NUTRIENT RELEASE RATES FROM ORGANIC MULCHES AND COVER CROPS

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ABSTRACT

Traditional organic vegetable production relies on tillage for weed control, but organic producers may adopt no-till if sufficient weed suppression can be achieved. A combination of high biomass cover crops with organic mulches may provide vegetable producers with multiple benefits, including improved weed control, but information on nutrient release from these residues is lacking. Information on the timely release of nutrients from organic residues will help producers make informed decisions regarding residue management, including adoption of conservation or conventional tillage. The objective of this study was to assess nutrient release rates and mass loss from organic residues (mimosa, lespedeza, straw, and soybean) under conventional and conservation tillage. The experiment used litterbag methodology and consists of a 2x4 factorial split plot design with four replicates. Nitrogen (N) and carbon (C) release and mass loss rates are presented. Buried residues decompose faster than surface residues; therefore more N is potentially available to spring crops from surface residues, which act as a slow release fertilizer, compared to incorporated residues. This study demonstrates that *in situ* cover crops and mulches may be utilized under conservation tillage for the enhancement of SOM and soil N status.

INTRODUCTION

Traditional organic vegetable production relies on tillage to achieve weed suppression, although other methods may be employed, such as flame weeding, hand weeding, etc. One alternative to tillage for weed control is the utilization of high biomass cover crops and organic mulches. Applied in sufficient quantities, high biomass residues, either grown as cover crops or applied as mulches, have been shown to suppress weeds, limit erosion and conserve soil moisture (Rathore et al., 1998).

Under conservation tillage, mulches are left on the soil surface, whereas a conventional tillage system may incorporate mulches at the end of the season. The two systems can be expected to release nutrients from organic residues at different rates, and thereby affect the soil nutrient status for succeeding crops. Nutrient release rates from organic mulches and cover crops need to be determined in order to optimize synchronicity with nutrient uptake by succeeding crops.

Previous work has demonstrated the feasibility of high biomass cover crop mulches under no-tillage production systems. No-till, herbicide-free broccoli production under high biomass cover crops was shown to produce similar yields compared to conventional tillage without a cover crop in Maryland and Virginia (Abdul-Baki et al., 1997). Such a system could achieve even greater weed suppression by using high biomass cover crops, such as forage soybean (*Glycine max L.*), in conjunction with organic mulches. Mulches may be grown *in situ* in order to minimize transportation costs. These mulches could be obtained from invasive species already present in the production area, such as lespedeza (*Sericea lespedeza*) and mimosa (*Albizia julibrissin*) cuttings, and utilized as mulch material before seeds become viable.

The objective of this study was to quantify mass loss and nutrient release rates from decomposing organic residues under conservation and conventional tillage. Information on timely release of nutrients from organic residues will help producers make informed decisions regarding residue management, including the adoption of conservation or conventional tillage.

MATERIALS AND METHODS

A field decomposition study is being conducted at the E.V. Smith Research Center Plant Breeding Unit (32.488ºN, 85.888ºW, 213 feet elevation) in S. Tallassee, AL on a Wickham fine sandy loam, 0 to 2 percent slopes (Fine-loamy, mixed, semiactive, thermic Typic Hapludults). Four organic residues, lespedeza, mimosa, oat (*Avena sativa*) straw, and soybean (*Glycine max* var. Stonewall, group VII) were obtained locally to supply residue. Air-dried residues were packed into nylon mesh bags measuring 7.87 by 3.94 inches with 0.00197 to 0.00236 inch openings at a rate equivalent to 3.0 tons ac^{-1} (0.4744 ounces per bag) on an air-dry basis.

Sealed litterbags were placed on the soil surface or buried at four inches depth on Oct. 9, 2007. The site was maintained under no-till for at least three years prior to placement. Conventional till plots were disked immediately before placement. The treatments were arranged in a randomized split-plot design with four replicates. Bags were retrieved from the field periodically at 0, 3.5, 7, 14, 28, 56, 112, and 224 days after application. The contents of each bag were oven-dried and weighed for dry matter determination. They were then ground to pass a 16 mesh sieve and analyzed for total C and N by LECO TruSpec CN (Leco Corp, St. Joseph, MI). Sample contamination by soil was accounted for by converting all data to an ash-free dry weight basis by ashing approximately 0.035 ounces of the samples in muffle furnace at 752^{o}F for 12 h and determining the ash free dry weight (Cochran, 1991).

