1976

Measurements of Carbon and Nitrogen Changes in a Desert Soil

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1974 PROGRESS REPORT
[FINAL]

MEASUREMENTS OF CARBON AND NITROGEN CHANGES IN A DESERT SOIL

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US/IBP DESERT BIOME
RESEARCH MEMORANDUM 76-29

in

REPORTS OF 1975 PROGRESS
Volume 3: Process Studies
Microbiological Section, pp. 59-72

1973 Proposal No. 2.3.4.3 and IBP Grassland Biome

Printed 1976

Citation format: Author(s). 1976. Title.
US/IBP Desert Biome Res. Memo. 76-29.
Utah State Univ., Logan. 14 pp.

Ecology Center, Utah State University, Logan, Utah 84322

ABSTRACT

Decomposition of *Bouteloua eriopoda* leaves, stems, crowns and roots was determined under natural field conditions in an arid grassland during the late spring, summer and early fall of 1973. Losses were measured by employing both CO_2 evolution and litter bag weight loss techniques. Other parameters measured during the course of this investigation were soil temperature, soil moisture and leaching of plant materials. Weight loss data of many plant materials exceeded, to a great extent, the CO_2 evolution losses measured on the same plant materials. These discrepancies were associated with observed termite activity noted in conjunction with data collection. The loss due to CO_2 evolution was primarily induced by microorganisms. This total was then subtracted from the larger weight loss value which gave a positive value in all but one instance. A value equal to the highest level of leaching that could occur was then subtracted from the resultant value from the first subtraction. The amount remaining was considered to be the quantity removed by termites during the period of this investigation. Decomposition was more prevalent on the May-placed leaf, stem and crown material than that placed in the field in February or July. Termite losses were most abundant on July-buried roots and July-placed crowns and leaves than noted for May or February. Roots were most commonly removed by termites and were followed by leaves, crowns and stems, respectively. It was apparent that combinations of measurements should be conducted to investigate decomposition under field conditions. Without the two measurements utilized, each measurement would have individually yielded erroneous data. Employing both techniques, data that expressed indicative estimates of source carbon losses from the desert grassland in 1973 were obtained.

INTRODUCTION

Decomposition that occurred under arid grassland conditions was examined during the past two years. The 1971 season was exceptionally dry during the major portion of the growing season and the decomposition which occurred was rapid during short intervals following periods of rainfall. During 1972, greater amounts of precipitation induced much more decomposition than that measured in 1971. Insufficient soil-temperature and soil-moisture data were collected during these two years, and influences of these parameters on decomposition could not be critically examined. Observations on both filter paper and plant tissue litter bags exhibited losses followed by gains in weight during a dry period. These data would not be considered consistent with the continuous process of decomposition. Therefore, decomposition under field conditions was examined by measuring the evolution of CO_2 and the volatilization of NH_3 from a precise area in the field over a given period of time. Other parameters measured included soil temperature, soil moisture and litter-bag weight loss. These measurements were comparable to those made of creosotebush tissues in the desert experiment so comparisons could be made at a later time.

OBJECTIVES

1. Determine the rates of decomposition of leaves, stems, crowns and roots in field exposures by determining the amount of carbon dioxide (CO_2) and ammonia (NH_3) loss, and comparing these to the substrate weight loss.
2. Determine the influence of soil temperature and soil moisture changes on the decomposition process.
3. Determine the relative importance of activity sites for microbial decomposition by comparing buried root litter bags with surface positioning of leaf-, stem- and crown-tissue litter bags.
4. Examine any differences that might be associated with winter incorporation of substrate as compared to incorporations during the spring or summer.

METHODS

Site Selection and Development

The experimental area selected was within the Jornada grassland site enclosure. It was selected because reduced experimental activity during 1973 assured a relatively convenient, yet undisturbed site. This site was originally selected a few years earlier because it was representative of major sections of the arid grassland community. The selected area was gridded into 144 experimental plots of 1.0 x 1.0 m. Within this experimental area, the primary vegetation was black grama (*Bouteloua eriopoda*) and an occasional small mesquite (*Prosopis glandulosa*) extended above the canopy formed by the grass.

In almost all cases, the tubes were driven into the soil at the center of the 1.0 x 1.0 m plot. Where this was not possible due to the height of the caliche layer, the tubes were placed 0.5 m off-center to the north.

Asbestos Plastic Tubes

Asbestos plastic cylinders, approximately 183 cm in length with an inside diamater of 11.5 cm, were obtained as surplus items. These cylinders were cut into 28-cm lengths and the cut ends were sanded and prepared for placement in the field. This preparation included using a felt pen to number the tubes and to draw a line around the tube 8 cm from the top, which was the level the tubes were driven into the soil. This saved a substantial amount of time during the placement of the tubes in the soil and later during the testing period. When the plant tissues were placed into the field, these plastic asbestos tubes were driven into the soil at the center of the square-meter plot.

Plant Tissue Litter Bags

Leaf, stem, crown and roots of *Bouteloua eriopoda* were collected at the end of the 1972 growing season. After separation of these tissues into the above four categories, they were placed in an oven maintained at 50 C. These tissues reached a constant dry weight within 24 hr in the oven. One g of leaf tissue and 3 g of stem, crown or root tissue were weighed out and then placed in a nylon bag which was completely closed by sewing shut the open end. The nylon employed was white hose (rejects) from the Hanes Manufacturing Plant located in Las Cruces. Openings in this nylon varied from 0.5 to 0.9 mm, with an average opening of 0.75 mm. Twelve nylon bags containing leaves, stems, crowns or roots, or a total of 48 bags, were taken to the field on February 26, 1973. The bags containing the leaves, stems and crowns were placed on the soil surface within the tube after the asbestos plastic tube was driven into place at the center of the plot. Bags containing grass roots were buried in the soil at the 10-cm depth. This was accomplished by driving the tube 10 cm into the soil, breaking the soil column at that depth, removing the tube containing the soil, placing the bag at the 10-cm depth, replacing the tube containing the soil and driving it to the appropriate depth. The plant materials buried in February could not be measured for CO_2 evolution or NH_3 volatilization until May when sufficient time and help became available. Therefore, the weight loss information was used to give the baseline data for decomposition that occurred prior to May 15. Tissues buried in February were removed on May 15, June 18 and July 18, 1973, to determine weight loss and changes in chemical composition as a result of decomposition.

Twenty-one bags containing leaves, stems, crowns or roots (or a total of 84 bags) were placed in the field on May 18, 1973. The litter bags containing leaves, stems and crowns were placed on the surface inside the tubes, while those containing roots were buried in the soil as in the February burial. Carbon dioxide evolution and NH_3 volatilization were measured until the buried plant parts were removed. Plant parts introduced into or onto the soil in May were removed on June 18, July 18, August 4 and 25, 1973. These removals were made to determine weight loss and changes in chemical composition of the tissue.

Eighteen nylon bags containing leaves, stems, crowns or roots were placed in the field on July 18, 1973. Again the litter bags were placed as they were in February and May. Plant materials were removed on August 4 and 25, 1973, for weight loss and chemical composition determinations. The plastic asbestos tubes for this burial were driven into the soil 0.25 m from the center of the plot. A few of the plots had been utilized in an earlier portion of the experiment.

Soil Temperature and Soil Moisture

Soil temperature and soil moisture readings (DSCODE A3USG03) were obtained from the same type of gypsum blocks as employed by the Jornada Validation Site personnel (Whitford et al. 1972). Soil block resistances were read on a converted, battery-operated Soil Test, Inc., ohmmeter. Readings were then converted from calibration curves developed by validation site personnel for estimating soil water potentials and temperatures from gypsum soil block resistances. Periodically, calibrated thermometers were taken to the field to compare the converted values with those obtained directly from the calibrated instruments.

The gypsum blocks were placed in the field at the time the February burials of plant tissue were made. Ten gypsum blocks were used on the plot and all of them were placed at the 10-cm depth. Five blocks were placed inside the plastic asbestos tubes and the placement followed the procedure used for the root burial. The remaining five blocks were placed outside of the tubes and 50 cm away from them to determine how the tubes influenced the soil temperature and soil moisture regimes.

Carbon Dioxide Evolution

Determinations of CO_2 evolution (A3USG04) generally followed the methods outlined by Coleman (1971). Wide-mouthed, screw-cap, plastic vials were used to contain the alkali (KOH) employed for trapping the CO_2. Ten ml of a 0.6M KOH solution were placed in each plastic vial and the cap was screwed on tightly. The vials were taken to the field and placed next to the tubes to be tested. The cap of the vial was removed and the vial and cap placed on the soil surface inside the asbestos tube. Next, a square plastic sheet was placed over the top of the tube and tightly retained with a rubber band. This was followed with a square of aluminum foil which again fit tightly over the opening and was held in place with an additional rubber band.

