives in order to close these knowledge gaps.

The aim of the first experiment was to investigate the effect of frequent wheat residue addition on C mineralization and N dynamics. The experiment consisted of five treatments with different frequency of residue addition (2% w/w of wheat residues in total): once (100%W), every 16 days (25%), every 8 days (12.5%) or every 4 days (6.25%) and noresidue addition (control) with four replicates. The results showed that increasing frequency of low-N wheat residue addition increased C mineralization. Compared to 100%W, cumulative respiration per g residue at the end of the incubation (day 80) was increased by 57, 82 and 92% at 25%W, 12.5%W and 6.25%W, respectively. Despite large increases in cumulative respiration, frequent residue addition did not affect inorganic N or available N concentrations, microbial biomass C and N or soil pH. It is concluded that experiments with single residue additions may underestimate residue decomposition rates in the field because with several additions, soil microbes respire more of the added C (and possibly native soil C) per unit biomass but that this does not change their N requirements or the microbial community composition.

In the second experiment, the effect of mixing of high and low C/N residues at different times during incubation was investigated. There were 4 addition times; 25% of a total of 2% (w/w) residue was added either as wheat (high C/N) or lupin (low C/N) residue. Wheat residue was added to lupin residues on days 16 (LW-16), 32 (LW-32) or 48 (LW-48). Additional treatments were 100%L (added 25% of lupin residues on days 0, 16, 32

and 48) and 100%W (added 25% of wheat residues on days 0, 16, 32 and 48) and 0% (the control) with four replicates. Adding high C/N residues into decomposing low C/N ratio residue strongly decreased the respiration rate compared to the addition of low C/N residues, and lowered the availability of inorganic N, but significantly increased soil pH and altered microbial community composition. By the end of the incubation on day 64, the cumulative respiration of LW-16, LW-32 and LW-48 was similar and approximately 30% lower than in the treatment with only lupin residue addition.

The third experiment studied the effect of spatial separation of high and low C/N residues on decomposition and N mineralization. Each microcosm consisted of two PVC caps of 70 mm diameter and 20 mm height with the open end facing each other separated by a 30 μm mesh. The caps were filled with soil mixed with either low or high C/N residue with three replicates. Contact of high and low C/N residues led to an increase in the decomposition rate of the high C/N residues at the interface whereas it decreased it in the low C/N residues. The results showed that N and soluble C compounds moved from the easily decomposable residues into the surrounding soil, thereby enhancing microbial activity, increasing inorganic N and significantly changing soil pH in the layer 0-5 mm from the interface compared to the 5-10 mm layer of the high C/N residues, whereas the movement of soluble C and N to high C/N residues decreased the decomposition of the low C/N residues.

The final experiment investigated the effect of living plants on decomposition of high and low C/N residues. Wheat was grown in pots with a 30 μm mesh at the bottom. After a root mat had formed (>50% root coverage), a PVC cap with soil with high and low C/N residues (2% w/w) was placed against the mesh. The presence of plant roots significantly increased the respiration rate, N immobilization and increased the soil pH in the 0-5 mm layer in the first 4 days compared to the 5-10 mm layer. This enhanced microbial activity (and probably microbial biomass) can be explained by root exudates. The microbial community composition of plant treatments differed significantly from treatments without plants and the effect was greater in the immediate vicinity of the roots.