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Measurements of Carbon and Nitrogen Changes in Soil

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MEASUREMENTS OF CARBON AND NITROGEN CHANGES IN SOIL

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ABSTRACT

Experimental plots were established in the southeastern corner of the Jornada Bajada Validation Site. Data were taken on predominant plants in the area as to their frequency, canopy-size and relative position in the experimental area.

Measurements of carbon and nitrogen losses within sunken asbestos tubes were conducted under field conditions. Changes in amounts of carbon were determined using CO_2-evolution, and weight loss using plant tissue litter bags. Percentage loss based on CO_2-evolution from leaf tissue indicated that tissue placed in the field in February decomposed less rapidly than tissue placed in the field during May or July. However, results of CO_2-evolution from stem tissue indicated that tissue placed in the field in February decomposed at the same rate as tissue place in the field in May. Stem tissue decomposed less rapidly in May and July than did the leaf tissue. Percentage loss based on CO_2-evolution from root tissue indicated the decomposition occurred most rapidly in July and less rapidly in May and February, respectively.

Variations in nitrogen content were determined on a NH_3-volatilized basis. However, during the brief research period of this experiment, little data were obtained to indicate significant NH_3 production.

Other parameters considered during the course of this experiment include soil temperature, soil moisture, precipitation, plant tissue chemical composition, and leaching of plant tissue.

Soil moisture was found to be more important than temperature in influencing decomposition and, in most instances, had a direct relationship in causing an increase in CO_2-evolution, or decomposition. For example, as soil moisture increased to -2 bars, CO_2 evolved from May leaf tissue rose to 155 mg CO_2/24 hr. However, when soil moisture decreased to -117 bars, CO_2 evolved from May leaf tissue fell to 10 mg CO_2/24 hr.

Studies were conducted to determine the possible effects of leaching on creosote leaf, stem and root tissue. Substantial weight loss was noted for each tissue (i.e., 16.4-2.4% for leaf tissue, 2.4-1.8% for stem tissue and 3.3-2.4% for root tissue), and varied according to season.

Further research covering longer periods of time is required in order to elucidate a more accurate interpretation of decomposition in desert soils.

INTRODUCTION

Decomposition that occurs under arid conditions when using filter paper, litter bag weight loss data, appears to be very sporadic and then explosive when all the appropriate environmental parameters prevail. There exists then the necessity for selecting the appropriate methods that would best tend to measure the suspected changes and the conditions which cause these changes. Methods employing the removal of soil samples followed by laboratory testing tend to induce too many arbitrary conditions on the process to be examined. These activities included the disruption of any established structure of the sandy soil to be employed, the complete aeration and replacement of the established gaseous regime, and subjecting the soils to selected stable temperature and moisture conditions which would be unusual under the arid conditions that prevail in the southwestern United States. Therefore, measurements of the evolution of CO_2 and the volatilization of NH_3 from a precise area in the field and measured over a given time period were deemed the most desirable way to pursue this problem.

OBJECTIVES

1. Determine the rates of decomposition of leaves, stems and roots in field exposures by determining the amount of carbon dioxide (CO_2) and ammonia (NH_3) loss and compare 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 and stem 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 was selected to be representative of major sections of the Jornada Bajada Validation Site. It is located approximately 200 m due east of the southeastern corner of the bajada site. In this location, environmental parameters from the validation site could be utilized if they were necessary in the interpretation of the data collected. This selected area was gridded into 144 experimental plots of 1.0 x 1.0 m (Fig. 1) and the predominant plants and their canopies were drawn on the plot diagram as they occurred in the field. Based on a paper weight determination, it was found that 92.3% of the area was subjected to an open exposure. Canopies of *Larrea divaricata* could influence 6.9% of the area while 0.4, 0.2 and 0.2% of the area could have been influenced by *Yucca elata*, *Ephedra trifurca* and *Opuntia engelmannii*, respectively. As soon as more root

distribution data becomes available, more complete understanding of underground influences can be added to the above.

In almost all cases, the tubes in which the tests were conducted were driven into the soil at the center of the 1.0 x 1.0 m plot.

Asbestos Plastic Tubes

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

Plant Tissue Litter Bags

Leaf, stem and roots of *Larrea divaricata* were collected at the termination of the 1972 growing season. The tissues were separated into the above three categories, placed in an oven at 50 C and maintained there for 24 hr to achieve a constant dry weight. Three g of leaves, stems or roots were weighed out and placed in a nylon bag which was sewn closed. The nylon used was rejected white hose obtained from the Hanes Manufacturing Plant in Las Cruces. Openings in this nylon varied from 0.5 mm to 0.9 mm with an average opening of 0.75 mm.

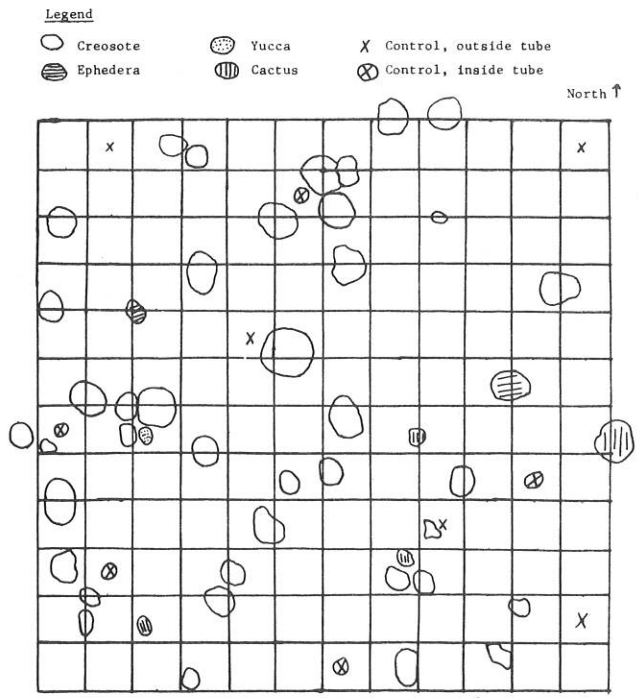

Figure 1. Desert plot layout of 144 m^2 located immediately adjacent to the Jornada Validation Site.

Fifteen nylon bags containing leaves, stems or roots were taken to the field on February 27, 1973. Those containing leaves and stems were placed on the soil surface within the tube after it was driven into place in the center of the plot. Bags containing the root tissue were buried 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, and driving it to the appropriate depth. The February buried tissue 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 after the May date. 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.

Thirty bags containing leaves, stems or roots were placed in the field on May 18, 1973. The litter bags containing leaves and stems were placed on the surface inside the tubes while those containing roots were buried as in February. Carbon dioxide evolution and NH_3 volatilization were measured until the tissues were removed. Tissues buried in May were removed on June 18, July 18, August 4, and August 25, 1973. These removals were made to determine weight loss and changes in chemical composition of the tissue.

Eighteen nylon bags containing leaves, stems and roots were placed in the field on July 18, 1973, following the same procedure as in February and May. Plant tissues 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.

Soil Temperature -- Soil Moisture

Soil temperature and soil moisture readings (DSCODE A3USG01) were obtained from the same type of gypsum blocks as those 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 the 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 blocks were used on the plot and all were placed at the 10 cm depth. Five blocks were placed inside the plastic asbestos tubes following the procedure used for the root burial. The remaining five blocks were placed 50 cm away from the tubes to determine how they influenced the soil temperature and soil moisture regimes.