Means, standard errors, and statistical significance of treatments were determined using Proc Mixed (SAS Institute Inc., 2003) at the 95% confidence level. Least squares estimates for nonlinear models were determined using four parameter double exponential decay models (Systat Software Inc., 2006).

RESULTS AND DISCUSSION

Decomposition of organic residue occurs in two phases. Initially, a labile portion of the residue, such as sugars, starches and proteins, is readily consumed by soil microbes, leaving behind a recalcitrant portion of the residue, such as cellulose, fats, waxes, lignin and tannins (Wieder and Lang, 1982). This recalcitrant portion is slowly decomposed and contributes to the development of organic matter in soil. Such a system is best described by double exponential decay models, with one exponential segment describing the labile portion and the other exponential segment describing the recalcitrant portion of the residue (Wieder and Lang, 1982). The double exponential decay model is represented by $Y = Ae^{-k_1 t} + Be^{-k_2 t}$, where Y = the nutrient or mass remaining, A = the labile portion, B = the recalcitrant portion, k_1 and k_2 are rate constants fitted to the data, and t = time in days after application. This model serves as the basis for comparison of N, C, and mass loss between conservation and conventional tillage in this study.

Mass loss from organic residues under conservation and conventional tillage is shown in Figure 1. Buried residue generally exhibits faster mass loss in both the labile and recalcitrant portions of all residues, as shown by the greater rate constants k_1 and k_2 for buried material compared to surface residue (Table 1).

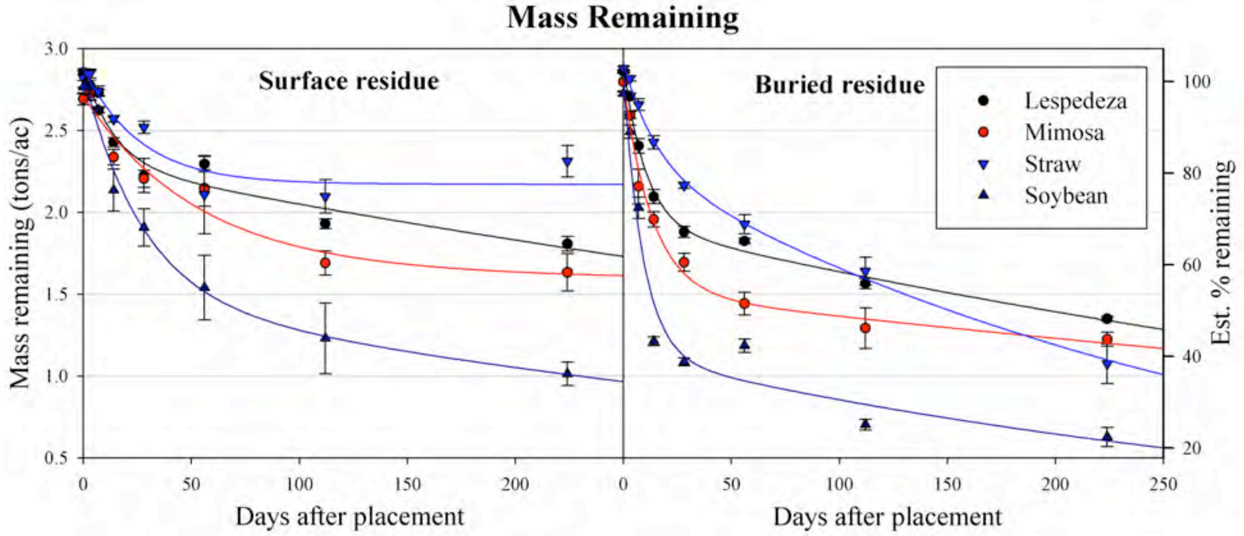

Figure 1. Mass loss from surface and buried residue on an oven dried basis. Residues were placed at an equivalent rate of 3.0 tons ac^{-1} on an air dried basis. The second Y axis represents the estimated percent mass remaining, with 100% representing the average mass of all oven dried residues at day = 0. Error bars represent standard errors of the mean.

Table 1. Double exponential decay coefficients obtained for surface and buried residue for the model $Y = Ae^{-k_1 t} + Be^{-k_2 t}$, where Y = mass or the nutrient loss, A = the labile portion, B = the recalcitrant portion, k_1 and k_2 are rate constants fitted to the data, and t = time in days after application.

