

Use of the Carbon: Nitrogen Ratio SOILS, AGRON 305

When fresh organic material undergoes decomposition in soil, both the rate of decomposition and the amount of humus formed are related to the C:N ratio of the residue. When other conditions are equal, the rate of decomposition increases as the C:N ratio narrows.

Four conditions that are constant for all residue decomposition.

1. A maximum of 35% of the carbon in fresh organic material will be converted into soil humus IF there is sufficient nitrogen present.
 2. A minimum of 65% of the carbon in fresh organic material will be given off to the atmosphere as carbon dioxide due to microbial respiration.
 3. The humus formed from the decomposition of fresh organic material will contain approximately 50% carbon and 5% nitrogen. In other words, the C:N ratio of the humus is 10:1.
 4. Most fresh plant material contains 40% carbon. The C:N ratio varies because of differences in nitrogen content, not carbon content.
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Using these relationships, the quantity of humus formed from the addition of a known amount of plant residue can be calculated.

1. If sufficient nitrogen is present to maximize humus formation, use this relationship.

weight of humus x percent carbon in humus = weight of carbon, or
weight of humus = weight of carbon / percent carbon in humus, or
weight of humus = weight of carbon / 0.5, or
weight of humus = weight of carbon x 2 (Equation #1)

2. If insufficient nitrogen is present to maximize humus formation, use this relationship.

weight of humus x percent nitrogen in humus = weight of nitrogen, or
weight of humus = weight of nitrogen / percent nitrogen in humus, or
weight of humus = weight of nitrogen / 0.05, or
weight of humus = weight of nitrogen x 20 (Equation #2)

Application of Principles.

Case 1. (Sufficient nitrogen is present to maximize humus formation). How much humus forms from the decomposition of 2000 lb of alfalfa residue which has a C:N = 13:1?

1. Determine % carbon and % nitrogen in residue.

a. Use condition #4 to set %C at 40%.

b. Convert 13:1 C:N ratio to %C and %N by setting up a ratio that expresses 13 to 1 to be the same as 40 to ?

$13 / 1 = 40 / x$, therefore; $x = 3\%$ nitrogen

2. Calculate the pounds of carbon and nitrogen in 2000 lb alfalfa residue.

$0.40 \times 2000 = 800$ lb carbon, and $0.03 \times 2000 = 60$ lb nitrogen

3. Apply conditions #1 and #2: $0.35 \times 800 = 280$ lb carbon will be converted to humus IF sufficient nitrogen is present.

4. Apply condition #3: $280 / 10 = 28$ lb of nitrogen need for maximum humus formation.

5. Nitrogen available (60 lb from step #2) compared to the nitrogen needed (28 lb from step #4) shows that not only is there sufficient nitrogen for maximum humus formation, but an excess of 32 lb exists ($60 - 28 = 32$).

6. Therefore, applying Equation #1, the amount of humus formed from 2000 lb alfalfa would be:

$280 \times 2 = 560$ lb humus

Case 2. (Insufficient nitrogen is present to maximize humus formation). How much humus forms from the decomposition of 2000 lb of wheat straw residue which has a C:N = 80:1?

1. Determine % carbon and % nitrogen in residue.

a. Use condition #4 to set %C at 40%.

b. Convert 80:1 C:N ratio to %C and %N by setting up a ratio that expresses 80 to 1 to be the same as 40 to ?

$80 / 1 = 40 / x$, therefore; $x = 0.5\%$ nitrogen

2. Calculate the pounds of carbon and nitrogen in 2000 lb wheat straw residue.

$0.40 \times 2000 = 800$ lb carbon, and $0.005 \times 2000 = 10$ lb nitrogen

3. Apply conditions #1 and #2: $0.35 \times 800 = 280$ lb carbon will be converted to humus IF sufficient nitrogen is present.
4. Apply condition #3: $280 / 10 = 28$ lb of nitrogen need for maximum humus formation.
5. Nitrogen available (10 lb from step #2) compared to the nitrogen needed (28 lb from step #4) shows there is insufficient nitrogen for maximum humus formation, a shortage of 18 lb exists ($28 - 10 = 18$).
6. Therefore, applying Equation #2, the amount of humus formed from 2000 lb wheat straw would be:
 $10 \times 20 = 200$ lb humus
7. Alleviating the nitrogen shortage by adding the deficient 18 lb nitrogen would maximize humus formation.
 $(10 + 18) \times 20 = 560$ lb humus
8. Thus, there was 360 lb of humus ($560 - 200$) lost (i.e. never produced) from each ton of wheat straw during decomposition.

Sample Problems

1. Calculate the supplemental nitrogen needed to attain maximum humus formation from 2000 lb of corn stalks (C:N = 60:1) incorporated into one acre furrow slice.

1-1. Determine % carbon and % nitrogen in residue.

- a. Use condition #4 to set %C at 40%.
- b. Convert 60:1 C:N ratio to %C and %N by setting up a ratio that expresses 60 to 1 to be the same as 40 to ?
 $60 / 1 = 40 / x$, therefore; $x = 0.67\%$ nitrogen

1-2. Calculate the pounds of carbon and nitrogen in 2000 lb corn stalk residue.

$0.40 \times 2000 = 800$ lb carbon, and $0.0067 \times 2000 = 13$ lb nitrogen

1-3. Apply conditions #1 and #2: $0.35 \times 800 = 280$ lb carbon will be converted to humus IF sufficient nitrogen is present.

1-4. Apply conditions #3: $280 / 10 = 28$ lb of nitrogen need for maximum humus formation.

1-5. Nitrogen available (13 lb from step #2) compared to the nitrogen needed (28 lb from step #4) shows there is insufficient nitrogen for maximum humus formation, a shortage of 15 lb exists ($28 - 13 = 15$).

1-6. Therefore, applying Equation #2, the amount of humus formed from 2000 lb corn stalks would be:

$$13 \times 20 = 260 \text{ lb humus}$$

1-7. Alleviating the nitrogen shortage by adding the deficient 15 lb nitrogen would maximize humus formation.

$$(13 + 15) \times 20 = 560 \text{ lb humus}$$

1-8. Thus, there was 300 lb of humus ($560 - 260$) lost (i.e. never produced) from each ton of wheat straw during decomposition.

2. What is the C:N ratio at the break even point; i.e. where a wider ratio provides insufficient nitrogen for maximum humus formation and a narrower ratio provides sufficient nitrogen? Hint: The carbon available for maximum humus formation from any plant residue is always 280 lb. Thus, one-tenth of that, or 28 lb of N should be supplied by the residue.

3. For each of the following four residues, determine the information requested below. Use one ton of residue for all calculations and report answers in pounds.

Residue type and C:N Ratio:

Alfalfa, 13:1

Corn Stalks, 60:1

Wheat Straw, 80:1

Sawdust, 200:1

Maximum humus formed if sufficient nitrogen is present.

Maximum humus formed if no additional nitrogen is added.

Humus lost if no nitrogen is added during decomposition.

Nitrogen needed per ton of residue to maximize humus formation