Carbon Dioxide Evolution

Determinations of CO_2 evolution (A3USG02) 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 was 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 was removed and the vial and cap placed on the surface inside the tube. A square plastic sheet was then placed over the top of the tube and retained with a rubber band. This was followed with a square of aluminum foil which also fit tightly over the opening of the tube and was held in place with another 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 ml of a barium chloride solution was added to precipitate the absorbed CO_2 as carbonate. Five drops of thymolphthalein was 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) obtain the mean of the ml HCl titrated in the controls, (2) subtract the experimental values in ml HCl from that of the mean of the controls, (3) multiply the value obtained in (2) by the mg CO_2 equivalent to obtain mg CO_2, (4) multiply the value in (3) by the conversion factor to a 24-hr period to obtain values for mg CO_2/24 hours. The other calculation consisted of the following: (1) obtain the mean of the ml HCl titrated in the blanks, (2) subtract the experimental control values in ml HCl from that of the mean of the blanks, (3) multiply the value obtained in (2) by the mg CO_2 equivalent to obtain mg CO_2, (4) multiply the value in (3) by the conversion factor to 24 hr to obtain values for mg CO_2/24 hr, and finally multiply the value in (4) by the factor of the area in the tube to a m^2 basis. This final value would give the total soil respiration on a m^2 basis. Carbon dioxide evolution from the plant tissue is expressed as mg CO_2/24 hr while soil respiration is expressed as mg CO_2/24 hr/m^2.

When environmental parameters were suitable and CO_2 was evolved, determinations were made on an alternate day basis. The tubes would be covered and contained in the vial with KOH for approximately 24 hr, and then remain exposed to the environment for the next 24 hours. 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 ml of a 0.5N H_2SO_4 solution was placed in each plastic vial and the cap screwed on tightly. The vials were taken to the field, placed in the tubes and later removed and brought back to the laboatory 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 Nesslers reagent. The three materials were mixed together and 5 min allowed for the reaction to occur before being used in taking readings.

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

Weight Loss Determination

As mentioned under the plant tissue litter bag section, tissues 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 when taken to the field. The bags were removed after given exposures and returned to the laboratory. The tissues were removed from the nylon bag, oven dried, weighed, ashed, and the ash weighed. The actual weight of the exposed tissue was divided by the original weight and this value multiplied by 100 to obtain percent of tissue remaining. Two values remain to be determined to complete this evaluation; these are the original ash content of the tissue and 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, for analysis. Results of these changes have not been received to date.

Leaching of Plant Tissue

Simple leaching experiments were conducted on leaf, stem and root tissue of *Larrea divaricata*. This consisted of determining the thickness of leaf and stem litter in the field and setting up the same situation in a Buchner funnel. A simulated rain equivalent to 2.54 cm was passed through the tissue in four 15-min intervals. The tissue was oven dried and weighed. Since some of the tissue was exposed to free soil water for longer periods of time, this tissue was placed in beakers and exposed to free moisture for a 24-hr period. After removal, the tissues were again oven dried and weighed to determine any possible loss of soluble materials from the leaves, stems and roots.

RESULTS

Soil Temperature - 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 calibration of the blocks placed 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. After the blocks were stabilized and calibrated, the soil temperatures inside the tubes were essentially the same as the soil temperatures of the surrounding soil.

Soil moisture values (Table 2) were found to be much more variable than the soil temperatures. At times great variations existed between the moisture levels measured inside the tubes as compared to those observed in the surrounding soil. This was especially true as the soil was drying 5-10 days after a rainfall. The moisture was retained by the soil in the tubes two and one-half times longer than the soil outside the tubes. This occurred when the rainfall was very sporadic and a long, dry interval intervened between the rainfall incidents.

Greater variations between individual soil blocks were observed in the blocks outside the tubes than those in the tubes. For example, on June 24, plots 2, 12 and 132 were totally open and had suction pressures of 129.0, 17.0 and 50.2 while plots 53 and 105 were near plants and exhibited pressures of 15.6 and 129.0. Plants did not appear to exert as much influence as did some other aspects of the soil composition. When the time between rainfall incidents shortened, the soil at the 10 cm depth possessed sufficient moisture to allow microbial activity to proceed through the major part of the season.

Daily rainfall data (A3UWJ63) were obtained from the bajada validation site personnel (Fig. 2). The bulk of the precipitation occurred in July and lesser amounts were received during May, June and August. When the rainfall data were compared with soil temperatures (Fig. 3) a slight cooling effect was usually observed following the rainfall. This change was not drastic since the temperatures throughout the summer varied between 67.9 and 93.4 F (20 and 34 C). The temperature at the 10 cm depth did get warmer between noon and 3:00 p.m. but was never measured over 110 F (43.5 C).

When the rainfall data were compared with the soil-moisture data (Fig. 4), sufficient changes occurred to induce stresses on the microbial populations in the soil. This was expressed by the relatively high peaks of dry soil in May and June. In general there was a positive effect expressed between the rainfall and soil moisture data at the 10 cm depth even with small quantities of moisture. An interesting comparison was the 6 mm rainfall on June 12 and 13 which resulted in increasing the moisture and lowering the negative bars of pressure from -128 to -0.6, and the 4.5 mm of rainfall on July 1 that did not change the soil-moisture regime or lower the suction pressure. In the first case the cloud cover remained over the area after the rainfall, there was no wind and the temperature was in the low 80's. In

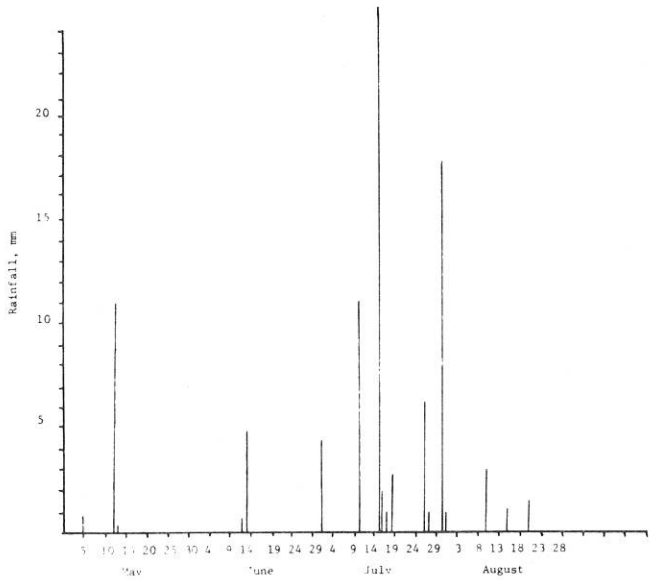

Figure 2. Precipitation measured for summer months, 1973.

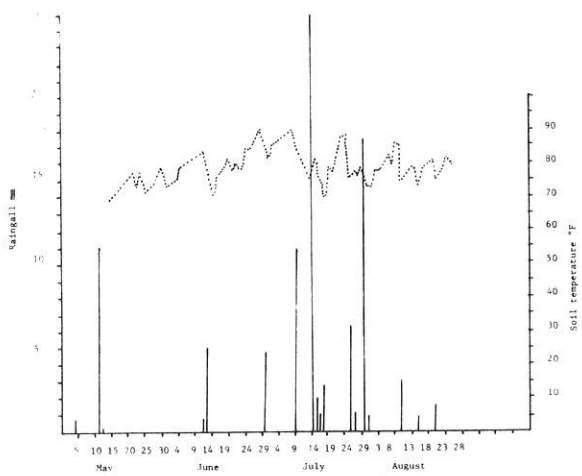

Figure 3. Comparison of precipitation and soil temperatures (···) measured during summer, 1973.

contrast to the June rainfall, the July moisture was accompanied by immediate direct sunlight, a hot dry wind and a temperature in the low 80's. It appears that soil moisture would have a much greater effect than temperature on microorganisms carrying on the decomposition process at the Jornada Validation Site.