	Surface residue											
	Mass (tons/ac)				N (lbs/ac)				C (lbs/ac)			
Coeff.	Lespedeza	Mimosa	Straw	Soybean	Lespedeza	Mimosa	Straw	Soybean	Lespedeza	Mimosa	Straw	Soybean
A	2.30	1.07	2.18	1.48	71.9	131.0	22.0	98.9	221	2052	625	1109
k_1	0.0011	0.019	4.26E-12	0.0017	0.0010	0.0005	2.18E-12	0.015	0.094	0.002	0.0164	0.0018
B	0.59	1.65	0.72	1.37	42.3	11.7	3.27	63.2	2125	237	1572	980
k_2	0.072	0.0001	0.038	0.037	0.0010	0.17	11.10	2.87E-13	0.0019	0.0486	8.95E-12	0.0277
Adj R^2	0.93	0.93	0.82	0.98	0.71	0.05	0.00	0.93	0.88	0.91	0.93	0.97
	Buried residue											
A	1.92	1.51	2.31	1.13	106.6	37.81	-6.04	93.0	634	1540	2018	950
k_1	0.0016	0.001	0.0033	0.0028	0.0021	0.28	0.048	0.088	0.11	0.0028	0.0045	0.0041
B	0.98	1.28	0.60	1.71	13.0	116.4	27.28	68.1	1734	832	201	1171
k_2	0.097	0.075	0.068	0.11	0.12	0.0023	0.0012	0.0033	0.0026	0.096	0.091	0.12
Adj R^2	0.99	0.98	1.00	0.93	0.88	0.85	0.00	0.91	0.98	1.00	0.98	0.93

Nitrogen loss from organic residues under conservation and conventional tillage is shown in Figure 2. Buried residue generally exhibits faster N loss in both the labile and recalcitrant portions of all residues. This is evidenced by the greater rate constants k_1 and k_2 for buried material compared to surface residue (Table 1), though notable rate constant exceptions exist in cases where the curve fit (Adj. R^2) is exceptionally low, such as in the case of straw, which has a very low original N content and negligible labile N pool. For residues with a high N content, there is considerably more N potentially available to a spring crop from surface residue than buried residue. For example, at planting on May 1 (day 204), there is approximately 33 lbs ac^{-1} more N potentially available from surface soybean residue than incorporated soybean residue. Upon mineralization, N is subject to the competing processes of nitrification, immobilization, plant uptake, ammonium fixation, and volatilization. This study does not determine the fate of the lost N (i.e., the proportion mineralized, immobilized, etc.).

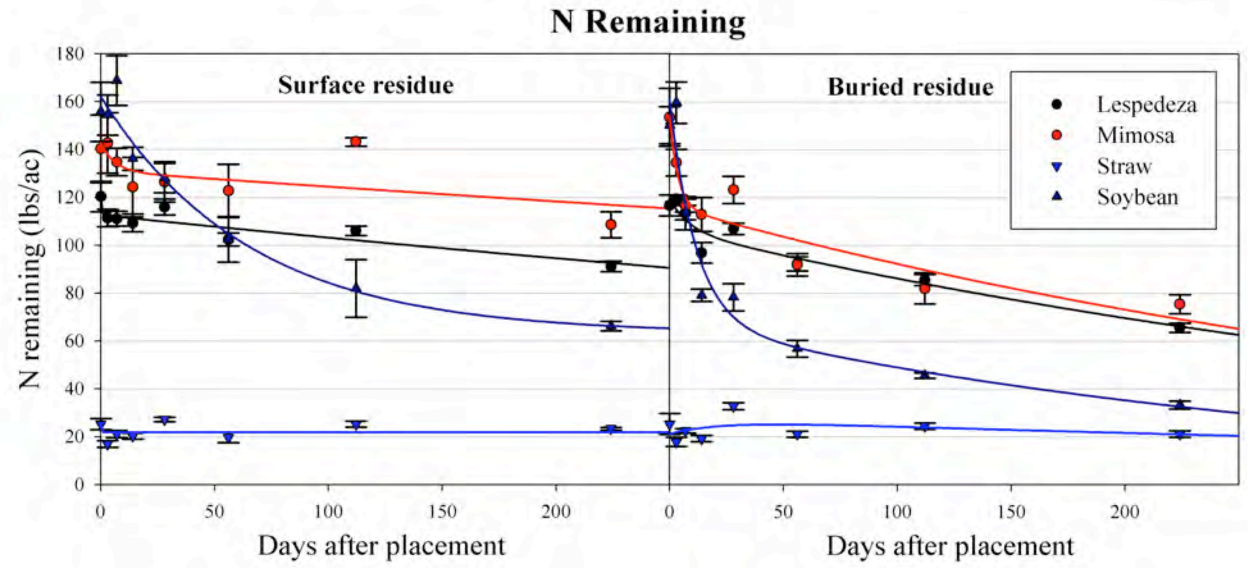

Figure 2. Nitrogen loss from surface and buried residue. Error bars represent standard errors of the mean.

