DECOMPOSITION OF ^{14}C-LABELLED PLANT MATERIAL UNDER FIELD CONDITIONS

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Mature, uniformly labelled (^{14}C, ^{15}N), chopped, wheat straw incorporated in the plow layer of a Brown Chernozemic soil and a Gray Wooded soil was allowed to decompose in the field. Labelled grass material (^{14}C) was added to the surface of an adjacent virgin Brown Chernozemic soil. After 4 yr of normal cropping practices, one-fifth of the C of added straw remained in the Brown soil and one-sixth in the Gray Wooded. The initial decomposition rate of straw was retarded in plots under wheat as compared with those under fallow. Decomposition of labelled grass was initially dependent on sufficient rainfall to compress it to the soil surface. When winter periods are excluded from the time scale, the half-life of resistant straw components or soil organic matter derived from the straw was equivalent to 24 mo in Gray Wooded soil and 48 mo in Brown soil. Resistant grass material decomposed more slowly with a half-life of 96 growing mo. Distribution of labelled C among the various fractions of soil organic matter after different periods of time was investigated. The rapid decline of labelled straw from the fraction that floated in water, the high specific activity of fulvic acid, coupled with fluctuations in humic acid and the fraction <0.04 μ suggested a higher degree of biological activity in the Gray Wooded soil. In the Brown soil, the major transfer of labelled C was from the floated fraction to the humin (>0.2 μ) suggesting that the rate of decomposition was controlled to a greater extent by abiotic factors.

On a laissé se décomposer au champ de la paille de blé mûre, hachée, uniformément marquée (^{14}C, ^{15}N) et incorporée à la couche de labour d'un sol chernozémique brun et d'un sol gris boisé. Des graminées marquées (^{14}C) ont été épandues à la surface d'un sol chernozémique brun, vierge, adjacent. Après 4 ans de culture normale, on a retrouvé le cinquième du C de la paille ajoutée dans le sol brun, et le sixième dans le sol gris. Le taux initial de décomposition de la paille a été plus faible dans les parcelles emblavées que dans les parcelles en jachère. La décomposition des graminées marquées était d'abord fonction de précipitations suffisantes pour les presser à la surface du sol. Si l'on exclut les saisons d'hiver de l'échelle de temps, la période de demi-décomposition des composants résistants de la paille ou de la matière organique du sol provenant de la paille équivalait à 24 mois dans le sol gris boisé et à 48 mois dans le sol brun. Les composants résistants des graminées se sont décomposés plus lentement, leur période de demi-décomposition étant de 96 mois utiles. On a étudié à différentes périodes la distribution du C marqué entre les diverses fractions de la matière organique du sol. La décomposition rapide de la paille marquée provenant de la fraction baignant dans l'eau, l'activité spécifique élevée de l'acide fulvique, les fluctuations de celle de l'acide humique et la fraction <0.04 μ semblent indiquer un degré élevé d'activité biologique dans le sol gris boisé. Dans le sol brun, la principale migration de C marqué s'est faite de la fraction baignée dans l'eau à l'humine (>0.2 μ), ce qui pourrait indiquer que le taux de décomposition était régularisé dans une plus grande mesure par des facteurs abiotiques.

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INTRODUCTION

The amount and type of organic matter in a soil under cultivated conditions is dependent on both the natural soil-forming factors and cultural practices. Although soil organic matter reflects the environmental factors controlling the accumulation and turnover of plant and animal residues, the dynamics of the active portions such as the microbial residues, and those of the more resistant humic constituents are known to control the release of nitrogen, and to a large extent that of sulfur and phosphorus. Organic residues returned to the soil from cereal crops are estimated to range from 2,000 to 5,000 kg/ha annually. A portion of this material is rapidly attacked, but the turnover of the remainder is measured in years. A knowledge of the rates of decomposition of the various organic components is essential to an understanding of the agronomic factors associated with the incorporation of plant residues and to a knowledge of the dynamics of soil organic matter under both cultivated and native conditions in the field.