Table 1. Soil temperature measured at the 10 cm depth inside and external to the plastic asbestos tubes which were taken between 7:30 and 9:30 a.m. during the summer of 1973.

Days, 1973	Temperature (°F) outside tubes in plots					Temperature (°F) inside tubes in plots				
	2	12	53	105	132	18	73	95	110	139
5-15	70.0	73.2	63.8	68.9	73.2	65.8	63.8	-	67 9	71.0
5-22	81.2	80.0	80.0	81.2	82.3	78.8	78.8	-	67.9	67.9
5-23	74.3	74.3	74.3	75.4	75.4	-	73.2	-	-	75.4
5-24	78.9	80.0	78.9	81.2	82.3	-	80.0	-	-	80.0
5-26	76.6	76.6	78.8	74.3	78.8	-	77.7	-	-	77.7
5-27	73.2	73.2	75.4	71.0	75.4	-	73.2	-	-	73.2
5-28	73.2	73.2	74.3	73.2	74.3	-	73.2	-	-	74.3
5-29	73.2	74.3	74.3	74.3	76 [illegible]	-	74.3	81.2	80.0	74.3
5-30	77.7	78.8	78.0	78.8	80.0	-	80.0	78.8	78.8	80.0
5-31	81.2	80.0	80.0	78.8	81.2	-	78.8	78.8	78.8	78 8
Average	75.95	76 36	75.78	75.71	77.95	72.30	75.30	79.6	74.7	75.29
6-1	73 2	73.2	74.3	73.2	74.3	-	74.3	71.0	72.1	73.2
6-4	76.6	75.4	76.6	75.4	76.6	-	76.6	74.3	75.4	76.6
6-5	78.8	80.0	78.8	78.8	80.0	-	80.0	77.7	77.7	78.8
6-12	85.9	84.7	84.7	85.9	84.7	-	85.9	83.5	83 [illegible]	80.0
6-15	71.0	70.0	71.0	73.2	73.2	-	70.0	68.9	71.0	70.0
6-16	76.6	76.6	74.3	76.6	77.7	-	77.7	74.3	76.6	76.6
6-17	80.0	77.7	77.7	77.7	80.0	-	77.7	75.4	77.7	76.6
6-19	80.0	78.8	80.0	80.0	80.0	-	80.0	77.7	77.7	78.8
6-20	83.5	82.3	81.2	81.2	81.2	-	81.2	80.0	82.3	82.3
6-21	77.7	77.7	80.0	77.7	78.8	-	78.8	75.4	77.7	77.7
6-22	80.0	80.0	81.2	80.0	82.3	-	81.2	80.0	81.2	81.2
6-23	81.2	77.7	81.2	75.4	80.0	-	77.7	76.6	76.6	77.7
6-24	77.7	80.0	81.2	77.7	81.2	-	80.0	77.7	80.0	80.0
6-25	84.7	84.7	84.7	84.7	87.2	-	84.7	84.7	84.7	84.7
6-26	84.7	84.7	84.7	84.7	85.9	-	84.7	84.7	84.7	84.7
6-27	87.2	85.9	87.2	84.7	85.9	-	85.9	84.7	84.7	85.9
6-28	87.2	87.2	89.6	87.2	88.4	-	89.6	87.2	87.2	89.6
6-29	89.6	90.9	90.9	89.6	90.9	-	90.9	88.4	89.6	89.6
6-30	89.6	87.2	90.9	87.2	88.4	-	89.6	87.2	85.9	89.6
Average	81.33	80.77	81.59	80.57	81.93	-	81.39	79.44	80.33	80.72
7-2	81.2	81.2	83.5	80.0	82.3	-	82.3	80.0	78.8	81.2
7-3	85.9	85.9	87.2	84.7	85.9	-	85.9	84.7	84.7	87.2
7-9	92.2	90.9	93.4	89.6	90.9	-	90.9	89.6	89.6	90.9
7-10	87.2	85.9	88.4	83.5	87.2	-	87.2	83.5	83.5	85.9
7-15	76.6	75.4	77.7	75.4	75.4	-	74.3	73.2	73.2	74.3
7-16	84.7	83.5	82.3	82.3	82.3	-	82.3	81.2	82.3	81.2
7-17	77.7	76.6	80.0	77.7	77.7	-	76.6	75.4	76.6	75.4
7-18	77.7	73.2	77.7	75.4	75.4		73.2	76.6	73.2	73.2
7-19	72.1	70.0	73.2	71.0	71.0		71.0	66.8	70.0	68.9
7-20	78.8	78.8	76.6	83.5	78.8	-	76.6	78.8	80.0	78.8
7-21	78.8	77.7	78.8	78.8	78.8	-	77.7	77.7	77.7	78.8
7-22	82.3	81.2	80.0	82.3	81.2	-	81.2	81.2	81.2	80.0
7-23	81.2	80.0	82.3	81.2	82.3	-	80.0	77.7	80.0	80.0
7-25	98.7	97.3	97.3	97.3	93.4	-	96.0	96.0	97.3	94.7
7-26	77.7	75.4	77.7	75.4	76.6	-	75.4	73.2	74.3	75.4
7-27	76.6	75.4	77.7	76.6	77.7	-	76.6	74.3	75.4	76.6
7-28	80.0	78.8	78.8	77.7	78.8	-	78.8	77.7	78.8	78.8
7-29	77.7	76.6	78.8	75.4	77.7	-	77.7	74.3	76.6	76.6
7-30	80.0	78.8	78.8	78.8	78.8	-	78.8	78.8	80.0	78.8
7-31	75.4	74.3	75.4	74.3	74.3	-	73.2	73.2	73.2	73.2
Average	81.13	79.85	81.28	80.05	80.33	-	79.79	78.70	79.32	79.50
8-1	76.6	73.2	74.3	73.2	73.2	-	73.2	72.1	73.2	73.2
8-2	75.4	73.2	74.3	73.2	73.2	-	73.2	71.0	73.2	72.1
8-3	80.0	77.7	77.7	78.8	78.8	84.7	77.7	76.6	77.7	78.8
8-4	78.8	75.4	80.0	77.7	77.7	85.9	76.6	74.3	75.4	76.6
8-6	81.2	78.8	81.2	77.7	80.0	87.2	80.0	78.8	78.8	78.8
8-7	83.5	81.2	83.5	81.2	83.5	87.2	83.5	82.3	83.5	83.5
8-8	81.2	80.0	83.5	78.8	81.2	87.2	81.2	80.0	67.9	80.0
8-9	85.9	87.2	84.7	87.2	88.4	89.6	85.9	87.2	87.2	89.6
8-10	82.3	82.3	84.7	93.4	82.3	90.9	83.5	81.2	84.7	94.7
8-11	73.2	74.3	76.6	72.1	75.4	78.8	75.4	74.3	74.3	75.4
8-13	76.6	76.6	80.0	75.4	78.8	83.5	78.8	76.6	76.6	78.8
8-14	80.0	78.8	81.2	77.7	80.0	85.9	82.3	80.0	78.8	80.0
8-16	73.2	73.2	76.6	72.1	74.3	78.8	74.3	73.2	72.1	73.2
8-17	77.7	77.7	80.0	75.4	78.8	83.5	78.8	77.7	77.7	78.8
8-20	81.2	81.2	83.5	78.8	82.3	85.9	81.2	80.0	78.8	81.2
8-21	74.3	74.3	77.7	74.3	74.3	78.8	76.6	74.3	73.2	75.4
8-22	75.4	75.4	78.8	73.2	74.3	84.7	80.0	78.8	77.7	78.8
8-23	76.6	77.7	80.0	76.6	78.8	83.5	81.2	78.8	77.7	78.8
8-24	81.2	82.3	83.5	81.2	82.3	85.9	82.3	82.3	81.2	83.5
8-25	81.2	80.0	82.3	77.7	81.2	85.9	82.3	80.0	80.0	81.2
Average	78.78	78.03	80.21	77.79	78.94	84.88	79.40	77.98	77.49	79.62