After an exposure of 22 to 25 hr in the field, or the complete diurnal pattern, the vials were removed from the tube, capped immediately and returned to the laboratory for titration.

Ten milliliters of a barium chloride solution were added to precipitate the absorbed CO_2 as carbonate. Five drops of thymolphthalein were added to give a sharp end point. The solution was then neutralized with 0.6M hydrochloric acid (HCl), and the quantity of HCl used to reach the end point was recorded. Five blanks were also titrated.

The first calculation was as follows: 1) the mean of the ml HCl titrated in the controls was obtained; 2) the experimental values in ml HCl were subtracted from that of the mean of the controls; 3) the value obtained in step 2 was multiplied by the mg CO_2 equivalent to obtain mg CO_2; 4) the value in step 3 was multiplied by the conversion factor to a 24-hr period to obtain values for mg CO_2/24 hr. The other calculation consisted of the following: 1) the mean of the HCl titrated in the blanks was obtained; 2) the experimental control values in ml HCl were subtracted from that of the mean of the blanks; 3) the value obtained in step 2 was multiplied by the mg CO_2 equivalent to obtain mg CO_2; 4) the value in step 3 was multiplied by the conversion factor to 24 hr to obtain values for mg CO_2/24 hr and, finally, the value in step 4 was multiplied by the factor of the area in the tube to a square-meter basis. This final value would give the total soil respiration on a square-meter basis. Carbon dioxide evolution from the plant material is expressed as mg CO_2/24 hr, while soil respiration is expressed as mg $CO_2 \cdot 24\ hr^{-1} \cdot m^{-2}$.

When environmental parameters were suitable and CO_2 was evolved, determinations were made on an alternate-day basis. The tubes containing the vials with KOH would be covered for approximately 24 hr and then would remain exposed to the environment for the next 24 hr. It was assumed that this would allow for equilibration and help maintain a more natural condition.

Amounts of KOH employed in the vials were increased to 30 ml after a rainfall. This amount was used to trap the quantities of CO_2 evolving. The distance from the field to the laboratory eliminated the possibility of maintaining the 10-ml quantities and exposing them to shorter time periods.

Ammonia Volatilization

Determinations of NH_3 volatilization were made using a relatively simple technique. Wide-mouthed, screw-cap, plastic vials were used to contain the acid employed for trapping the NH_3. Ten milliliters of a 0.5N H_2SO_4 solution were placed in each plastic vial and the cap was screwed on tightly. The vials were taken to the field, placed in the tubes and later removed and brought back to the laboratory as in the CO_2 determinations.

A standard curve of absorption was determined for known concentrations of NH_3. Ammonium chloride was used to prepare the standard, using serial dilutions to obtain the desired μg quantities. The spectrophotometer (Spec 20) was set at 480 nm. A blank was prepared by adding together 1 ml of 0.5N H_2SO_4, 9 ml distilled H_2O and 0.5 ml Nessler's reagent. The three materials were mixed together and 5 min allowed for the reaction to occur before taking readings.

Five milliliters of the field-exposed H_2SO_4 were used for analysis, and were combined with 45 ml of distilled H_2O and 2.5 ml of Nessler's reagent. Again, 5 min were allowed for the reaction to occur before readings were taken. The percent transmittance was recorded for each sample, and this reading was converted to absorption. Absorption was then converted to μg quantities of NH_3 trapped per sample.

Weight Loss Determination

As mentioned in the plant-tissue litter bag section, plant materials were removed periodically to determine how much weight was lost due to decomposition. The original dry weight of the litter in each bag was 3 g for stems, crowns and roots, and 1 g for leaves when they were taken to the field. The bags were removed after given exposures and returned to the laboratory. There plant parts were removed from the nylon bag, oven-dried, weighed, ashed and the ash was weighed. The actual weight of the exposed material was divided by the original weight and this value was multiplied by 100 to obtain the percentage of material remaining. Two values remain to be determined to complete this evaluation; 1) the original ash content of the plant parts, and 2) the soil ignition value. It is believed that these values are minor but could induce some variations in the data obtained.

Chemical Composition of Decomposed Plant Tissue

In most instances, tissue litter bags were removed for both weight loss determinations and chemical analysis. These litter bags have been sent with soil samples to the Natural Resources Ecology Laboratory at Colorado State University, Fort Collins, Colorado, for analysis. Results of these changes have not been received to date.

Leaching of Plant Parts

Simple leaching experiments were conducted on leaf, stem, crown and root materials. This consisted of determining the thickness of leaf, stem and crown litter in the field and setting up a similar situation in a Büchner funnel. A simulated rain, equivalent to 2.54 cm, was passed through the plant materials in four 15-min intervals. The plant materials were oven-dried and weighed. Since some of the material is exposed to free soil water for longer periods of time, the same plant parts were then placed in beakers and exposed to free moisture for a 24-hr period. After removal the materials were again oven-dried and weighed to determine any additional loss.

RESULTS

Soil Temperature and Soil Moisture

Soil temperatures (Table 1) were generally taken between 7:30 and 9:30 a.m. throughout the investigation period. Difficulty was encountered in placement of the blocks inside the tubes. When insufficient slack was given in the gypsum block wire, the wire was stripped of the insulation or totally broken as the tube was driven into the soil. These wires had to be completely replaced when either of the above occurred. After the blocks were stabilized and calibrated, the soil temperatures inside the plastic asbestos tubes were essentially the same as the soil temperatures of the surrounding soil.

Soil moistures (Table 2) were found to be much more variable than the soil temperatues. At times, large variations existed between the moisture levels measured inside the tubes as compared to those measured in the surrounding soils. Those blocks placed in the soil external to the tubes were more consistent than those placed inside the tubes. A wet-dry regime could be observed with blocks in Plots 2, 12, 53, 105 and 132. The soil in all five plots was moist on May 15 and dried out between June 2 and 5. Again, on June 15 the soil was moist, and dried out between June 28 and July 2. On July 15 and 16 all soils became moist and slowly dried out in four plots on August 9 and 10. Plot 132 did not dry down to the same extent and all received additional moisture on August 13 and 16. Soil blocks placed in tubes on Plots 18, 73 and 139 caused much difficulty. Much of the early change was based on changes in Plots 95 and 110. Plot 95 revealed the wet-dry sequence, but the soil was moist for a much longer period of time than blocks not placed in tubes. The soil block in Plot 110 yielded results that the soil lost a substantial amount of moisture (—38.9 and —51 bars) but never dried out (—128 bars). In late July, when all of the blocks were functioning, none of the readings exhibited substantial drying prior to the additional moisture on August 13 and 16.

Table 1. Soil temperature (°C) measured at the 10-cm depth inside and external to the plastic asbestos tubes; readings taken between 7:30 and 9:30 a.m. during the summer of 1973