Production of plant material uniformly labelled with ^{14}C has made it possible to determine the relative turnover of C within the soil system. Labelled plant materials added under field conditions (Jenkinson 1965; Oberlander and Roth 1968) were generally cut while green, were dried, ground, and incubated in soil kept free of vegetation. Mature cereal straw was added by Führ and Sauerbeck (1968) who studied the effects of different cropping rotations. A summary of ^{14}C investigations (Jenkinson 1971) indicated that the proportion of added carbon retained by the soil was similar despite differences in plant materials and in climatic conditions of soils. About one-third of the added material remained after 1 yr, decreasing to about one-fifth after 5 yr.

Fractionation of soil organic matter after the addition of a number of labelled substrates, varying from glucose through crop residues to microbial bodies, has indicated a rapid distribution of the label after very short periods of incubation. This probably can be attributed to inadequate fractionation techniques to separate the young from the resistant materials, rather than to the rapid turnover rate of the organic fractions (Jansson and Persson 1968; Sauerbeck and Führ 1968).

Uniformly labelled wheat straw is particularly useful in measuring the turnover of crop residues under conditions such as those of cultivated arid grasslands where the straw is required on the surface to maintain a stable soil structure and erosion resistance. The first objective of this study was to compare the decomposition rate of mature wheat straw in two cultivated soils in different climatic zones. The second was to study litter decomposition under natural conditions where plant material accumulates on the surface of the soil. The third objective was to determine the distribution of labelled C throughout various fractions of soil organic matter as decomposition progressed.

MATERIALS AND METHODS

The sites used for this study occurred within the Brown and Gray Wooded soil zones of Saskatchewan (Mitchell et al. 1944). The cultivated and virgin sites in the Brown soil zone were 3 km apart on the Matador IBP Project site southeast of Kyle. These Brown Chernozemic soils developed under medium grass prairie vegetation (*Stipa comata, Koeleria cristata, Agropyron dasytachyum*) on fine-textured lacustrine parent materials and are subsequently referred to as Sceptre soils. In the plow layer (0–12 cm), organic C was 2.14%; inorganic C, 0.11%; total N, 0.24%; total clay, 49%; and the pH 7.2. The cultivated site in the Gray Wooded soil zone was located northeast of Kelvington. These Waitville soils developed under boreal forest (*Populus tremuloides, Picea glauca*) on medium-textured glacial till. The organic C in the plow layer (0–12 cm) was 2.37%; total N, 0.19%; total clay, 22%; and the pH 6.8. There was no inorganic C in the plow layer of Waitville soil.

Production of Uniformly Labelled Plant Material

Wheat seedlings, fertilized with $K^{15}NO_3$, were grown to maturity (90 days) in an atmosphere enriched with $^{14}CO_2$ within a growth chamber consisting of a clear Plexiglas canopy (75 cm diam $\times$ 85 cm high) sealed with rubber cement to a metal base (20 cm high). The base containing the soil in which the seedlings were growing was connected to a gas circulation sys-

tem for uniformly labelling the plant tissue. The mature plant material contained 1.88% N and 38.25%C with a specific activity of 80 μc/g C.

The labelled grass (34.4% C, 16 μc/g C) was produced in the same growth chamber. The surface layer (15 cm) of virgin grassland soil from the Sceptre site was clipped free of vegetation and placed in the metal base of the growth unit. The canopy was sealed and the grass grown for 100 days in an atmosphere enriched with [14]CO$_2$ as described above.

Addition of Labelled Plant Material to Soil

On the cultivated sites, four open galvanized cylinders (30 cm diam $\times$ 25 cm long) were driven into the soil to a depth of 20 cm in July 1968. The plow layers (Ap horizon) removed from each of these small plots were mixed together, sieved, subsampled, and the moist soil mixed with mature labelled wheat straw (16.35 g) chopped into 2.5-cm lengths. Equal amounts of the soil–straw mixture (9,890 g) were then returned to each plot. Differences in moisture content of the two soils resulted in a small difference in the amount of straw C added when expressed on a dry weight basis.

