MULCHES AND SOIL CONDITIONERS

Carbon and Nitrogen in Farm and Forest Products

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The nitrogen content of organic matter used as mulches or soil conditioners not only influences rate and extent of their decomposition and humidification but also determines the available nitrogen released or required. Data on the carbon-nitrogen ratio of such materials are therefore essential for decomposition studies and for predicting additional nitrogen requirements for optimum microbial activity. Carbon-nitrogen values are also indicative of B.O.D. and pollutional potentials of organic wastes dumped into streams. Carbon-nitrogen values were determined for 55 agricultural and forest wastes used on soils in the Pacific Northwest. All coniferous wood wastes are similar in containing approximately 50% carbon and little nitrogen. Hay and straw average 45% carbon and also are low in nitrogen. Young plants and leguminous materials are higher in nitrogen, decompose readily, and liberate nitrogen in available form. Wood, straw, and similar residues of wide carbon-nitrogen ratio decompose slowly, demanding available nitrogen in inverse proportion to resistant components. With much lignocellulose and little water-soluble substance present, the carbon-nitrogen ratio is of secondary importance in controlling microbial decomposition.

THE CARBON-NITROGEN RATIO of organic matter is an important factor influencing its microbial decomposition. Rate and extent of the decomposition as well as the nature of end products under given environmental conditions vary with available nitrogen. Microorganisms suffer from nitrogen starvation on substrates of wide carbon-nitrogen ratio, unless a high proportion of the organic matter is extremely resistant. With a sufficiently narrow carbon-nitrogen ratio, on the other hand, nitrogen is present in excess of assimilation requirements and some will be liberated as ammonia. Optimum decomposition in soils results when the ratio is approximately 20 to 1, while about 40 to 1 is favorable in water (*3*). Carbon and nitrogen determinations in materials that may be added to soils are therefore indicative of whether or not they may have immediate nitrogen fertilizing value or may require nitrogen additions, either to hasten decomposition or to forestall plant food deficiency. Similarly, analyses of organic industrial wastes indicate more or less closely their B.O.D. and pollutional potentials (*5*). The carbon-nitrogen ratio of soil organic matter exerts a predominating influence on both rate and amount of carbon dioxide production and has been extensively studied (*1*, *4*).

In connection with investigations on organic decomposition in soils and streams, a variety of agricultural residues and industrial wastes have been analyzed in this laboratory. Many of these are products characteristic of the Pacific Northwest and comparable data apparently have not been published elsewhere. Comparatively few carbon analyses on industrial wastes, crop residues, and manures appear in the literature. Proximate analyses commonly are given, and from these the carbon-nitrogen ratios may be calculated to a close approximation. However, exact values are often desirable, especially in soil respiration studies. In the belief that results may be of interest to other investigators, they are presented here. Ash values are included, as in some instances the ash accounts for a considerably lower carbon content.

Carbon and Nitrogen Determination

Representative samples of 10 to 100 pounds were obtained in most cases. Sawdust samples, except mill run, were obtained directly from gang saws cutting bark-free cants. Except for waste sulfite liquor and cannery wastes, samples were air-dried at room temperature. For the analytical sample 100 grams of air-dry material was ground in a Wiley mill to pass 60-mesh. Cannery wastes were prepared for analysis by treatment in a Waring Blendor.

Moisture was determined by drying to constant weight at 105° C. Cannery wastes, however, were first dehydrated in a vacuum oven at 60° C. Waste sulfite liquor was analyzed on the wet basis.

Standard analytical methods were employed. For total nitrogen, Hibbard's mixture was used in the Kjeldahl digestion. The distilled ammonia was absorbed in saturated boric acid solution and titrated directly with 0.0714 *N* sulfuric acid, using methyl red–bromocresol green mixed indicator.

Total carbon was determined by dry combustion. Liquid samples were weighed directly into porcelain boats and evaporated to dryness on a steam plate. Samples were covered with 60-mesh Alundum and burned in a tube furnace at 950° C. Negative pressure was maintained in the train, and the carbon dioxide was absorbed by Ascarite in a Turner bulb, oxygen flow being sufficient to ensure complete combustion in 10 minutes.

Results

Results are presented in Table I; except for waste sulfite liquor, all are calculated on the water-free basis. Because dextrose and peptone are often used as standards for comparison in decomposition studies, data for these materials are included.

Sawdust, wood, and bark are similar in containing approximately 50% carbon. Nitrogen is very low in all, but ranges widely. Excluding alder, which is relatively high in nitrogen, the average for this element in wood products is about 0.1%. Carbon in hay and straw averages close to 45%. Nitrogen is about the same in cereal straw as in wood; in leguminous material it is much higher. It is highest in young actively growing plants, as illustrated by the values for peas in bloom and for grass clippings.