Table 2. Soil moistures measured at the 10 cm depth inside and external to plastic asbestos tubes between 7:00 and 9:00 a.m. during the summer of 1973.

Days, 1973	Moisture (- Bars) outside tubes in plots					Moisture (-Bars) inside tubes in plots				
	2	12	53	105	132	18	73	95	110	139
5-15	2.0	3.0	2.7	1.0	7.2	26.6	0.8	-	0.5	0.5
5-22	38.0	32.9	43.2	15.6	31.5	129.0	1.4	-	128.2	0.9
5-23	42.5	39.6	42.5	25.0	40.0	-	1.6	-	127.0	1.5
5-24	129.0	49.7	49.2	40.7	128.6	-	2.0	-	125.3	2.5
5-26	129.1	129.1	129.0	129.0	129.0	-	2.8	-	108.0	8.7
5-27	128.9	128.9	129.0	128.7	129.0	-	3.5	-	-	14.3
5-28	128.9	128.9	129.0	128.9	129.0	-	4.6	-	-	19.4
5-29	128.9	129.0	129.0	129.0	129.1	-	5.6	128.8	128.9	33.2
5-30	129.0	129.0	129.0	129.0	129.0	-	7.4	129.0	129.0	44.7
5-31	128.8	128.9	128.9	129.0	128.8	-	9.4	129.0	47.5	47.5
Avg.	98.51	89.9	91.15	85.59	98.12	77.8	3.91	128.93	99.30	17.32
6-1	128.9	128.9	129.0	128.9	129.0	-	12.8	128.7	46.4	45.2
6-4	129.1	129.0	129.1	129.0	129.1	-	26.9	129.0	129.0	129.1
6-5	129.0	128.9	129.0	129.0	128.9	-	37.6	129.0	129.0	129.0
6-12	128.0	128.2	128.2	128.0	128.2	-	128.0	128.4	128.4	128.9
6-15	0.6	0.6	0.6	0.7	1.8	-	0.6	0.5	0.5	0.6
6-16	0.6	0.7	0.6	0.8	1.5	-	0.6	0.6	0.6	0.6
6-17	0.8	1.0	0.7	1.0	1.7	-	0.6	0.6	0.6	0.6
6-19	1.4	2.3	1.1	2.8	3.5	-	0.6	0.8	0.6	0.7
6-20	3.4	3.9	1.9	8.6	7.3	-	0.6	1.1	0.7	0.7
6-21	11.4	5.8	3.6	24.0	19.2	-	0.7	1.4	0.8	0.8
6-22	34.0	8.3	6.2	37.6	34.8	-	0.8	1.8	0.9	1.0
6-23	46.8	11.9	9.9	44.5	43.2	-	0.8	2.2	1.2	1.2
6-24	129.0	17.0	15.6	129.0	50.2	-	0.9	2.8	1.3	2.1
6-25	128.2	28.4	23.0	128.2	127.7	-	1.1	3.2	1.6	2.2
6-26	128.2	45.1	32.2	128.2	128.0	-	1.4	4.1	2.2	3.5
6-27	127.7	128.0	44.6	128.2	128.0	-	2.1	4.9	2.9	6.4
6-28	127.7	127.7	54.0	127.7	127.3	-	4.1	6.2	4.7	12.2
6-29	127.0	126.6	126.6	127.0	126.6	-	9.6	7.3	6.5	25.6
6-30	127.0	127.7	126.6	127.7	127.3	-	22.8	9.8	9.0	41.2
Avg.	79.41	60.53	50.66	80.57	75.96	-	13.29	29.60	24.57	27.98
7-2	128.8	128.8	128.4	128.9	128.6	-	39.8	17.5	15.2	48.5
7-3	128.0	128.0	127.7	128.2	128.0	-	41.2	17.9	21.1	51.1
7-9	126.1	126.6	125.6	127.0	126.6	-	126.[illegible]	127.0	127.0	126.6
7-10	127.7	128.0	127.3	128.4	127.4	-	127.7	128.4	128.4	128.0
7-15	0.5	0.5	0.6	0.5	0.5	-	0.6	0.5	0.5	0.5
7-16	0.6	0.6	0.6	0.7	0.6	-	0.6	1.7	0.6	0.6
7-17	0.5	0.6	0.6	0.5	0.5	-	0.6	0.6	0.6	0.6
7-18	0.5	0.5	0.6	0.5	0.5	-	0.6	0.5	0.6	0.6
7-19	0.5	0.5	0.5	0.5	0.5	-	0.5	0.5	0.5	0.6
7-20	0.5	0.6	0.6	0.6	0.5	-	0.6	0.6	0.6	0.6
7-21	0.6	0.6	0.6	0.6	0.5	-	0.6	0.6	0.6	0.6
7-22	0.6	0.6	0.7	0.6	0.6	-	0.6	0.6	0.6	0.6
7-23	0.6	0.7	0.8	0.7	0.6	-	0.6	0.6	0.6	0.6
7-25	0.9	1.5	4.6	0.8	0.7	-	0.8	0.7	0.7	0.8
7-26	0.6	1.2	5.9	0.8	0.7	-	0.9	0.6	0.6	0.7
7-27	0.9	1.1	4.5	0.8	0.7	-	1.3	0.7	0.7	0.8
7-28	1.1	1.6	7.2	1.0	0.7	-	2.2	0.8	0.7	0.9
7-29	1.3	2.6	11.8	1.4	0.8	-	3.7	0.8	0.8	0.9
7-30	1.9	5.2	18.7	3.1	1.1	-	5.9	1.2	1.0	1.1
7-31	0.5	0.6	0.6	0.5	0.5	-	0.6	0.5	0.5	0.5
Avg.	26.41	26.52	28.40	26.31	26.05	-	17.8	15.12	15.10	18.26
8-1	0.5	0.5	0.6	0.5	0.5	-	0.5	0.5	0.5	0.5
8-2	0.5	0.5	0.6	0.5	0.5	-	0.6	0.5	0.5	0.6
8-3	0.6	0.6	0.6	0.8	0.6	-	0.6	0.6	0.6	0.6
8-4	0.6	0.7	0.6	0.7	0.6	-	0.7	0.6	0.6	0.6
8-6	1.2	3.5	1.3	30.0	0.9	0.7	0.7	0.6	0.6	0.7
8-7	5.4	9.2	2.6	43.7	6.6	0.8	0.8	0.7	0.7	0.7
8-8	33.2	20.0	7.3	45.9	35.5	0.9	0.9	0.8	0.7	0.7
8-9	47.2	33.0	18.4	127.7	48.3	1.0	1.6	1.0	1.2	0.8
8-10	43.6	25.5	31.8	48.1	46.1	1.5	6.1	2.5	5.3	1.0
8-13	39.0	17.3	36.4	44.5	45.9	2.6	16.4	4.7	15.2	1.4
8-14	43.2	25.9	40.7	47.0	48.0	3.3	21.8	6.6	20.4	1.8
8-16	26.9	8.5	43.4	46.4	49.0	4.5	28.1	2.2	18.9	0.9
8-17	11.9	5.2	38.9	28.4	44.3	5.5	12.0	1.0	4.1	0.7
8-20	50.2	43.7	49.5	51.0	128.6	6.1	17.2	12.7	19.2	0.9
8-21	47.3	44.0	47.0	129.0	129.0	7.6	24.5	18.9	22.9	1.1
8-22	42.9	2.9	44.3	0.5	0.5	0.6	0.6	0.6	0.6	0.6
8-23	41.8	5.5	44.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6
8-24	45.2	15.8	49.5	0.8	0.7	0.7	0.7	1.4	0.7	0.7
8-25	46.8	32.9	49.0	5.5	2.1	1.2	0.9	15.8	3.4	0.8
Avg.	27.79	15.54	26.69	34.29	30.96	2.24	7.12	3.81	6.14	0.83