The plots and surrounding field were fallowed during the first summer period and seeded to wheat during the next three growing seasons. Samples were taken immediately before seeding and after harvest. When sampled, the soil within the plow layer (0–12 cm) of each plot was removed, mixed, subsampled for analysis, and returned. A similar field technique was used to establish new field plots on the Sceptre soil in May 1971. Two of these plots were seeded to wheat and two plots were kept free of vegetation during the growing season.

On the virgin site, open galvanized cylinders (15 cm diam $\times$ 15 cm long) were driven into the soil to a depth of 12 cm and the standing plant material was clipped and removed from each cylinder. Grass material (3.5 g), uniformly labelled with ^{14}C, was distributed on the soil surface within the cylinder in May 1969. A nylon screen was placed over each cylinder to prevent removal of the plant material by the wind and was removed 1 mo later. Replicates were removed at different periods throughout the growing season and brought into the laboratory for analysis. The upper 3-cm layer of the cylinder core was separated from the lower (3–10-cm) layer. Both portions were dried, weighed, ground by mortar and pestle to pass a 10-mesh sieve, and stored for analysis. New plots were established on the virgin site in May 1970.

The plant residue present in the upper 3-cm layer was separated from the soil by passing these materials through successively finer sieves and by removing plant material by the following electrostatic technique. A small portion of the 10-mesh material was added to a 20-mesh sieve that was agitated briefly until plant material accumulated on top of the soil remaining in the sieve. An electrostatically charged "nalgene" bottle was passed over the contents of the sieve and plant material collected on the surface of the bottle was removed onto a collecting area. The agitation and electrostatic collection were repeated until all visible plant material in the added portion was removed from the sieve. The remaining soil was ground to pass the sieve, then another portion of 10-mesh soil was added and the above sequence repeated until all the 10-mesh soil was passed through the 20-mesh sieve. A small amount of 20-mesh soil was added to a 30-mesh sieve and treated in a similar manner until the plant material was collected and the soil was ground to pass the sieve. This procedure was also repeated with a 40-mesh sieve. The weights of the soil and the collected plant material were recorded and the soil was subsampled for analysis. The plant material was finely ground.

Fractionation of Soil Organic Matter

The soil samples from four replicates were bulked, subsampled, and fractionated according to the procedure developed by Anderson (1972) with modifications described by McGill (1972). Soil (20 g) was stirred for 2 h with 0.01 N sulfuric acid (200 ml) to remove carbonates, then allowed to stand while the floating debris was removed by suction. On three successive occasions, the soil residue was stirred for 20 h (under N$_2$) with 200 ml of 0.1 M sodium pyrophosphate. The combined acid and pyrophosphate extracts were further fractionated by the addition of 2 N sulfuric acid until pH 1.7 was reached. The precipitate, removed by centrifugation, was dissolved by adjustment to pH 8.5 in 0.5 N NaOH, reprecipitated (pH 1.7), and dissolved again at pH 8.5; this fraction was termed humic acid (HA). The decantates from the humic acid precipitation were combined to give a fraction termed fulvic acid (FA).

The soil residue from the above extraction was mixed vigorously with 200 ml distilled water, sonicated for 10 min at the maximum power (125 W) of a Biosonik II, and the suspension allowed to stand for 48 h before centrifugation (1,000 $\times$ g for 30 min). The residue after sonication contained particles greater than 0.2μ in diam. The material in the decantate was further separated according to par-

ticle size by centrifugation (12,000 × g for 60 min). Material containing particles from 0.2 to 0.04 μ diam was termed fine clay. The dissolved and suspended material remained in the <0.04 μ fraction.