	Temperature (°C) outside tubes in plots					Temperature (°C) inside tubes in plots				
Days 1973	2	12	53	105	132	18	73	95	110	139
5-15	14.9	14.9	15.4	14.9	14.9	14.9	16.5	16.5	16.5	14.9
5-22	24.8	24.1	24.1	22.9	23.5	23.5	25.4	23.5	22.9	22.3
5-23	26.0	26.0	26.0	26.0	25.4	24.1	26.0	23.5	25.4	22.9
5-24	24.1	24.1	24.1	23.5	22.9	23.5	25.4	23.5	24.1	22.9
5-26	23.5	22.9	25.4	23.5	22.9	25.4	26.0	25.4	25.4	24.8
5-27	24.1	23.5	25.4	24.1	23.5	24.1	26.7	25.4	25.4	23.5
5-28	22.3	20.9	22.9	22.3	22.3	22.3	24.8	23.5	23.5	22.9
5-29	24.1	23.5	24.1	24.1	22.9	23.5	25.4	24.1	24.8	22.9
5-30	23.5	23.5	24.1	23.5	23.5	24.1	26.0	25.4	24.1	24.1
5-31	26.7	26.0	27.3	26.0	26.0	26.7	27.3	26.0	27.3	26.0
Average	23.40	22.95	23.88	23.08	22.77	23.21	25.01	23.68	23.94	22.72
6-1	21.7	21.1	22.9	21.7	21.7	22.9	24.8	23.5	23.5	22.9
6-2	22.3	21.7	23.5	21.7	21.7	23.5	25.4	24.1	23.5	23.5
6-4	22.9	23.5	24.1	21.7	22.3	22.3	25.4	24.1	24.1	22.9
6-5	23.5	23.5	25.4	23.5	23.5	24.8	26.7	26.0	25.4	25.4
6-12	27.3	27.3	27.9	26.7	26.7	28.6	31.3	29.9	28.6	28.6
6-15	22.3	23.5	22.9	22.9	22.9	22.3	23.5	22.9	22.9	21.7
6-16	21.7	21.1	22.9	22.9	21.1	22.3	23.5	22.3	23.5	22.3
6-17	26.7	26.0	26.0	26.7	25.4	25.4	26.7	25.4	26.0	23.5
6-19	26.7	26.7	26.7	25.4	26.0	26.7	27.3	26.7	27.9	25.4
6-20	26.7	25.4	26.7	26.0	25.4	26.7	27.9	26.7	26.7	26.7
6-21	26.0	26.0	26.7	26.0	26.0	26.0	27.9	26.7	27.9	26.0
6-22	25.4	25.4	26.7	25.4	24.1	26.7	27.9	26.7	27.3	26.7
6-23	26.0	25.4	26.7	25.4	25.4	26.0	27.9	26.7	27.9	27.3
6-24	26.7	25.4	27.9	26.7	25.4	27.3	28.5	27.9	27.9	27.3
6-25	29.9	30.7	29.3	29.9	29.3	29.3	30.7	29.3	29.9	28.6
6-26	28.6	27.9	28.6	27.3	27.3	28.6	29.9	29.3	29.3	28.6
6-27	29.9	29.3	29.9	29.3	28.6	29.9	31.3	29.9	29.9	29.9
6-28	30.7	29.9	31.3	29.9	29.3	31.3	32.0	31.3	31.3	30.7
6-29	30.7	29.9	30.7	29.9	29.3	30.7	32.0	30.7	32.0	30.7
6-30	29.9	29.3	30.7	28.6	29.3	30.7	32.0	27.3	30.7	30.7
Average	26.27	25.70	26.87	25.87	25.53	26.59	28.14	26.87	27.32	26.47
7-2	30.7	30.7	32.0	29.9	30.7	30.7	32.7	32.0	32.0	31.3
7-3	31.3	31.3	32.0	30.7	30.7	32.0	32.7	32.0	32.0	32.0
7-9	33.4	32.0	33.4	32.7	32.0	33.4	34.1	33.4	32.7	32.7
7-10	31.3	30.7	32.0	30.7	30.7	32.0	32.7	32.7	32.7	32.0
7-15	25.4	24.8	26.7	24.1	24.1	26.7	27.3	27.3	27.3	27.3
7-16	27.9	28.6	28.6	27.9	27.3	29.3	29.9	29.9	29.9	29.3
7-17	25.4	26.0	26.7	25.4	25.4	26.7	33.4	26.7	26.7	33.4
7-18	22.9	22.9	23.5	22.9	22.9	23.5	23.5	23.5	23.5	22.9
7-19	22.9	22.9	24.1	23.5	22.9	23.5	25.4	24.8	24.1	23.5
7-20	25.4	24.1	26.0	---*	24.1	25.4	26.0	26.0	24.8	22.9
7-21	27.3	26.7	27.3	26.0	26.7	27.3	27.9	27.3	27.3	27.3
7-22	26.0	25.4	26.7	---*	25.4	26.0	27.3	26.7	26.7	26.0
7-23	27.3	27.3	27.3	----	26.7	27.3	28.6	27.3	27.9	27.3
7-25**	36.3	37.0	35.5	----	36.3	37.8	34.1	34.8	34.1	33.4
7-26	24.1	24.1	26.0	----	24.1	24.1	26.7	26.0	26.0	25.4

Table 1, continued

	Temperature (°C) outside tubes in plots					Temperature (°C) inside tubes in plots				
Days 1973	2	12	53	105	132	18	73	95	110	139
7-27	26.7	26.7	26.7	----	26.0	26.7	28.6	27.3	27.9	26.7
7-28	24.8	24.8	26.0	24.8	24.1	24.8	26.7	26.0	26.0	26.0
7-29	25.4	24.8	26.0	26.0	24.1	25.4	27.3	26.7	27.3	26.7
7-30	26.7	25.4	26.7	25.4	24.8	26.0	26.7	26.7	26.7	26.0
7-31	24.8	24.8	25.4	24.8	---*	25.4	26.0	25.4	26.0	24.8
Average	27.30	27.04	27.93	26.77	26.78	27.69	28.89	28.13	28.09	27.85
8-1	22.9	22.9	22.9	22.3	21.7	---*	25.4	24.1	24.8	24.1
8-2	26.0	26.7	26.7	26.0	25.4	26.7	27.9	27.3	27.3	26.7
8-3	27.3	26.7	28.6	26.0	25.4	27.3	29.3	28.6	29.3	27.9
8-4	26.7	26.7	27.3	26.0	25.4	26.7	29.3	27.9	28.6	27.9
8-6	27.9	27.3	27.9	27.3	26.7	27.3	29.9	29.3	29.9	29.3
8-7	28.6	27.9	29.3	27.3	27.3	27.9	30.7	29.9	29.9	29.3
8-8	27.9	27.3	27.9	26.7	27.3	27.9	29.9	29.3	29.3	28.6
8-9	29.3	29.3	29.9	31.3	29.3	29.9	31.3	29.9	29.9	29.3
8-10	29.3	29.9	29.9	29.3	28.6	29.3	31.3	29.9	29.9	29.9
8-11	24.8	24.1	26.0	25.4	24.8	24.8	26.7	26.0	26.7	26.0
8-13	23.5	23.5	24.1	24.1	23.5	24.1	26.0	24.8	26.0	24.8
8-14	26.7	26.0	26.7	26.0	25.4	26.7	27.9	27.3	27.9	27.3
8-16	24.1	24.8	25.4	24.8	24.8	24.8	26.0	25.4	26.0	25.4
8-17	26.0	25.4	26.7	26.0	25.4	26.0	27.9	26.7	27.3	26.7
8-20	27.9	27.9	28.6	27.3	27.3	27.9	29.9	28.6	29.9	28.6
8-21	25.4	25.4	26.0	24.8	24.1	26.0	27.3	26.7	27.9	26.7
8-22	25.4	26.0	26.0	25.4	24.8	25.4	27.3	26.0	28.6	26.7
8-23	25.4	25.4	26.7	25.4	24.8	26.7	28.6	27.3	28.6	27.3
8-24	27.3	27.3	27.3	26.0	26.7	27.3	29.3	27.9	29.3	27.3
8-25	27.3	26.7	27.9	26.7	26.7	27.3	29.3	27.3	29.3	27.3
Average	27.04	26.36	27.10	26.20	25.76	26.85	28.57	27.52	28.33	27.36

* Repair necessary

** 3 p.m. reading

Table 2. Soil moisture measured at the 10-cm depth inside and external to the plastic asbestos tubes; measurements made between 7:30 and 9:30 a.m. during the summer of 1973

	Moisture (-Bars) outside tubes in plots					Moisture (-Bars) inside tubes in plots				
Days 1973	2	12	53	105	132	18	73	95	110	139
5-15	0.5	0.5	0.5	0.5	0.6	---*	----	1.3	0.5	----
5-22	0.7	0.6	0.6	0.6	0.7	----	----	0.6	0.5	----
5-23	0.8	0.6	0.6	0.8	0.8	----	----	0.6	0.6	----
5-24	0.9	0.8	0.6	0.8	0.9	----	----	0.7	0.6	----
5-26	1.9	0.7	0.6	1.0	2.1	----	----	0.7	0.6	----
5-27	2.9	0.7	0.7	1.6	3.9	----	----	0.7	0.7	----
5-28	5.3	0.9	0.7	1.8	6.9	----	----	0.7	0.8	----
5-29	10.2	1.4	0.8	2.5	11.5	----	----	0.7	0.9	----
5-30	18.3	1.3	1.0	6.1	18.9	----	----	0.8	1.0	----
5-31	35.1	2.1	1.3	26.7	31.4	----	----	1.0	1.3	----
Average	7.66	0.96	0.74	4.24	7.77	----	----	0.78	0.75	----