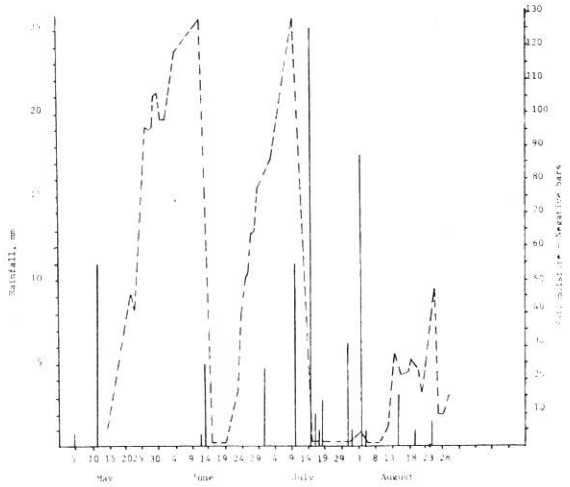

Figure 4. Comparison of precipitation and soil moisture (---) measured during summer, 1973.

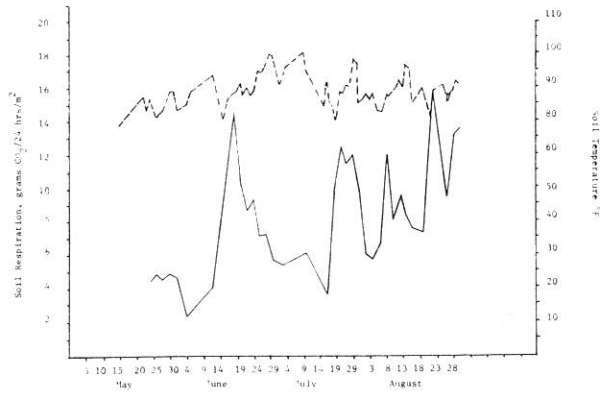

Figure 6. Comparison of soil respiration (—) and soil temperature (---) measured during the summer, 1973.

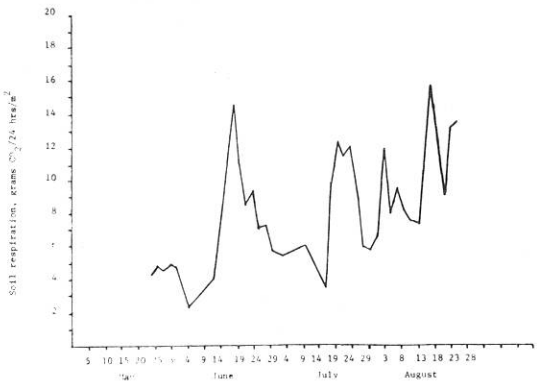

Figure 5. Total soil respiration as measured by CO_2 evolution from the Jornada plots during the summer, 1973.

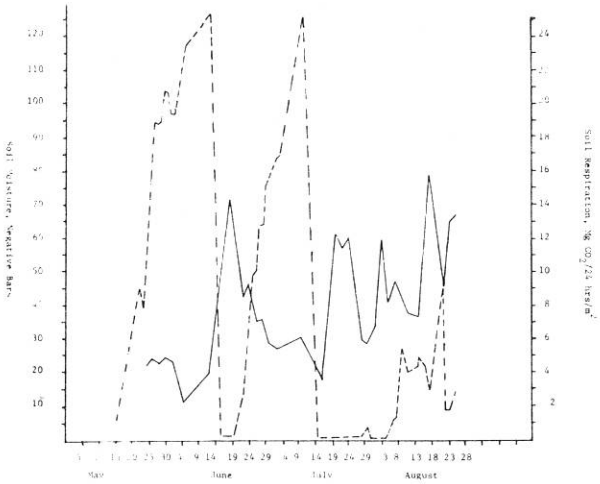

Figure 7. Comparison of soil respiration (—) and soil moisture (---) measured during summer, 1973.

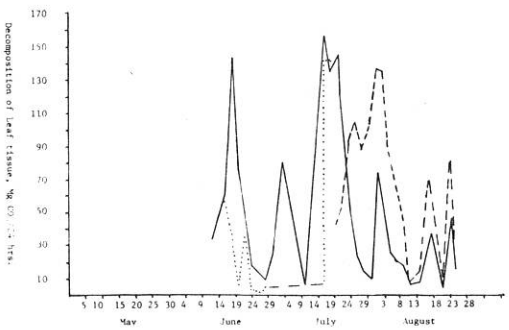

Figure 8. CO_2 evolution from leaf tissue placed in the field during February (···), May (—), and July (---), 1973.

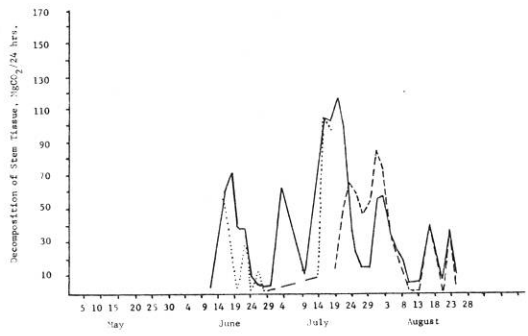

Figure 9. CO_2 evolution from stem tissue placed in the field during February (···), May (—), and July (---), 1973.

Carbon Dioxide Evolution

Although soil respiration (Fig. 5) was not directly sought, it had to be subtracted from the total CO_2 which included soil respiration plus tissue respiration. This aspect becomes more important and imparts a greater understanding of the overall aspect when the quantities of CO_2 evolved are examined. Quantities of CO_2 as low as 2 g/24 hr/m^2 and as high as 16 g/24 hr/m^2 indicate substantial losses in this relatively arid site. The soil respiration activity was compared with the soil temperature information (Fig. 6). It appeared as if each parameter was basically not influenced by the other. This was not the case when soil respiration was compared with soil moisture (Fig. 7). In general, 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. During the months of May and June the soil became completely dry, but the CO_2 level was never measured as zero during this experiment.