Carbon Determinations

Total C in plant material and soil was determined by wet combustion in vacuo by a modification of the method described by Thorn and Shu (1951). The reagents were potassium dichromate and a combustion mixture consisting of 600 ml concentrated sulfuric acid and 400 ml phosphoric acid (Shaw 1959). Inorganic C was determined by the above procedure except the reaction mixture consisted of 2 N sulfuric acid. Total and inorganic C were determined in triplicate unless indicated otherwise.

Radioactivity Determinations

One ml of the 0.2 N NaOH solution used for the absorption of carbon dioxide was transferred to 20 ml low activity, glass scintillation vials. Addition of 10 ml of toluene-Triton-X-100 scintillant (Turner 1968) yielded a clear homogeneous fluid that was counted in a Picker Nuclear scintillation counted at a counting efficiency of 77%.

RESULTS

Decomposition of Labelled Plant Materials

The amount of labelled C retained by amended field soil from July 1968 to September 1971 is given in Table 1. There were relatively large sampling variations among

replicates of the Sceptre soil during the early stages of decomposition while large portions of undecomposed straw were present. These variations decreased during the later sampling periods. Standard deviations among the Waitville replicates were generally less than 1.1 mg C/100 g soil. The C content of the bulked sample (data not shown) from the four replicates sampled on each date occurred within one standard deviation of the average.

A small amount of labelled inorganic C occurred in the Sceptre soil (data not shown) as indicated by the difference between total and organic labelled C (Table 1). This amount (0.4%) is insignificant compared with that reported by Sorensen and Paul (1971) who observed that 20% of the labelled CO_2 evolved were present as carbonates when virgin Sceptre soil was amended with radioactive acetate under laboratory conditions. The Waitville soil contained no labelled inorganic C, thus total C and organic C are regarded as synonymous.

The labelled straw C added in 1968 (Table 1) was more slowly degraded in the Sceptre soil than in the Waitville. This difference was particularly apparent during the second season (1969) when the amount of labelled C remained unchanged in the Sceptre soil compared with a relatively large decrease in the Waitville soil. Very little decay occurred in either soil during the fourth season. The

Table 1. Recovery of labelled wheat straw carbon incorporated into the plow layer of field soils

Date	Treatment	Sceptre soil (mg C/100 g soil)		Waitville soil (mg C/100 g soil)
		Total	Organic	
7–68		Added 75.6 mg C/100 g soil		72.0 mg C/100 g
5–69	Fallow	33.4±3.8†	33.1	26.1±1.1
9–69	Wheat	34.1±3.6	33.8	18.9±0.8
5–70	Wheat	22.3±1.0	22.1	17.3±0.9
9–70	Wheat	20.7±0.5	20.5	13.7±0.3
5–71	Wheat	17.4±0.5	17.2	11.4±0.3
9–71	Wheat	16.2±0.5	16.0	11.1±0.1
5–71		Added 100.7 mg C/100 g soil		
9–71	Fallow	42.8±2.0‡	42.5	–
9–71	Wheat	53.1±5.4	52.8	–

†Mean and standard deviation of four replicates.
‡Mean and standard deviation of two replicates.

results for straw added to the Sceptre field soil in May 1971 and incubated throughout the growing season indicate that plots sown to wheat retained one-fifth more labelled C than those under fallow (Table 1).