Table 2, continued

Days 1973	Moisture (-Bars) outside tubes in plots 2	12	53	105	132	18	73	Moisture (-Bars) inside tubes in plots 95	110	139
6-1	41.2	3.8	2.2	44.3	37.0	----	----	0.9	2.0	----
6-2	44.7	10.3	4.2	128.7	41.2	----	----	0.9	2.7	----
6-4	48.5	47.3	38.6	128.7	46.4	----	----	1.2	5.0	----
6-5	129.0	129.0	129.0	129.0	129.0	----	----	2.3	9.9	----
6-12	128.8	128.8	128.6	128.9	128.9	----	----	--**	38.9	----
6-15	0.5	0.6	0.5	0.7	0.5	---*	---*	0.6	0.5	---*
6-16	0.5	0.6	0.5	0.6	0.5	----	----	0.6	0.5	----
6-17	0.6	0.6	0.6	0.7	0.6	----	----	0.5	0.6	----
6-19	0.6	0.6	0.6	0.7	0.6	----	----	0.6	0.6	----
6-20	0.7	0.7	0.6	0.7	0.8	----	----	0.6	0.6	----
6-21	0.7	0.7	0.6	0.8	0.8	----	----	0.6	0.6	----
6-22	0.9	0.8	0.6	0.9	1.1	----	----	0.6	0.6	----
6-23	1.2	1.0	0.6	1.2	2.0	----	----	0.6	0.6	----
6-24	1.7	1.7	0.7	1.7	3.4	----	----	0.6	0.6	----
6-25	2.6	1.9	0.8	1.9	6.2	----	----	0.6	0.6	----
6-26	4.8	8.6	0.9	13.5	9.4	----	----	0.6	0.6	----
6-27	10.2	51.8	1.3	46.7	15.2	----	----	0.6	0.7	----
6-28	25.7	128.0	2.6	128.0	25.9	----	----	0.7	0.7	----
6-29	49.4	128.0	10.8	128.0	39.3	----	----	0.7	0.7	----
6-30	128.0	128.0	47.7	128.4	87.2	----	----	0.7	0.8	----
Average	31.02	38.64	18.60	50.71	28.80			7.125	3.39	
7-2	127.7	127.7	127.0	128.0	127.7	----	----	1.1	1.3	----
7-3	127.3	127.3	127.0	127.7	127.7	----	----	1.9	2.8	----
7-9	126.1	127.0	126.1	126.6	127.0	----	----	126.1	51.0	----
7-10	127.3	127.7	127.0	127.7	127.7	----	----	126.6	49.3	----
7-15	1.9	129.1	46.3	47.8	1.2	27.0	----	40.7	32.2	----
7-16	0.6	0.8	2.1	1.1	0.6	0.9	45.6	10.9	2.5	---*
7-17	0.6	0.6	0.9	0.9	0.5	0.7	51.6	3.5	1.1	----
7-18	0.5	0.5	0.5	0.5	0.5	0.6	47.3	0.5	0.5	----
7-19	0.5	0.5	0.5	0.5	0.5	0.5	38.1	0.5	0.5	----
7-20	0.5	0.6	0.6	----	0.5	0.6	45.9	0.5	0.5	----
7-21	0.5	0.6	0.6	0.6	0.6	0.6	45.7	0.6	0.6	----
7-22	0.6	0.6	0.6	----	0.6	0.6	--**	0.6	0.6	----
7-23	0.6	0.6	0.6	----	0.5	0.6	44.6	0.5	0.6	----
7-25	0.7	0.7	0.7	----	0.6	0.7	0.6	0.6	0.6	0.6
7-26	0.7	0.6	0.7	----	0.6	0.6	0.6	0.6	0.6	0.7
7-27	0.8	0.7	0.9	----	0.6	0.6	0.6	0.6	0.6	0.7
7-28	1.0	0.7	1.3	1.2	0.6	0.7	0.6	0.6	0.6	0.7
7-29	1.3	0.8	2.4	1.4	0.7	0.7	0.6	0.6	0.6	0.7
7-30	1.9	0.8	7.5	1.9	0.9	0.8	0.6	0.6	0.6	0.7
7-31	2.5	1.0	22.0	2.7	----	0.9	0.6	0.6	0.6	0.7
Average	26.18	32.45	29.77	40.61	27.35	2.32	26.6	15.91	7.39	0.7
8-1	2.8	0.9	25.2	4.0	0.7	----	0.6	0.6	0.6	0.7
8-2	1.5	0.9	26.2	5.8	0.7	1.1	0.6	0.6	0.6	0.8
8-3	2.6	1.0	34.0	8.1	0.8	1.2	0.7	0.7	0.6	0.8
8-4	6.5	1.3	36.8	12.8	1.4	1.7	0.7	0.7	0.7	0.8
8-6	37.2	4.7	42.6	30.1	9.8	3.6	0.7	0.7	0.7	0.9

Table 2, continued

Days 1973	Moisture (-Bars) outside tubes in plots 2	12	53	105	132	18	73	Moisture (-Bars) inside tubes in plots 95	110	139
8-7	46.2	18.9	46.7	45.2	17.7	5.1	0.7	0.8	0.7	0.9
8-8	50.8	38.0	49.0	51.5	26.5	7.7	0.8	0.8	0.8	0.9
8-9	53.7	--**	54.2	127.3	33.3	7.9	0.9	0.8	0.8	1.0
8-10	128.2	54.2	--**	128.2	41.7	13.7	0.9	1.0	0.8	1.2
8-11	129.1	49.0	51.0	129.0	43.4	12.2	1.2	1.2	0.8	1.8
8-13	13.2	42.5	44.5	47.8	1.2	2.3	1.0	1.3	1.2	1.9
8-14	3.4	24.3	43.2	42.7	0.9	1.4	0.9	1.2	1.3	1.6
8-16	0.6	0.9	1.8	1.0	0.5	0.6	0.6	0.8	0.8	1.0
8-17	0.6	0.7	0.8	0.8	0.5	0.6	0.6	0.6	0.6	0.7
8-20	0.8	0.8	2.1	1.0	0.7	0.6	0.6	0.6	0.6	0.6
8-21	1.1	1.0	6.7	0.9	1.1	0.6	0.6	0.6	0.6	0.6
8-22	0.5	0.6	0.8	0.5	0.5	0.5	0.6	0.6	0.6	0.5
8-23	0.6	0.6	0.9	0.6	0.5	0.6	0.6	0.6	0.6	0.6
8-24	0.6	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6
8-25	0.7	0.9	0.9	0.8	0.7	0.6	0.6	0.6	0.6	0.6
Average	23.94	12.7	29.81	31.94	9.16	3.29	0.73	0.77	0.73	0.93

* Repair necessary

** Missing data

Rainfall data were obtained from the Jornada grassland site personnel (Fig. 1). When they were compared with the soil moisture readings, some discrepancies existed. The 15+ mm of moisture received on May 13 and June 14 correspond well with the soil moisture measurements. The 25 mm of moisture on July 20 must be an accumulation from previous days because the soil acquired moisture on July 15 and 16 according to the soil readings taken.

Similarly, the 9 mm of moisture recorded for August 1 should have been sufficient to reduce the suction pressure of some of the soils that were starting to dry. In addition to the above, some amounts of moisture should have been recorded for August 13 and 16.

When the rainfall data were compared with soil temperature (Fig. 2), a slight cooling effect was usually observed following the rainfall. This change was not drastic since the temperatures throughout the summer varied between 14.5 in May and 34 C in July. The temperature at the 10-cm depth did get warmer between noon and 3 p.m., but never exceeded 43.5 C.

Comparison of the rainfall data with those of the soil moisture (Fig. 3) more clearly showed the discrepancies that were mentioned earlier. Sufficient changes occurred June 8-14 and July 1-14 to induce stresses on the microbial populations in the soil at the 10-cm depth due to drying. These effects would have stressed the populations located at or near the surface over a greater time span than at the 10-cm depth. Soil moisture measurements were not taken at the surface level during this experimentation. Greater variation was observed in the soil moisture than in the soil temperature determinations.

Carbon Dioxide Evolution

Although soil respiration (Fig. 4) was not directly sought during this experimentation, it has to be subtracted from the total CO_2 which included soil respiration plus microbial respiration of plant parts. It was observed that measurable quantities of CO_2 were evolved from the soil even during periods when the soil was relatively dry. Quantities of CO_2 as low as 2 g $\cdot$ m^{-2} $\cdot$ 24 hr^{-1} and as high as 9 g $\cdot$ m^{-2} $\cdot$ 24 hr^{-1} represent substantial carbon loss from this carbon-deficient and relatively arid site. The soil respiration activity was compared with the soil temperature information (Fig. 5). It appeared as though soil temperature had little if any influence on the CO_2 evolved during this investigative period. This was not true when soil respiration was compared with soil moisture (Fig. 6). Generally, as the soil moisture increased the CO_2 evolved as the soil respiration product increased, and when the soil became dry the soil respiration decreased. The highest peaks of CO_2 evolution appeared to follow periods when the soil was lacking substantial moisture and was then rewetted. Between June 5 and 11 and July 8 and 12 the soil was exceptionally dry, but the CO_2 level was never measured as zero during these examination periods. Most of the readings during the summer of 1973 were found to be between 2.5 and 5 g CO_2 $\cdot$ m^{-2} $\cdot$ 24 hr^{-1}. Only twice in May were values found below 2.5 g CO_2 $\cdot$ m^{-2} $\cdot$ 24 hr^{-1} and three times after drying and rewetting, values were found above 5 g CO_2 $\cdot$ m^{-2} $\cdot$ 24 hr^{-1}. The increase observed in late August does not appear to follow any previous trend and requires additional evaluation.

The major portion of the field work had to be terminated at the end of August, and only two other readings were taken but have not been included in this set of data. Therefore, the influence of rising temperatures in the spring and decreasing temperatures in the fall is not included in this study.