The investigation had to be terminated at the end of August and, until the data were compiled, it was not apparent that the overall slope of the soil respiration activity was upward. It would have been beneficial to continue the investigaton for another three weeks in order to observe the change caused by the decrease in soil moisture and cooler temperatures. Reevaluations may be necessary to compare soil respiration in July (with substantial amounts of precipitation) against respiration in August (with very small amounts of precipitation).

Carbon dioxide evolution from the plant tissues was expressed as quantities over that recorded for soil respiration. Evolution of CO_2 was recorded from leaf tissues placed in the field in February, May and July (Fig. 8). Although there was a weight loss in leaf tissue between February and May that was not measured as CO_2 evolved, the tissue placed in the field in May evolved much greater quantities of CO_2 that that placed in the field in February during the time both were under the same environmental conditions. The May tissues did not undergo rapid decomposition (CO_2 evolution) immediately after being placed in the field. It was not until June 14 that any substantial activity could be measured, and this was followed by increased activity during July 4 and a real burst between July 11 and July 23. Leaf tissues introduced into the field on July 18 yielded CO_2 immediately. A prolonged period of decomposition July 19 to August 5 was measured by the CO_2 evolved. It appeared that leaf tissues introduced into the field in July decomposed more rapidly or in a shorter time period than those introduced in May, and those introduced in May decomposed more rapidly or in a shorter time period than those placed in the field in February.

Stem tissues placed in the field in May and July (Fig.9) yielded less CO_2 evolved or decomposed more slowly than leaf tissues (Fig. 8) placed in the field at these same times. This was not the case for the February stem tissue which yielded more CO_2 than the February leaf tissue. It appeared as if the CO_2 evolved from the May tissue exceeded that evolved from the February tissue during the examination period. In contrast to the leaf tissue, the July-introduced stem tissue did not evolve substantially more CO_2 than the May tissue between July 18 and August 25.

Root tissues introduced into the field in February and May (Fig. 10) again yielded less CO_2 than stem tissues placed in the field at the same time. Total CO_2 evolved from stem and root tissues introduced in July appeared to be quite similar. More CO_2 was evolved from the May root tissue than the February tissue between May 12 and July 19. Similarly more CO_2 was evolved from the July root tissue than from the May tissue between July 18 and August 25.

When the soil respiration activities exhibited an interesting relationship with the soil moisture data, it was decided that comparisons should be made between soil moisture and CO_2 evolved from plant tissue. The comparison between soil moisture and CO_2 evolved from leaf tissue introduced to the field in February and July (Fig. 11) showed increases in CO_2 evolution as the negative bars of soil moisture was reduced. This was easier to detect in the July tissue than the February tissue. Comparisons between soil moisture and CO_2 evolved from leaf tissue placed in the field in May showed the same response as earlier (Fig. 12). When soil moisture becomes available the quantity of CO_2 evolved increases. The CO_2 peak expressed between June 30 and July 8 was mentioned earlier in this report. This was the 4.5 mm rainfall that did not change the moisture content at the 10 cm depth, but it apparently moistened the leaf tissue at the soil surface and increased the decomposition activity.

When comparing soil moisture and CO_2 evolved from stemtissue placed in the field in February and July (Fig. 13) and May (Fig. 14), the same types of responses were observed as for the leaf tissue. This was also true for the CO_2 peak expressed between June 30 and July 8 on the tissue introduced in May.

These relationships were not as aparent when root tissues placed in the field in February and July (Fig. 15) were compared with soil moisture. Insufficient CO_2 was evolved from the February root tissue to be expressive of a peak between early June and the middle of July. Peaks were expressed immediately after placing the root tissue in the field in July, but they became less intense and possibly slower to react to additional rainfall. Carbon dioxide evolved from May root tissue (Fig. 16) exhibited little indication of being influenced dramatically by rainfall and increased soil moisture. Throughout most of the decomposition period between 5 and 13 mg of CO_2 were given off per 24 hr regardless if the soil was moist or dry.

To obtain additional perspective of the decomposition activity, the CO_2evolution data were manipulated 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 activity was high and occasionally longer intervening periods were employed when activity was low. 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 tissues 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 leaf, stem and

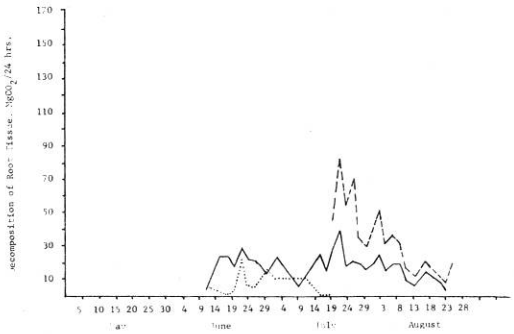

Figure 10. CO_2 evolution from root tissue placed in the field during February (···), May (—), and July (---), 1973.

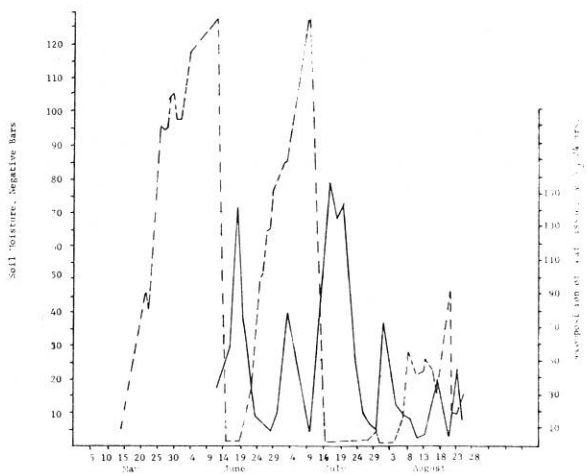

Figure 12. Comparison between soil moisture (---) and CO_2 evolved from May (–) leaf tissue, 1973.

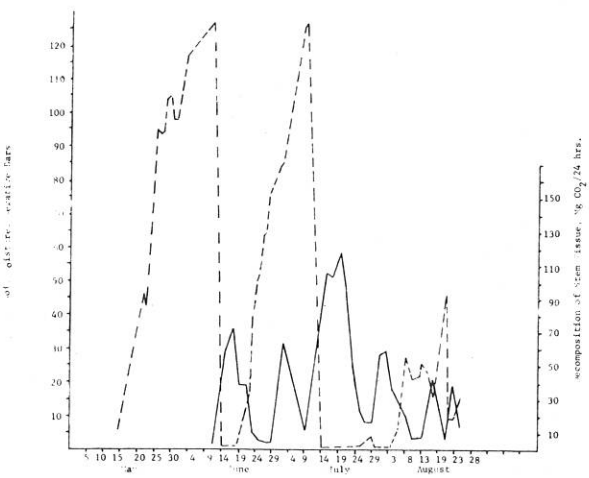

Figure 14. Comparison between soil moisture (···) and CO_2 evolved from May (—) stem tissue, 1973.