The decomposition curves of straw added to field soil and for grass added to virgin soil followed an exponential pattern indicating the rapid initial loss of easily degradable plant components was followed by a much slower release of the more resistant components (Fig. 1 and 2). The difference in decomposition rates between the two cultivated soils was most pronounced after the second sampling date when 44 and 26% of the added straw C remained in the Sceptre and Waitville soils, respectively. Except for the last sampling date, the slope of the curve for the Waitville soil corresponded to that of a line representing a half-life of 12 mo. The decrease in slope between the last two
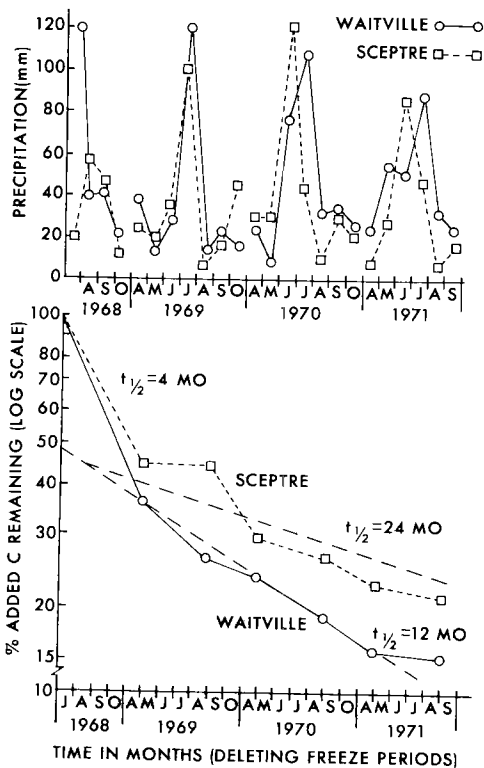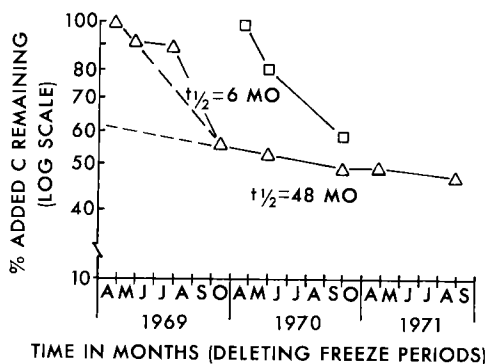

Fig. 2. Decomposition of labelled grass added to the surface of virgin Sceptre soil.

sampling dates is significant and suggests that the straw C is approaching equilibrium with soil organic matter. In the Sceptre soil, decomposition was greatly retarded in the 1969 growing season. However, the rate of decomposition in 1970 and 1971 corresponded to a half-life of 24 mo. Because the winter period (November–March) when the soil was frozen was deleted from the time scale, this is equivalent to four growing seasons. Extrapolation of the straight line portion of the curve back to zero time may be used to provide information on the biological stability of the added straw. The common Y-intercept of the curves from both field soils indicated that the proportion of biologically resistant straw components present at zero time was similar (46–48%). This similarity is to be expected as the straw added to both soils was from the same source.

Precipitation data (Fig. 1) indicated that the maximum monthly rainfall occurred during July and June at the Waitville and Sceptre sites, respectively. The Waitville site is characterized by higher seasonal precipitation coupled with lower temperature and evapotranspiration resulting in a lower annual water deficit than that for the semiarid Sceptre site (Chapman and Brown 1966).

Data for the amount of labelled C recovered from grass added to virgin Sceptre soil (Table 2) were extremely variable among replicates on the first three sampling dates; one-quarter to three-quarters of the labelled material occurred in the soil taken

Fig. 1. Decomposition of labelled wheat straw added to field soils.

Table 2.   Percent labelled C recovered from grass added to the surface of virgin Sceptre soil

Date	No. replicates	Plant material	Soil	Plant material + soil
		(0–3 cm depth)		
		Added 5–69		
6–69	3	66.1±16.9†	24.7±18.1	90.8± 5.9
8–69	4	41.3±15.5	45.7±10.3	87.0±10.1
10–69	4	11.2± 2.5	44.5± 4.9	55.7± 3.2
6–70	4	41.9± 4.0	9.6± 1.9	51.5± 2.5
10–70	4	37.1± 6.5	9.7± 1.0	46.8± 6.7
5–71	3	39.2± 5.9	7.5± 2.5	47.0± 4.8
9–71	3	37.9± 1.0	7.7± 1.9	45.7± 2.3
		Added 5–70		
6–70	2	70.5	8.7	79.2
10–70	2	46.0	10.8	56.8