Relative decomposibility of hay, straw, and leaves has been found to conform to the carbon-nitrogen relationships previously mentioned. Leguminous residues will decompose rapidly and liberate ammonia. Decomposition of mature non-leguminous straw and leaves is generally hastened by addition of nitrogen fertilizers; without this supplement, soil microorganisms metabolizing readily available carbon sources compete with plant roots for available nitrogen. Coniferous wood, bark, and sawdust, however, contain 60 to 70% of inherently resistant lignocellulose, which is so slowly decomposible that resistance to attack rather than available nitrogen controls the rate of decomposition. These wood products contain less than 5% cold water-soluble organic matter. Therefore, sawdust applications of 100 tons or more per acre require only little if any additional nitrogen to prevent nitrogen starvation of plants; greater additions may function directly as a fertilizer, but will not appreciably hasten decomposition of the sawdust. This phenomenon will be discussed in a later paper.

Alder sawdust decomposes readily in the soil and is considered a good source of humus. It contains more nitrogen but less water-soluble organic matter than the coniferous woods. Its lignocellulose complex is evidently less resistant than that of coniferous woods. As a mulch or soil conditioner alder sawdust is comparable to cereal straw, but it has the advantage of better mechanical condition.

Douglas fir needles are of interest because of their relatively high nitrogen content and a high percentage of water-soluble organic matter. Total cold and hot water extract exceeds 30%. The cold water-soluble organic matter in several samples was found to average nearly 20%, while reducing sugars, presumably melizitose in large part, ranged from 5.65 to 8.50%. Cellulose and lignin, present in almost equal amounts, made up only 26.6%, less than one half the percentage in wood and many crop residues. In line with these values and the carbon-nitrogen ratio, the needles were found to decompose more rapidly than bark, wood, sawdust, or cereal straw.

Only a few of the other materials listed in the table are discussed here. The carbon content of the Douglas fir charcoal, a commercial product, appears surprising low in view of the low ash. This may be due partly to incomplete carbonization and partly to occlusion. The cinders, obtained from a sawmill waste burner, are comparable to the charcoal in carbon but are much higher in ash and nitrogen. Decomposition of charcoal added to soil is extremely slow; in one soil respiration study less than 3% of a 10-ton-per-acre incorporation was oxidized to carbon dioxide in 600 days under optimum moisture and temperature. Scholler and Springfield lignins, hydrolysis residue from manufacture of wood molasses, although less resistant than charcoal, are also decomposed slowly. Lignin in waste sulfite liquor decomposes much more rapidly; it appears even more susceptible to microbial attack than does oat straw lignin (*2*).

It is thus evident that practical application of the carbon-nitrogen ratio to problems involving organic matter decomposition requires consideration of qualitative as well as quantitative factors. This is particularly true for sawdust and other by-products of the lumber industry in the Pacific Northwest, where more and more of these materials are finding horticultural and general agricultural

Table I. Carbon and Nitrogen in Farm and Forest Products Used as Mulches and Soil Conditioners

(Water-free basis)