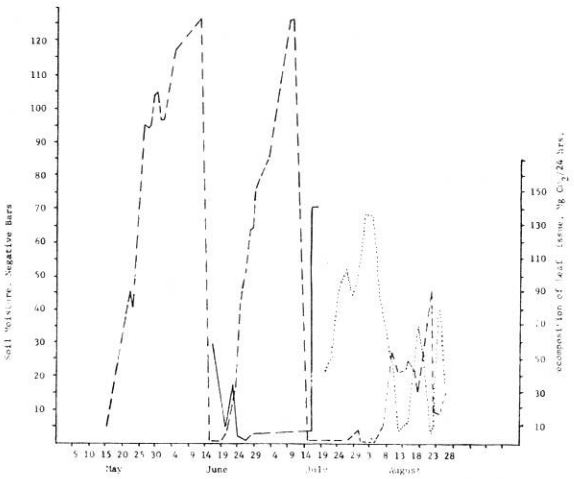

Figure 11. Comparison between soil moisture (---) and CO_2 evolved from February (—) and July (··) leaf tissue, 1973.

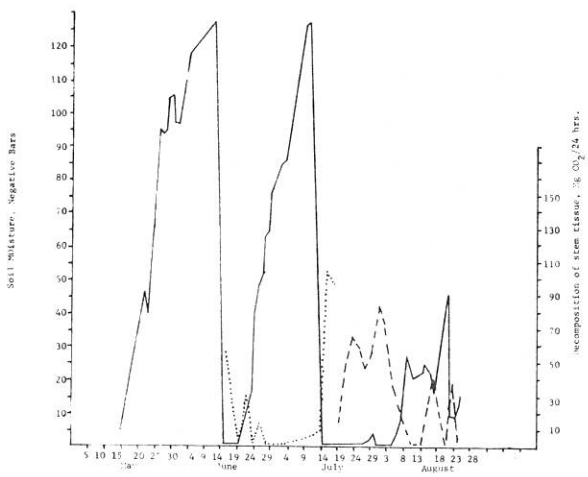

Figure 13. Comparison between soil moisture (—) and CO_2 evolved from February (···), July (---) stem tissue, 1973.

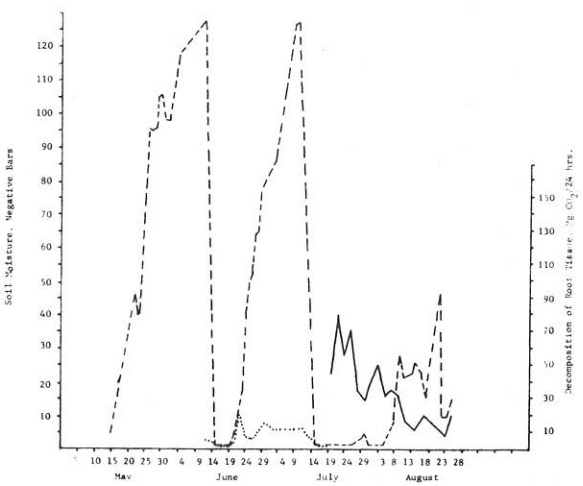

Figure 15. Comparison between soil moisture (---) and CO_2 evolved from February (···), July (—) root tissue, 1973.

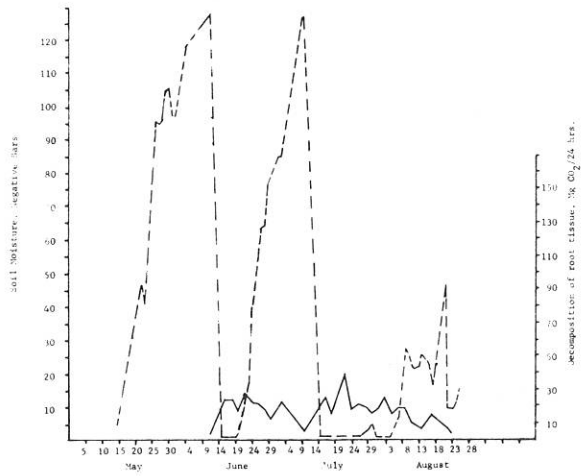

Figure 16. Comparisons between soil moisture (---) and CO_2 evolution from May (—) root tissue, 1973.

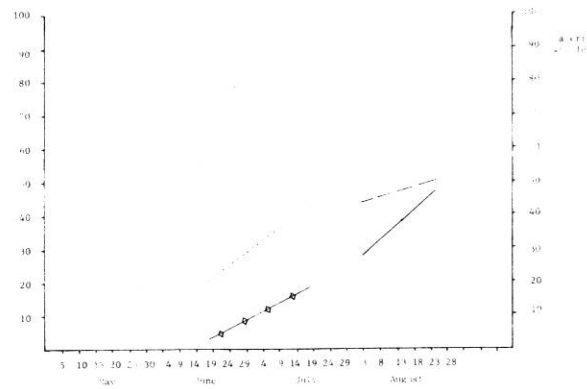

Figure 17. Percentage loss based on weight loss (··) and CO_2 evolution (◆—◆) determinations on February buried, and weight loss (---) and CO_2 evolution (——) determinations on July buried leaf tissue, 1973.

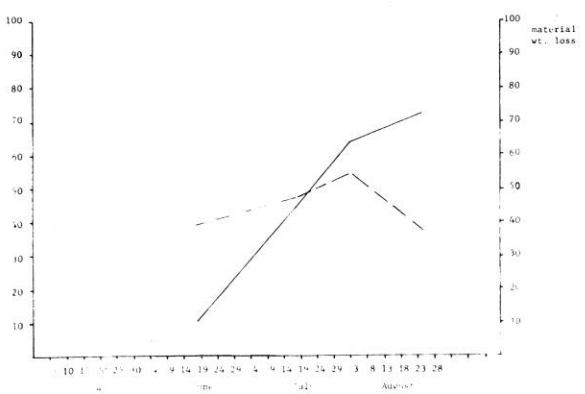

Figure 18. Percentage loss based on weight loss (---) and CO_2 evolution (——) on May buried leaf tissues, 1973.

root tissue employed in this experimentation. Comparing leaf tissue that was placed in the field in February and July (Fig. 17) large discrepancies exist between the weight loss and the CO_2 evolution loss in the early testing. As the test proceeded this difference became wider in the February tissue but much narrower in the July tissue. The same type of response was experienced in the early determinations of the May-introduced leaf tissue (Fig. 18). The continued determinations yielded a weight loss slope different than those observed for February- and July-introduced leaf tissues.

The discrepancy between the two types of losses that occurred early in the experiment received critical examination first. After reviewing the activities and parameters being tested, the May determinations offered the best prospects. Extra leaf tissues were available and the major change that had occurred was precipitation. Therefore, the question of leaching from the tissue became of prime importance. It was found that substantial weight changes could be encountered due to leaching from the leaf tissue (Table 3). In early June a 25 mm rainfall occurred and the soil surface remained moist for 3 days. Therefore it was determined that leachates due to both through-fall rain and standing moisture should be evaluated.

If the loss due to simulated through-fall rain and standing water (25.5%) were added to the loss as CO_2 evolved (10.0%) from the May tissue, the total value (35.5%) would not be drastically different from that recorded for the weight loss determination. It was of interest to see if the leaching values varied as the season changed. An additional test was conducted from leaf tissue obtained from the field in September (Table 4). Both the value for through-fall rain and that for tissue in standing moisture were different and substantially lower than the May leaf tissue. Therefore it appears that a leaching value would have to be determined for the original leaf tissue taken to the field in February and July.

Similar comparisons were made with the stem tissue placed in the field in February and July (Fig. 19) and May (Fig. 20). Again differences in percentage loss between weight loss measurements and CO_2 evolution measurements existed. Leaching experiments were conducted on the stem tissues that were placed in the field in May (Table 5). Losses due to through-fall rain and standing moisture were much less in stems than leaves. Again, tissues were collected in September for comparison (Table 6). The differences between May and September were not as large with rainfall (2.4 vs. 1.8%) or with standing moisture (7.4 vs. 7.9%) as observed with leaves.