Carbon dioxide evolution from the plant parts was expressed as quantities over that recorded for soil respiration. Evolution of CO_2 was recorded from leaves placed in the field in February, May and July (Fig. 7). Although there was a reduction in weight of leaf material between February and May that was not measured as CO_2 evolved, the leaves placed in the field in May evolved greater quantities of CO_2 than leaves placed in the field in February. This observation was expected if it is assumed that the soluble materials are utilized rapidly and then decomposition proceeds at a slower rate. The leaves introduced into the field in May did not undergo rapid decomposition (CO_2 evolution) immediately after being set out. It was not until June 14 that a real increase in activity was measured, and this was followed by minor fluctuations until a more distinct peak was produced on August 8. Leaf materials introduced into the field on July 19 yielded immediate CO_2 evolution followed by lesser peaks on August 2, August 13-19 and August 23. The height of the peaks were disappointing at first until it was realized that only 1 g of tissue was employed. It was noted that CO_2 evolved from the May leaves but not from the February leaves from June 19 to July 9 and the CO_2 evolved from the May leaves on August 8 was not accompanied by CO_2 being evolved from leaves placed in the field in July.

Grass stems placed in the field in February, May and July (Fig. 8) appeared to evolve more CO_2 than leaf materials placed in the field at these same times. Much of this difference resulted from the original weight differences of the plant parts utilized. Stems placed in the field in May yielded more CO_2 than similar parts placed in the field in February. This was expected based on previous experience, but when the May stems continued to yield more CO_2 than the stem material placed in the field in July, it was unexpected.

Crowns introduced into the field in February, May and July (Fig. 9) yielded less CO_2 than stems placed in the field during these same months. The amount of CO_2 evolved through the experimental period was relatively low and would indicate that the microorganisms were not too active. Although the peaks were not high, differences in activity between February and May plant parts appeared to exist on June 27, July 3 and July 14-19. One noticeable difference occurred on the May material on August 8. It was similar to that observed on the leaves.

Roots (Fig. 10) yielded less CO_2 than all of the previously mentioned parts. After examining the amount of CO_2 evolved from the February-, May- and July-buried roots, it might be suspected that the roots are very resistant to microbial decomposition or the conditions for decomposition were unfavorable.

When the soil respiration activities exhibited an interesting relationship with the soil moisture data, comparisons were made between CO_2 evolved from stems and soil moisture. The CO_2 evolved from exposed plant parts was generally low and only the stem comparisons are included to indicate the trends.

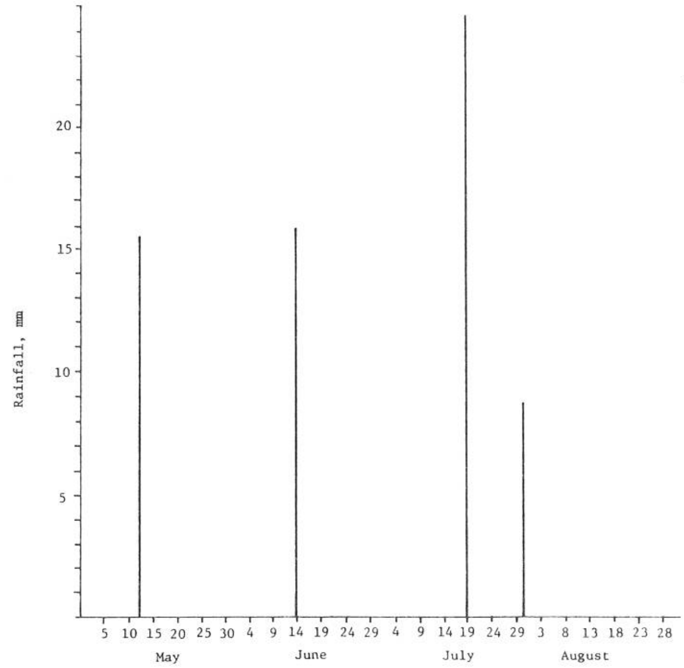

Figure 1. Precipitation measured for the summer months of 1973.

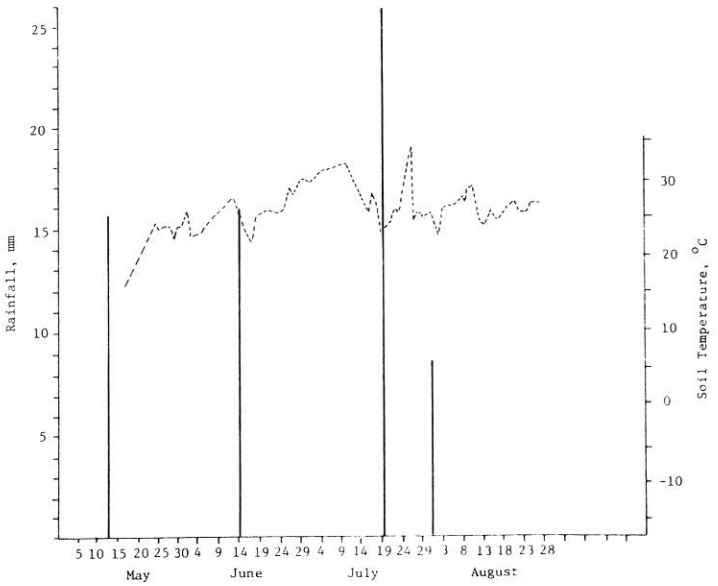

Figure 2. Comparison of precipitation and soil temperatures (---) measured during the summer of 1973.

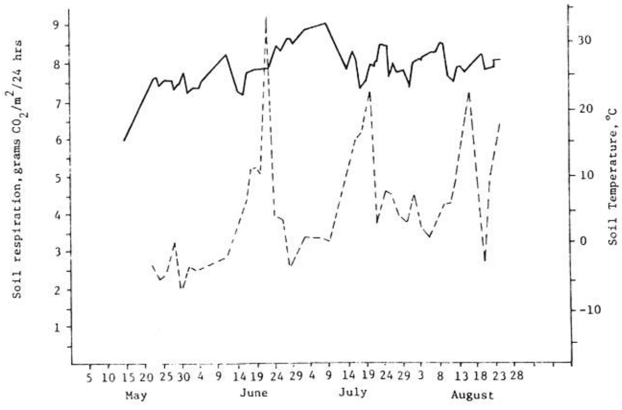

Figure 5. Comparison of soil respiration (——) and soil temperature (—) measured during the summer of 1973.

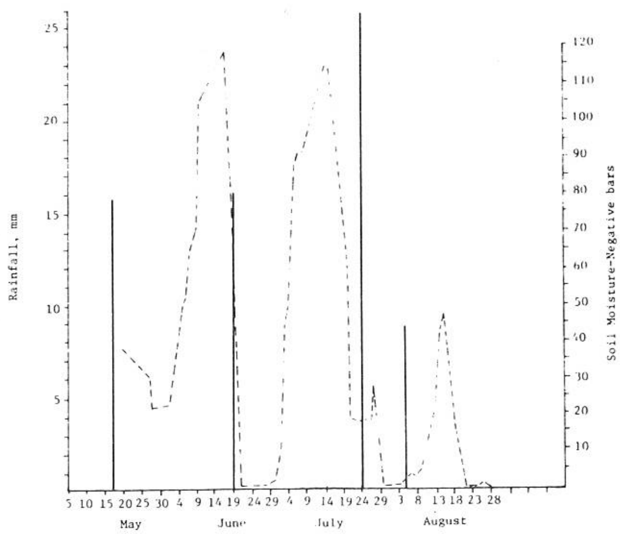

Figure 3. Comparison of precipitation and soil moisture (——) measured during the summer of 1973.

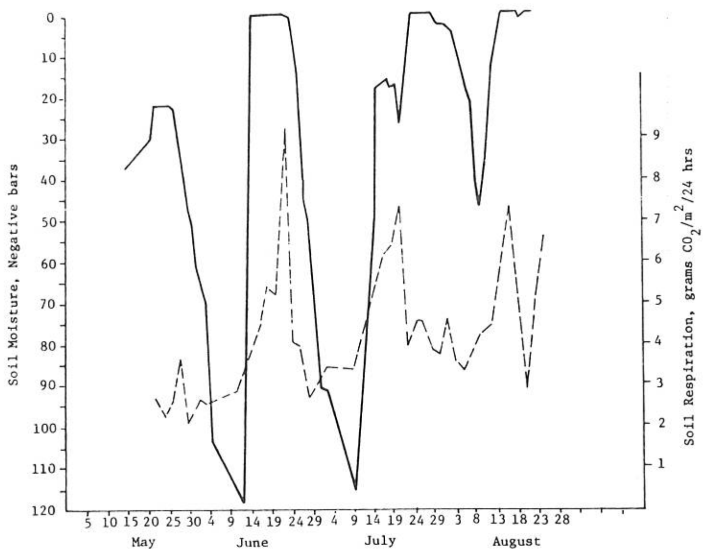

Figure 6. Comparison of soil moisture (—) and soil respiration (——) measured during the summer of 1973.