†Mean and standard deviation, respectively.

from the 0-3-cm depth. The high variation and anomalous distribution of the labelled C were attributed to the initial method used for the separation of plant material from those samples. This consisted of grinding the top 3-cm layer to pass a 10-mesh sieve and separating the coarse plant material by sieving. The subsequent application of the electrostatic technique in 1970 and 1971 reduced the variation among replicates and the amount of labelled C recovered in the soil. Approximately one-quarter of the residual labelled C was inseparable from the soil, suggesting that it was humified. No labelled C was detected (data not shown) in the 3-10-cm depth of any replicate.

Very little loss of the added grass C occurred during May, June, and July 1969 (Fig. 2), which coincided with a period of relatively low rainfall. However, rapid decomposition in autumn resulted in a half-life of 6 mo for added C during the first season. Thereafter, the rate of loss occurred slowly with a half-life of approximately 48 mo of growing season or about 8 yr under natural field conditions. Although decomposition of grass added in May 1970 was uniform throughout the season, the amount of grass C remaining at the end of the season was the same as in 1969 when the decomposition rate was not uniform.

Carbon Recovered from Various Fractions of Soil Organic Matter

Although the Sceptre clay soil retained more labelled C throughout the incubation period, its distribution among the different soil fractions was not markedly different from that in the Waitville loam soil (Table 3). Except for the second sample (September 1969) taken from the Sceptre soils, the total amount of C in the fractions from both soils decreased with time. The greatest decrease occurred in the floated fraction and the least in the fine clay. During the 1969 growing season, the decrease in the floated fraction from the fall sample of the Sceptre soil was accompanied by a corresponding increase in the >0.2 μ residue; the other fractions remained unchanged during that period. The average recovery of labelled C during fractionation for the four sampling dates was 96.7 ± 1.7 and 98.1 ± 1.7% in the Sceptre and Waitville soils, respectively.

Measurements of soil C in fractions from samples taken on the different dates (Table 4) were reproducible with standard deviations of less than 3% within each fraction. This precision may be used as an index of the variation in labelled C from a single fractionation. Additional information on the transformations of added straw within the soil organic pool was obtained by expressing

Table 3. Percent labelled C recovered in organic matter fractions of field soils

Date	Floated	Fulvic acid	Humic acid	<0.04 μ	Residue (>0.2 μ)	Fine clay (0.2-0.04 μ)	Sum	Soil	Recovery during fractionation
7–68	*Sceptre soil — added 75.6 mg C/100 g soil*								
5–69	8.5†	3.6	2.5	7.9	15.6	1.2	39.3	40.9	96.1‡
9–69	6.0	3.3	2.9	8.3	18.9	0.9	40.3	40.7	99.0
5–70	3.0	2.5	2.0	6.5	13.8	0.7	28.5	29.5	96.4
9–70	2.4	2.4	1.7	5.7	12.8	0.7	25.7	27.0	95.1
7–68	*Waitville soil — added 72.0 mg C/100 g soil*								
5–69	6.7	4.3	2.9	5.6	15.4	0.7	35.6	35.7	99.6
9–69	2.4	2.9	2.6	4.9	11.9	0.8	25.5	25.7	99.5
5–70	2.1	2.6	3.1	4.2	10.0	1.1	23.1	23.9	96.5
9–70	1.5	1.8	1.7	2.8	6.5	0.7	17.5	18.1	96.9

$$\dagger \frac{\text{Labelled C in fraction}}{\text{Labelled C added to soil}} \times 100.$$

$$\ddagger \frac{\text{Sum labelled C of fractions}}{\text{Labelled C in soil sample}} \times 100.$$