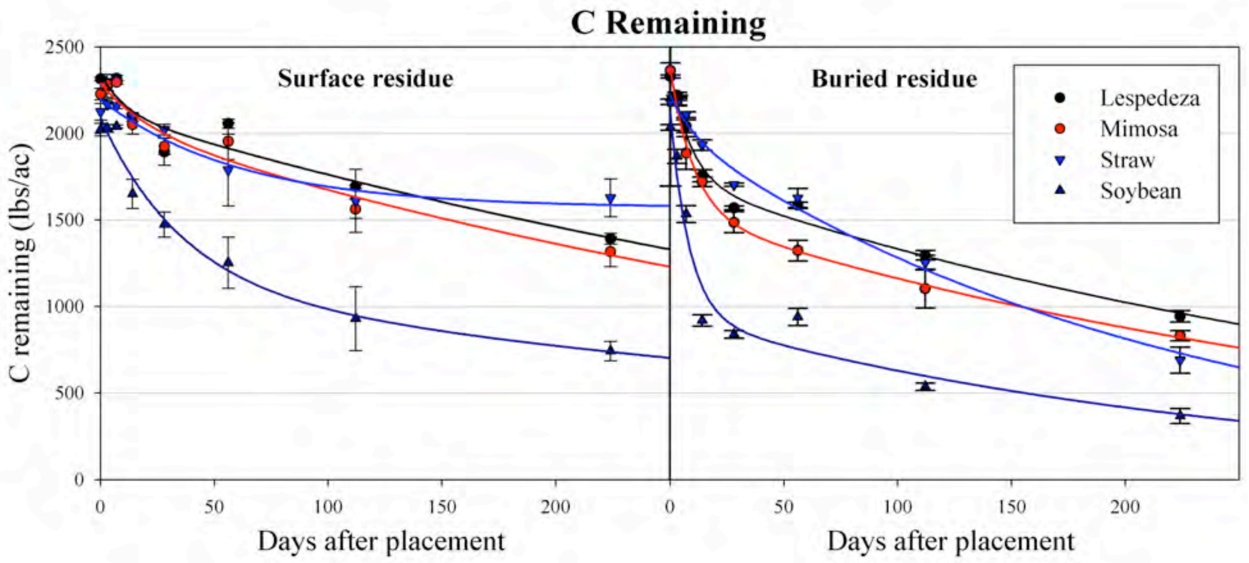

Figure 3. Carbon loss from surface and buried residue. Error bars represent standard errors of the mean.

Carbon loss from organic residues under conservation and conventional tillage is shown in Figure 3. Buried C loss models appear similar to buried mass loss models (Figure 1) because most mass loss is due to the respiration of C, which is then lost to the environment as CO_2. Buried residue exhibits faster C loss in both the labile and recalcitrant portions of all residues, as shown by the greater rate constants k_1 and k_2 for buried material compared to surface residue (Table 1). Carbon is therefore sequestered longer when residue is left on the surface compared to residue incorporation. This should result in greater soil organic matter (SOM) accumulation from surface residue over time. On a more speculative note, in an age when producers may be compelled to participate in a C market, conservation tillage practices may provide producers with a C offset or credit, while also enhancing SOM.

CONCLUSIONS

Buried residues decompose faster and release C and N quicker than surface residues. A winter cover crop may be able to recapture some of the N lost from buried residues in order to make it potentially available to spring crops. However, surface residues with a high N content retain N longer, and may provide more potentially available N to spring crops than buried residues. As such, surface residues may act as a slow release N fertilizer and contribute to organic matter accumulation on the soil surface. This study demonstrates that *in situ* cover crops and mulches may be utilized for the enhancement of SOM and soil N status. Further studies need to be conducted in order to determine the mineralized fraction of N lost from residues.

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