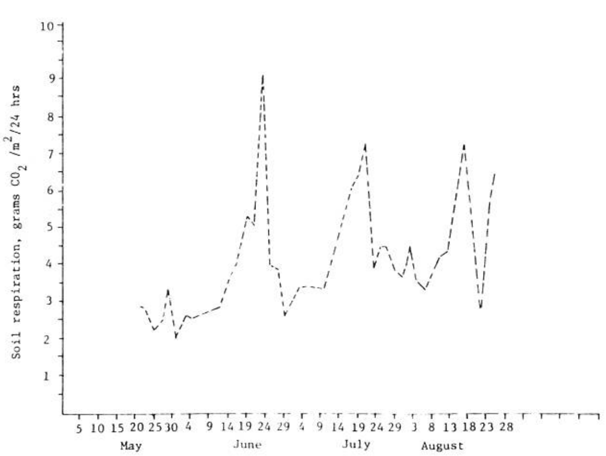

Figure 4. Total soil respiration as measured by CO_2 evolution from the Jornada plots during the summer of 1973.

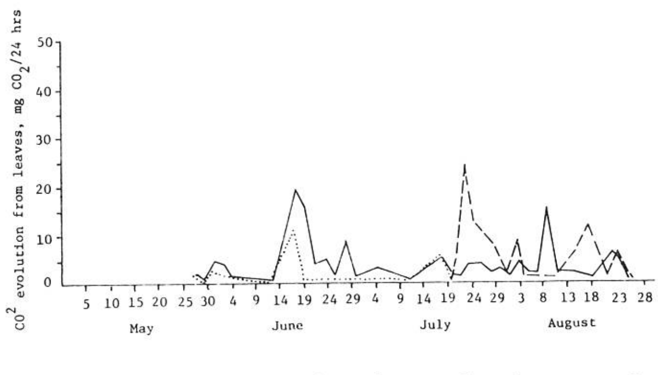

Figure 7. CO_2 evolution from leaves placed on Jornada soil during February (...), May (—) and July (——), 1973.

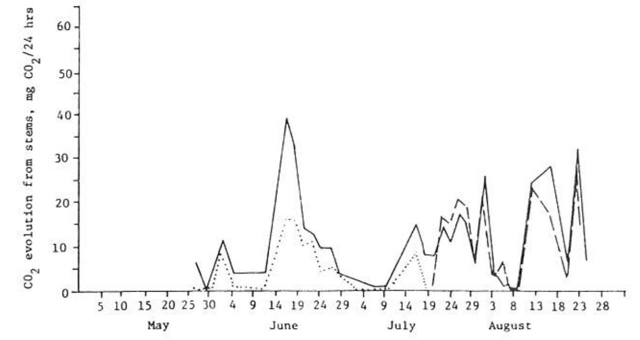

Figure 8. CO_2 evolution from stems placed on Jornada soil during February (...), May (—) and July (——), 1973.

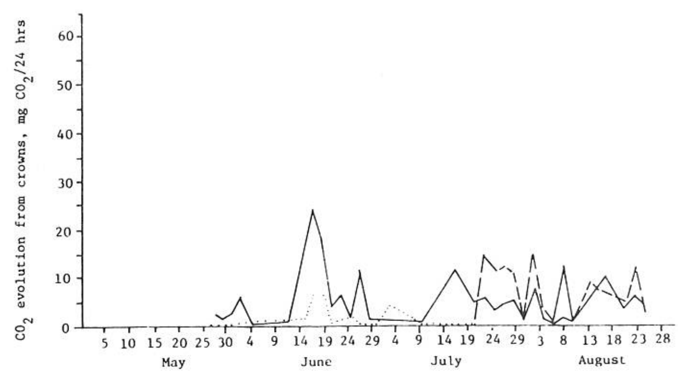

Figure 9. CO_2 evolution from crowns placed on Jornada soil during February (...), May (—) and July (——), 1973.

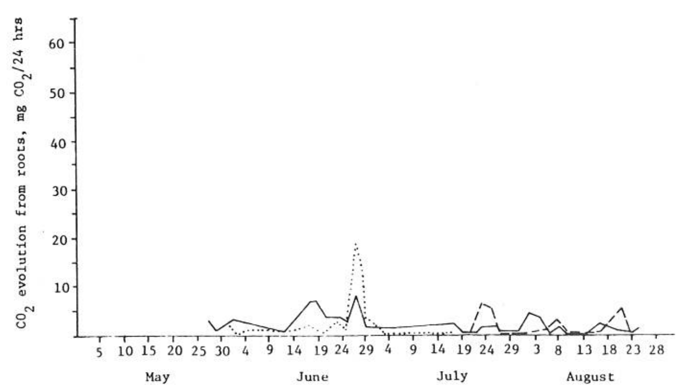

Figure 10. CO_2 evolution from roots placed in Jornada soil during February (...), May (—) and July (——), 1973.

Stems placed in the field in February and July (Fig. 11) and May (Fig. 12) exhibit similar peaks and troughs as were observed in the soil respiration data. When moisture in the soil increased, so did the CO_2 evolution. The soil moisture decrease was accompanied by a CO_2 evolution decrease.

Low values for CO_2 evolved in this experimentation and field observations of termite activity in association with the bags containing plant parts, provoked modification in the use of the data collected. To obtain additional perspective of the decomposition activity, the CO_2 evolution data were manipulated in order to make comparisons between percentage loss as measured by weight loss determinations and that due to CO_2 evolution. Determinations of CO_2 were made on an alternate-day basis when substantial activity was measurable and occasionally longer intervening periods were employed when measurable activity was minimal. Therefore, it was necessary to determine the probable CO_2 evolution during these "no test" periods. A piecewise linear relationship was used to determine these probable CO_2 evolution values.

It was assumed that the plant parts contained 46% carbon and this assumption will be changed as soon as the true test values become available. This value yielded a total of 5060 mg of CO_2 that could be evolved from the stem, crown and root segments and a value of 1687 mg CO_2 from the leaf material if each was totally mineralized to CO_2 and water.

Comparisons of leaf material placed in the field in February (Fig. 13), May (Fig 14) and July (Fig. 13) revealed discrepancies between the weight loss and CO_2 evolution values. Final readings of the leaf material placed out in May varied from 19 to 56%, while that placed out in July varied from 13 to 61%. It is quite evident that CO_2 evolution and weight loss determinations do not measure decomposition equally. Similar comparisons of stem segments placed in the field in February (Fig. 15), May (Fig. 16) and July (Fig. 15) did not exhibit the variations observed with leaves. Crowns placed in the field in July (Fig. 17) showed greater differences (4.5 to 46.5%) than similar material placed in the field in February (Fig. 17) or May (Fig. 18). Substantial differences were exhibited by the February (Fig. 19), May (Fig. 20) and July (Fig. 19) root burials.

Some loss could be encountered due to precipitation and it was necessary to determine the extent of this loss. Measurements were made on both simulated throughfall and 24-hr standing free water losses. Leaching of black grama leaf material (Table 3) was found to vary from 2.9 to 7.7%, while similar losses from stem segments (Table 4) varied from 2.9 to 8.5%. Leaching influences on black grama crown material (Table 5) varied from 4.3 to 10.2% and losses from root segments (Table 6) varied from 4.0 to 8.5%.

Ammonia Volatilization

Although readings were taken throughout the season no measurable NH_3 was volatilized from this grassland soil during this examination period. Greater attention will have to be focused on the late fall and early spring activities.

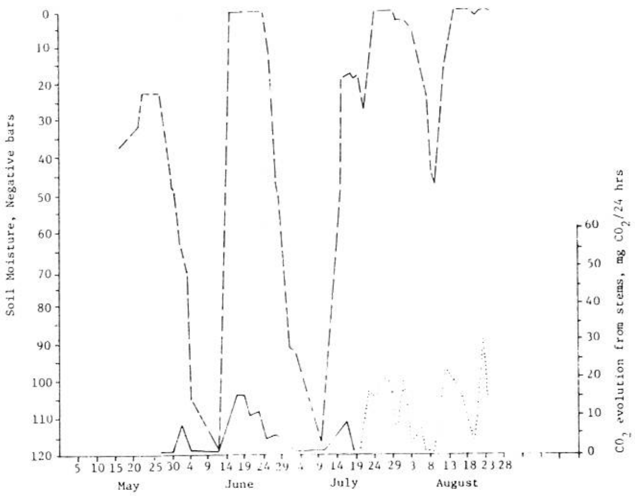

Figure 11. Comparisons between soil moisture (——) and CO_2 evolved from February- (—) and July- (...) placed stem segments on Jornada soil, 1973.