Table 4. Soil and labelled C in organic matter fractions as percent of the sum in all soil fractions

Date	Floated	Fulvic acid	Humic acid	<0.04 μ	Residue (>0.2 μ)	Fine clay (0.2-0.04 μ)
			Sceptre soil			
			(soil C†)			
	0.3	9.6±0.5	10.9±1.1	33.1±1.0	38.1±2.6	8.6±1.0
			(labelled C)			
5–69	21.5	9.1	6.4	20.2	39.7	3.0
9–69	14.8	8.2	7.2	20.7	46.9	2.3
5–70	10.7	8.8	7.0	22.8	48.4	2.3
9–70	9.3	9.3	6.7	22.2	50.0	2.6
			Waitville soil			
			(soil C†)			
	0.5	9.2±0.6	17.2±2.0	18.5±1.5	50.1±2.0	5.1±1.0
			(labelled C)			
5–69	18.8	12.1	8.2	15.6	43.4	2.0
9–69	9.2	11.4	10.3	19.0	46.7	3.2
5–70	9.0	11.4	13.3	18.1	43.4	4.8
9–70	8.7	10.3	9.5	15.9	51.6	4.0

†Mean and standard deviation of triplicate determinations from single fractionation of samples taken on four dates.

labelled C in each fraction as a percentage of that in all fractions (Table 4). After 2 yr the >0.2 μ residue contained about 50% of the residual labelled carbon. The other fractions of the Sceptre soil remained relatively stable in contrast to the variations observed in the humic acid, fine clay, and <0.04 μ fractions of the Waitville soil. In both soils, the amount of labelled C in the fulvic acid exceeded that in the humic acid fraction. Differences between soils were shown by the larger proportion of labelled C in the <0.04 μ fraction from Sceptre soil and the higher percentages of labelled humic acid and fulvic acid extracted from Waitville soil. The rate of transfer of straw C from the floated fraction to the >0.2 μ residue was also different, occurring more rapidly during the first summer in the Waitville soil.

The highest specific activity in either soil occurred in the floated fraction (Table 5) ranging from 25 to 100 times that of the labelled organic matter associated with fine clay. The residue was more heavily labelled than fulvic acid in the fine-textured Sceptre soil but the converse was true for the medium-textured Waitville soil. The specific activity of the <0.04 μ fraction was nearly double that of humic acid in the Waitville soil, whereas the specific activities of these fractions were similar in the Sceptre

soil. Except for the fine clay, the degree of labelling of the remaining fractions generally decreased with time. The decrease was most evident in the floated fraction, which declined by one-half in the Sceptre soil and two-thirds in the Waitville.

DISCUSSION

The rate of decomposition of labelled wheat straw differed within the Sceptre and the Waitville soils studied in this field investigation. The higher moisture efficiency at the subhumid Waitville site undoubtedly contributed to the higher biological activity and greater turnover of the straw in this soil than in the semiarid Sceptre soil. These observations are in agreement with other information on the properties of the organic matter in these soils. Anderson (1972) observed greater values for absorbance at 280 μ for the humic acid and <0.04 μ fraction of the Waitville soil as compared with the Sceptre. These values were indicative of the more strongly humified organic matter as a consequence of more intense biological activity associated with the moister soil environment at the Waitville site. Campbell et al. (1967) reported that the mean residence time of organic matter in the cultivated Waitville soil was 250 yr, which compares with 525 yr for a Sceptre soil (Martel 1972). Shields et al. (1968) showed that

Table 5. Specific activity of soil organic matter fractions from different sampling dates

| Date | Fraction | | | | | |
	Floated	Fulvic acid	Humic acid	<0.04 μ	Residue $(>0.2$ $\mu)$	Fine clay $(0.2–0.04$ $\mu)$
	Sceptre soil					
5–69	504†	12	7	8	16	4
9–69	395	12	8	9	17	4
5–70	277	10	7	7	12	3
9–70	214	9	8	6	10	3
	Waitville soil					
5–69	278	13	5	8	9	4
9–69	145	10	4	8	7	4
5–70	111	9	5	7	6	5
9–70	97	7	3	5	5	4

†$\dfrac{\text{mg labelled C}}{\text{g organic C}}$.