No.	Material	Ash, %	Total Carbon, %	Kjeldahl Nitrogen, %	C/N
1	Alfalfa hay	8.79	43.15	2.34	18
2	Bent grass clippings	17.98	43.22	3.23	13
3	Fiber flax, deseeded	3.73	44.70	0.12	373
4	Pea vines, in bloom	10.71	45.30	2.69	17
5	Pea vines, mature (less pods)	8.50	44.02	1.50	29
6	Meadow hay (rush and sedge)	8.46	45.60	1.07	43
7	Rye straw	3.51	47.39	0.33	144
8	Wheat straw	8.54	44.70	0.12	373
9	Oak leaves, weathered	32.33	35.11	1.36	26
10	Walnut leaves, weathered	43.42	29.48	1.12	26
11	Corn cobs	1.58	46.87	0.45	108
12	Rice hulls	19.83	39.80	0.55	72
	Douglas fir, 420-year-old tree				
13	Needles	7.02	55.75	0.96	58
14	Bark	0.45	53.97	0.11	491
15	Sap wood	0.27	49.36	0.09	548
16	Heart wood	0.29	51.51	0.12	429
17	Pitch, solid	0.00	72.70	0.00	..
	Douglas fir bark				
18	Young	0.69	51.66	0.17	304
19	Old	0.57	58.56	0.20	293
20	Cork	0.41	59.32	0.13	456
21	Bast	0.69	54.29	0.11	494
22	Fines	0.70	54.08	0.12	451
23	Dust	0.14	57.00	0.18	317
24	Douglas fir charcoal	2.33	82.35	0.27	305
25	Douglas fir cinders	11.67	84.74	0.98	86
26	Douglas fir cones	1.51	49.17	0.37	133
27	Sitka spruce cones	1.22	51.76	0.47	109
28	White fir cones	2.56	52.77	0.70	75
	Sawdust				
	Douglas fir				
29	Mill run, weathered 3 years	7.99	47.01	0.33	142
30	Mill run, weathered 2 mo.	1.56	49.84	0.08	623
31	Mill run, weathered 2 mo.	1.61	49.98	0.08	625
32	Resaw, fresh	0.17	49.80	0.05	996
	Sawdust, resaw				
33	Red alder	1.21	49.63	0.37	134
34	Western red cedar	0.29	51.05	0.07	729
35	Western hemlock	0.35	49.74	0.04	1244
36	Ponderosa pine	0.33	53.18	0.05	1064
37	Sitka spruce	0.22	51.50	0.05	1030
38	Cedar tow (Western red cedar)	0.14	52.47	0.07	750
39	Scholler lignin (Douglas fir)	0.99	61.70	0.07	881
40	Springfield lignin (Douglas fir)	0.79	66.72	0.08	834
41	Douglas fir white rot	0.75	48.68	0.67	73
42	Douglas fir red rot	0.19	59.30	1.21	49
43	Moss peat	3.12	48.29	0.83	58
44	Waste sulfite liquor (8.28% solids)	1.45	3.74	0.00	748
45	Orzan A[a]	1.02	51.55	3.42	15
46	Sewage sludge, digested	53.65	22.00	2.15	10
47	Sewage sludge, digested	54.91	23.70	1.91	12
	Cannery wastes, solid offal				
48	Beans		31.47	3.17	10
49	Beets		42.85	2.32	18
50	Peaches		46.43	1.15	40
51	Pears		32.69	0.52	63
52	Tomatoes		37.36	3.71	10
53	Dextrose, reagent	0.05	40.00	0.00	..
54	Peptone, Difco	3.51	47.10	15.80	3
55	Brazilian water weed	19.78	54.10	4.75	11

[a] Dehydrated ammonia-base waste sulfite liquor.

uses. Although such wastes are exceptionally low in nitrogen and high in carbon, the additional nitrogen necessary to offset microbial requirements during decomposition is much lower than indicated by the over-all carbon-nitrogen ratio. Accounting for this is the high proportion of resistant lignocellulose.

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Pesticides Effectiveness Is Influenced by Formulation

PESTICIDES FORMULATION
Liquid Concentrates Problems

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In the successful formulation of toxicants as emulsifiable concentrates, several factors are to be considered. The choice of the solvent depends on the toxicant solubility, especially at low temperatures; the solvent should have a moderately high flash point and a low order of phytotoxicity or irritation, and it should be low in cost and plentiful in supply. In choosing the inert ingredients, such as the emulsifying agent, special consideration should be given to its composition, so that its proper hydrophile-lipophile ratio balances effective emulsifying power against sufficient oil solubility. The differences in solubility characteristics in aromatic and aliphatic solvents are discussed and examples are given of multiple-purpose formulations which can be used as aqueous emulsions or diluted with aliphatic solvents. The liquid concentrates are then tested for emulsion characteristics, such as spontaneity, emulsion stability, re-emulsification, and effect of various natural waters. Several of the more commonly used methods are described and special emphasis is laid on the correlation of laboratory test methods with actual field use. The concentrates are also tested for aging qualities by accelerated aging tests at elevated temperatures, and for possible effects of corrosion on different containers. Their compatibilities should be determined with other materials and formulations which are likely to be encountered.

Of the world consumption of benzene hexachloride, only about one third was really used effectively to kill insects, and the remainder might as well have been wasted, is the opinion expressed in an editorial in *World Crops* (*12*). To remedy this deplorable situation, the editorial urges that it is not enough to consider merely the toxic potentialities of a pesticide, but it is also necessary to take strict account of the method of application and proper formulation.

Design of Proper Formulation

The design of a proper formulation of liquid concentrates should be based on a sound understanding of the following three questions:

1. What does one desire the formulation to do?
2. What is the best way to incorporate the pesticide into the formulation?
3. How can the desired functions be imparted to the formulation?

The first question involves a knowledge of the proposed use. For instance, is the pesticide intended to be a contact spray or a residual spray (*11*)? In a contact spray the insects are actually presens during the time of spraying, and for thit reason one is primarily concerned with