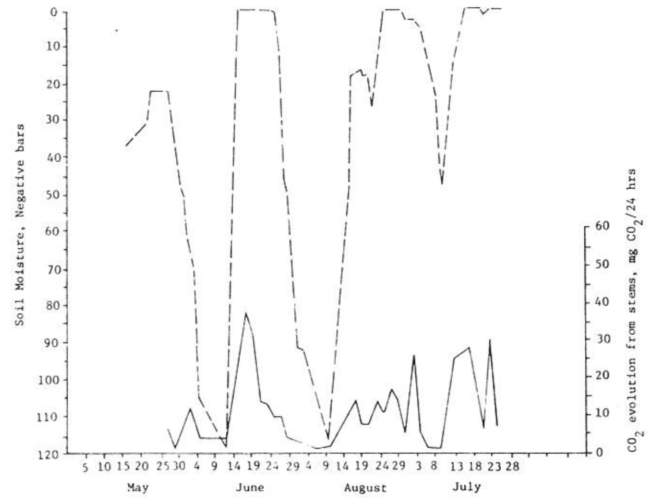

Figure 12. Comparison between soil moisture (——) and CO_2 evolved from May-placed (—) stems on Jornada soil, 1973.

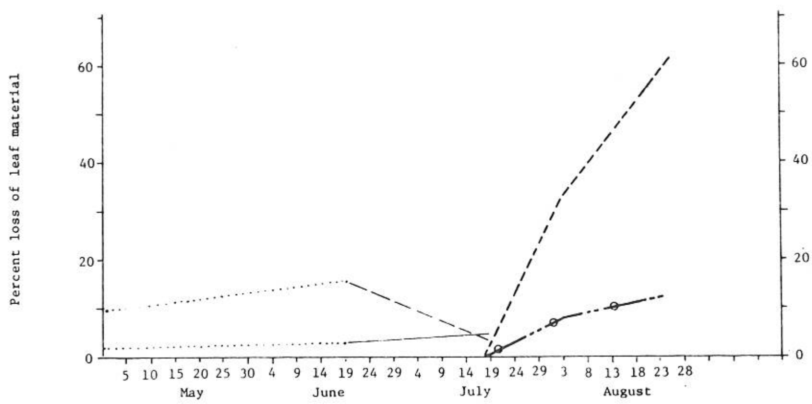

Figure 13. Percent loss based on weight loss (——) and CO_2 evolution (—) determinations on February-placed grass leaves, and weight loss (---) and CO_2 evolution (o---) determinations on July-placed grass leaves on Jornada soil, 1973.

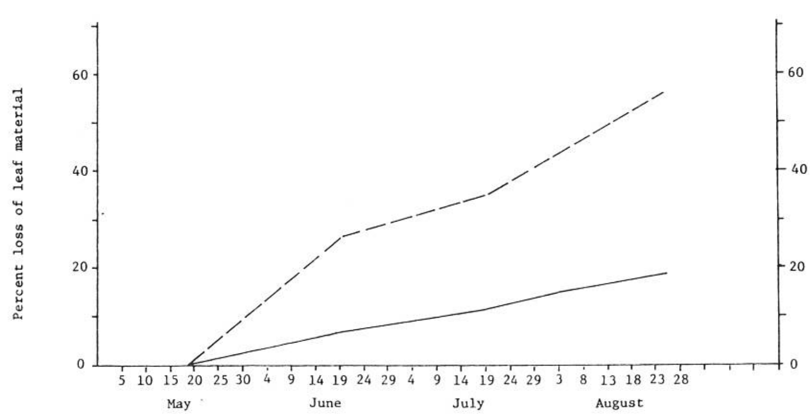

Figure 14. Percent loss based on weight loss (——) and CO_2 evolution (—) determinations on May-placed grass leaves on Jornada soil, 1973.

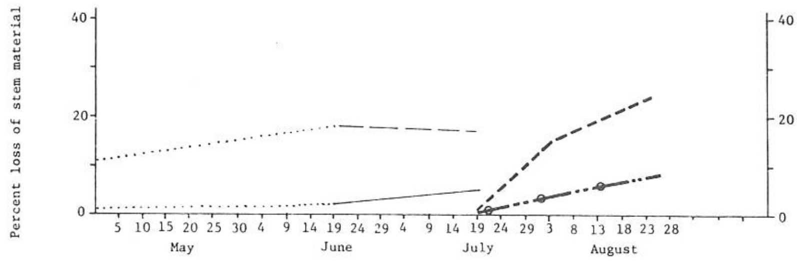

Figure 15. Percent loss based on weight loss (——) and CO_2 evolution (—) determinations on February-placed grass stems, and weight loss (---) and CO_2 evolution (ө---) determinations on July-placed grass stems on Jornada soil, 1973.

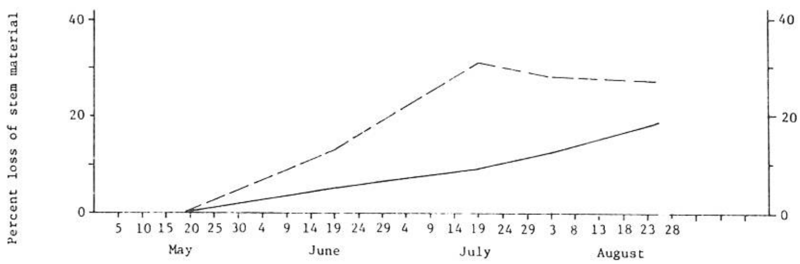

Figure 16. Percent loss based on weight loss (——) and CO_2 evolution determinations on May-placed grass stems on Jornada soil, 1973.

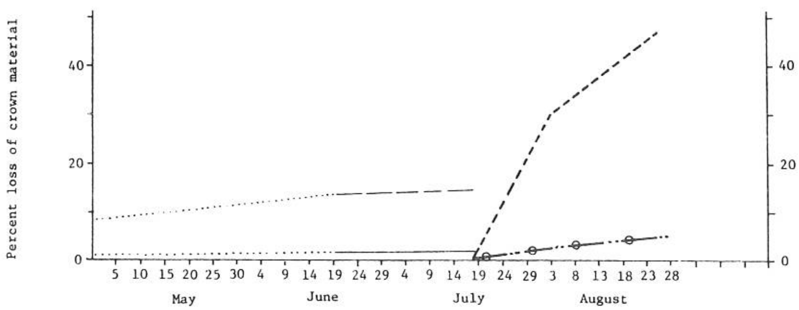

Figure 17. Percent loss based on weight loss (——) and CO_2 evolution (—) determinations on February-placed grass crowns, and weight loss (---) and CO_2 evolution (ө---) determinations on July-placed grass crowns on Jornada soil, 1973.

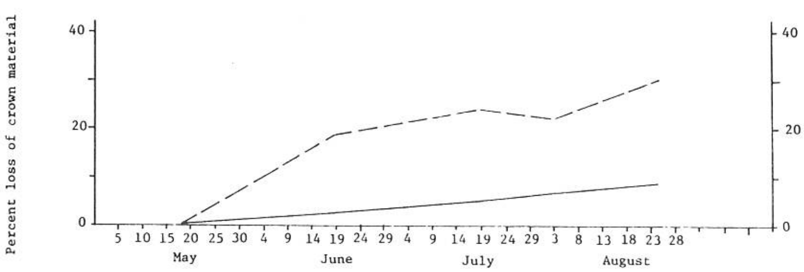

Figure 18. Percent loss based on weight loss (——) and CO_2 evolution (—) determinations on May-placed grass crowns on Jornada soil, 1973.

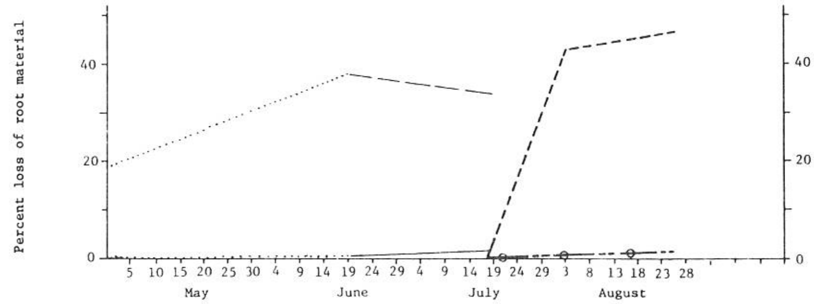

Figure 19. Percent loss based on weight loss (——) and CO_2 evolution (—) determinations on February-buried grass roots, and weight loss (---) and CO_2 evolution (o---) determinations on July-buried grass roots in Jornada soil, 1973.