Gray Wooded soils were characterized by a greater proportion of mobile (free) humic acids, and a higher $E_4:E_6$ ratio than Chernozemic soils. In contrast, Biederbeck (1966), investigating the degradation of ^{14}C-labelled immature oat residues under laboratory conditions, reported that similar amounts of added plant ^{14}C (41–42%) remained in a Gray Wooded and a Chernozemic soil after 222 days of laboratory incubation under similar abiotic factors for the two loam soils.

Under cropping, the rates of decomposition in the Sceptre soil were irregular (steplike) in contrast to a smooth curve for the Waitville. This was most obvious during the first season planted to wheat when no decomposition occurred, compared with that in the subsequent fall and early spring when 15% of the straw carbon was decomposed. Similar "carbon-saving" effects of growing plants were reported by Führ and Sauerbeck (1968) who found that, during the first summer, significantly more labelled C was retained in plots sown to wheat than in fallow plots; this difference disappeared later on. Further investigation of the effects of cropping showed that cropped plots retained 20% more labelled straw C than fallow. Undoubtedly, the moisture used by the growing crop resulted in droughty conditions within the plow layer over most of the growing season, which retarded the decomposition process.

Labelled grass added to the surface of the virgin Sceptre soil in 1969 and 1970 did not decompose to the same extent as straw incorporated into the plow layer of the Sceptre soil. The decomposition rate of grass during the first season was similar to that for wheat straw incubated in the plow layer but only one-half that of wheat straw incubated over the second and third seasons. The greater stability of grass C under our semiarid conditions must therefore be attributed to lack of incorporation where litter accumulates on the virgin surface horizon and is very subject to drought.

Decomposition of the grass added in 1970 was more uniform than that of the material added the previous year. Examination of the monthly precipitation data shows that the addition of grass in May 1970 was followed by heavy rainfall during June, which thoroughly soaked the added material, compressed it firmly to the soil surface, and aided in its physical deterioration. In contrast, the small amounts of rainfall recorded during April, May, and June 1969, were not sufficient to bring the material in contact with the soil. Once in contact with the soil, however, the material was subjected to mixing by the soil fauna (i.e., nematoda, arthropoda) and subsequent attack by microorganisms. Decomposition then occurred very quickly.

The droughty conditions prevalent at the Sceptre site in the spring of 1969 may also serve to explain the fact that virtually no decomposition took place in the wheat straw at the cultivated site until after the crop was harvested. Organic matter fractionation revealed that the decline in floated fraction observed between spring and fall sampling dates was accompanied by an increase in the >0.2 μ fraction. Absence of changes in the remaining fractions during the growing period indicated that comminution of straw particles was accompanied by stabilization of smaller particles by inorganic material. The role of the high clay content in the stabilization of the organic fractions of this soil cannot be overlooked. Sorensen (1967) reported that the presence of montmorillonite increased the recovery of added C in amino acids during the decomposition of ^{14}C-labelled carbohydrate.

The higher biological activity in the Waitville soil is shown by the rapid decline of the floated fraction and its subsequent cycling within the other fractions of the labelled organic pool. The high specific activity of the fulvic acid and its rapid decline, coupled with fluctuations in humic acid and the fraction <0.04 μ, is also suggestive of an active soil population during the initial phases of incubation but stabilization during the latter period. This is confirmed by the low slope of the decomposition curve during the 1971 season. These results are in agreement with those of McGill (1972) who observed a higher turnover rate of labelled N from Waitville fractions and concluded that a lag of N incorporated into the >0.2 μ fraction was indicative of cycling within other fractions.

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