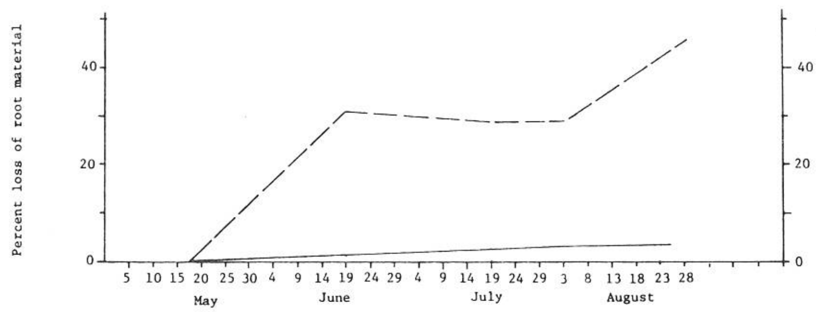

Figure 20. Percent loss based on weight loss (——) and CO_2 evolution (—) determinations on May-buried grass roots in Jornada soil, 1973.

Table 3. Possible leaching influences on black grama leaf material prior to decomposition, 1973

Simulated 2.54 cm rainfall			
Original weight (g)	Weight after rain (g)	Weight loss (g)	Percent weight loss
3.00	2.909	0.091	3.0
3.00	2.925	0.075	2.5
3.00	2.902	0.098	3.3
Average weight loss through leaching: 2.9%			
Total soluble loss after standing in water for 24 hours			
Original weight (g)	Weight after soak (g)	Weight loss (g)	Percent weight loss
1.00	.91	0.09	9.0
1.00	.94	0.06	6.0
1.00	.92	0.08	8.0
Average weight change through loss of solubles: 7.7%			

Table 4. Possible leaching influences on black grama stem tissues prior to decomposition, 1973

Simulated 2.54 cm rainfall			
Original weight (g)	Weight after rain (g)	Weight loss (g)	Percent weight loss
3.00	2.903	0.098	3.3
3.00	2.909	0.091	3.0
3.00	2.925	0.075	3.5
Average weight loss through leaching: 2.9%			
Total soluble loss after standing in water for 24 hours			
Original weight (g)	Weight after soak (g)	Weight loss (g)	Percent weight loss
3.00	2.760	0.245	8.0
3.00	2.744	0.246	8.5
3.00	2.734	0.266	8.9
Average weight change through loss of solubles: 8.5%			

Table 5. Possible leaching influences on black grama crown tissues prior to decomposition, 1973

Simulated 2.54 cm rainfall			
Original weight (g)	Weight after rain (g)	Weight loss (g)	Percent weight loss
3.00	2.899	0.158	5.3
3.00	2.871	0.129	4.3
3.00	2.899	0.101	3.4
Average weight loss through leaching: 4.3%			

Total soluble loss after standing in water for 24 hours			
Original weight (g)	Weight after soak (g)	Weight loss (g)	Percent weight loss
3.00	2.677	0.323	10.8
3.00	2.682	0.218	10.6
3.00	2.726	0.274	9.1
Average weight change through loss of solubles: 10.2%			

Table 6. Possible leaching influences on black grama root tissues prior to decomposition, 1973

Simulated 2.54 cm rainfall			
Original weight (g)	Weight after rain (g)	Weight loss (g)	Percent weight loss
2.96	2.838	0.122	4.1
2.95	2.821	0.129	4.4
2.947	2.848	0.099	3.4
Average weight loss through leaching: 4.0%			

Total soluble loss after standing in water for 24 hours			
Original weight (g)	Weight after soak (g)	Weight loss (g)	Percent weight loss
2.96	2.771	0.189	6.4
2.95	2.620	0.330	11.2
2.947	2.718	0.229	7.8
Average weight change through loss of solubles: 8.5%			

Other Observations

Substantial termite casts and tunnels were associated with the bags containing root segments. Many of the bags containing leaf material and the crown segments placed in the field in July also exhibited the presence of termites. Although there was extensive evidence of the presence of termites associated with the bags containing plant parts, only once was a termite observed. This suggested that the termites approached the bags containing the plant segments, removed the segments and carried the plant material away. These observations were supported by the limited, and often reduced, CO_2 evolution associated with termite-influenced bags containing various plant parts.

DISCUSSION

Soil temperature is probably a very important variable to the decomposition process under many circumstances, but it did not appear to be as important as moisture at the Jornada desert grassland site. This may be due to the favorable temperatures for the growth of microorganisms throughout most of the year.

Alexander (1961) cited that several techniques have been developed to measure decomposition rates, including: 1) CO_2 evolution or O_2 uptake; 2) weight loss or chemical measurements to determine organic matter decreases; and 3) disappearance of specific carbon-containing compounds. The above measurements are apparently more meaningful individually in the laboratory than they are in the field under arid grassland conditions. During this experimentation, measurements of both CO_2 evolution and weight loss were conducted. It appeared that the CO_2 evolution readings more accurately accounted for the activities of the microorganisms carrying on the decomposition processes, whereas the weight loss included the microbial activity, losses from leaching and the termite activity associated with this experimentation.

If assumptions were made on this basis and assignments were made to the various types of losses, then a rough estimate of the termite activity could be derived through the decomposition data. Assume that CO_2 evolution accounts for the major portion of the microbial activity, and that the maximum amount of leached carbon would be displaced during incidents of precitipation. Then when these two values are subtracted from the actual weight loss, any additional loss would be primarily due to termite activity (Table 7). This is certainly an oversimplification of the actual activity taking place on the Jornada site, but it yields a first approximation of the complexity of activities involved in the mineralization of organic materials in the field.

Plant segments placed into or on the surface of Jornada soil in February exhibited the least change (17% based on weight loss), while those taken to the field in May (39.5%) and July (44.1%) showed much greater losses. The above numbers are expessed as mean values of all plant materials. Mean losses from CO_2 evolution (which was primarily microbial) amounted to 3.9% of the February-placed material, 15% of the May-placed segments and 8% of the July-introduced plant parts. These values were compared to mean losses of 6.9% of February, 16.9% of May and 27.2% of July plant segments due to termite removal. Highest microbial activity was measured in the plant materials taken to the field in May and was less in July and least in the February materials. Termite activity was highest in materials placed in the field in July and was followed by the May and finally the February materials. Losses of grass stems appeared to be due to decomposition by microorganisms and little termite activity was observed in association with these plant parts. This is in contrast to root losses which were primarily induced by termite removal and very little microbial activity was measured. Substantial amounts of grass leaves were removed by termites following introduction into the field in May and July. Similar removal of crowns by termites occurred in the July-placed litter bags, but was not apparent with litter bags placed in the field in June.

Table 7. Factors influencing the decomposition process of plant materials on the Jornada grassland site, 1973

Plant material	% CO_2 evolved (A)	Weight loss (%) (B)	Difference (B - A = C)	Precipitation loss (%) Throughfall	Soak (D)	Termite removal (%) (C - D = E)
Leaf						
Feb	5.4	3.0	-2.4	2.9	7.7	----
May	22.5	56.0	33.5	2.9	7.7	25.8
Jul	15.3	61.0	45.7	2.9	7.7	38.0
Stem						
Feb	6.0	16.0	10.0	2.9	8.5	1.5
May	22.8	27.0	4.2	2.9	8.5	----
Jul	9.6	23.9	13.4	2.9	8.5	4.9
Crown						
Feb	2.4	15.0	12.6	4.3	10.2	2.4
May	10.5	30.0	19.5	4.3	10.2	9.3
Jul	5.4	46.5	41.1	4.3	10.2	30.9
Root						
Feb	1.8	34.0	32.2	4.0	8.5	23.7
May	4.2	45.0	40.8	4.0	8.5	32.3
Jul	1.5	45.0	43.5	4.0	8.5	35.0

Low loss values for February introductions resulted from final removal of these plant materials on July 18. Therefore, the litter bags taken to the field in February were not subjected to the termite removal which occurred during the latter part of July and August.

Losses due to termite removal were substantial and greatly exceeded the mineralization due to microbial activity in 1973. These losses do not occur every year to this extent. During the 1970-71 year, termite activity was minimal and the major reduction of plant material appeared to be due to microbial decomposition. It is important at this point to determine both the quantity of material that is removed or decomposed and the conditions under which removal or decomposition takes place.

Conducting CO_2 evolution studies concurrently with, and on the same material as the weight loss determinations, was necessary and essential to further partitioning of these losses. Either CO_2 evolution or weight loss determination would yield an indication of the decomposition process, but they are generally crude estimates of mineralization occurring under Jornada environmental conditions. In this study, CO_2 evolution data would have accounted for minimal portions of the loss while weight loss information would not have given the correct data about where the material was going. Recent work involving animal muscle decomposition (Cahenzli and Staffeldt, in press) exhibited a similar discrepancy where high CO_2 values and little weight loss were measured. These differences were found to be due to the presence and activities of maggots. It is becoming more apparent that either CO_2 evolution evaluations or weight loss determinations can overestimate or underestimate the process being measured. Based on data being accumulated, it should be emphasized that combinations of measurements be employed wherever possible. Until more multiple measurements are utilized, vague, incomplete and possibly incorrect conclusions will be drawn from the data collected.

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