Comparisons similar to those made on leaves and stems were also made with roots. Again, percentage loss based on weight loss determinations differed from those based on CO_2 evolution (Figs. 21 and 22). In all cases early weight losses exceeded the loss measured by CO_2 evolution determinations. Leaching experiments were also conducted on root tissues placed in the field in May and on additional tissue collected in September (Tables 7 and 8). As found in stems, the variation in leaching losses was not great between the two sampling times. Losses due to rainfall (3.3 vs. 2.4%) and that due to standing in moisture (8.4 vs 9.8%) were quite similar, and also similar to those observed with stems.

Tables 3-8. Possible leaching influences on creosote leaf tissue prior to decomposition, 1973.

Table 3.

Simulated 2.54 cm rainfall

Original Weight, g	Weight after rain, g	Weight loss, g	% Weight loss
3.00	2.539	0.461	15.3
3.00	2.582	0.418	13.9
3.00	2.401	0.599	20.0

Average weight loss through leaching 16.4%

Total soluble loss after standing in water for 24 hr

Original Weight, g	Weight after soak, g	Weight loss, g	% Weight loss
3.00	2.227	0.773	25.8
3.00	2.261	0.739	24.6
3.00	2.217	0.783	26.1

Average weight change through loss of solubles 25.5%

Table 4.

Simulated 2.54 cm rainfall

Initial Weight, g	Weight after rain, g	Weight loss, g	% Weight loss
2.999	2.936	0.063	2.1
2.999	2.924	0.075	2.5
3.000	2.926	0.074	2.5
2.999	2.923	0.076	2.5

Average weight loss through leaching 2.4%

Total solubles after standing in water for 24 hr

Initial Weight, g	Weight after soak, g	Weight loss, g	% Weight loss
2.999	2.488	0.511	17.0
2.999	2.489	0.511	17.0
2.999	2.501	0.498	16.0

Average weight change through loss of solubles 16.7%

Table 5.

Simulated 2.54 cm rainfall

Original Weight, g	Weight after rain, g	Weight loss, g	% Weight loss
3.00	2.934	0.066	2.2
3.00	2.923	0.077	2.6
3.00	2.925	0.075	2.5

Average weight loss through leaching 2.4%

Total soluble after standing in water for 24 hr

Original Weight, g	Weight after soak, g	Weight loss, g	% Weight loss
3.00	2.804	0.196	6.5
3.00	2.761	0.239	8.0
3.00	2.766	0.234	7.8

Average weight change through loss of solubles 7.4%

Table 6.

Simulated 2.54 cm rainfall

Initial Weight, g	Weight after rain, g	Weight loss, g	% Weight loss
2.999	2.941	0.058	1.9
3.000	2.951	0.049	1.6
3.001	2.948	0.053	1.8
3.000	2.957	0.043	1.4

Average weight loss through leaching 1.8%

Total soluble after standing in water for 24 hr

Initial Weight, g	Weight after soak, g	Weight loss, g	% Weight loss
2.999	2.773	0.226	7.5
3.000	2.721	0.279	9.3
3.001	2.787	0.214	7.1
3.000	2.767	0.233	7.8

Average weight change through loss of solubles 7.9%

Table 7.

Simulated 2.54 cm rainfall

Original Weight, g	Weight after rain, g	Weight loss, g	% Weight loss
3.00	2.936	0.064	2.1
3.00	2.922	0.078	2.6
3.00	2.840	0.160	5.3

Average weight loss through leaching 3.3%

Total soluble after standing in water for 24 hr

Original Weight, g	Weight after soak, g	Weight loss, g	% Weight loss
3.00	2.734	0.266	8.9
3.00	2.780	0.220	7.3
3.00	2.728	2.272	0.1

Average weight change through loss of solubles 8.4%

Table 8.

Simulated 2.54 cm rainfall

Initial Weight, g	Weight after rain, g	Weight loss, g	% Weight loss
3.000	2.921	0.079	2.6
2.999	2.937	0.062	2.1
2.999	2.933	0.066	2.2
2.999	2.913	0.086	2.9

Average weight loss through leaching 2.4%

Total solubles after standing in water for 24 hr

Initial Weight, g	Weight after rain, g	Weight loss, g	% Weight loss
3.000	2.683	0.317	10.6
2.999	2.746	0.253	8.4
2.999	2.726	0.273	9.1
2.999	2.665	0.334	11.1

Average weight change through loss of solubles 9.8%

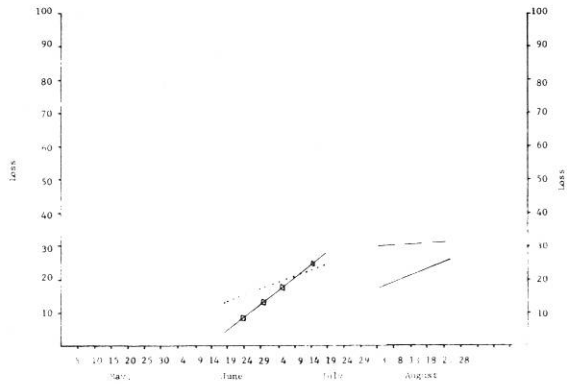

Figure 19. Percentage loss based on weight loss (··) and CO_2 evolution (◆–◆) determinations on February buried, and weight loss (---) and CO_2 evolution (——) determinations on July buried stem tissue, 1973.

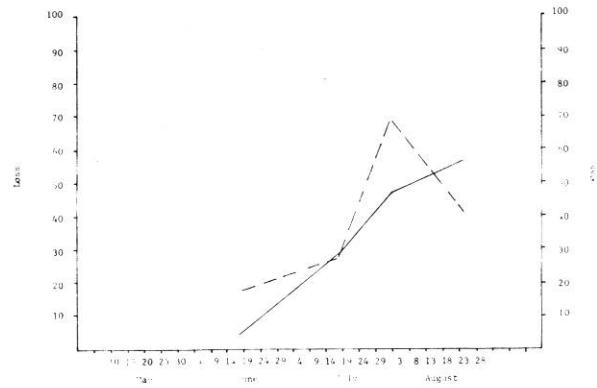

Figure 20. Percentage loss based on weight loss (---) and CO_2 evolution on May buried stem tissue, 1973.

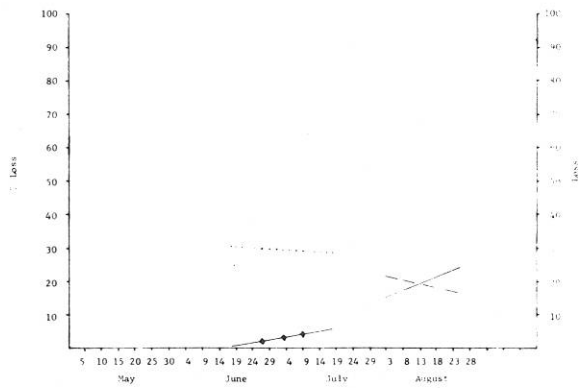

Figure 21. Percentage loss based on weight loss (···) and CO_2 evolution (◆–◆) determinations on February buried; and weight loss (---) and CO_2 evolution (——) determinations on July buried root tissues, 1973.

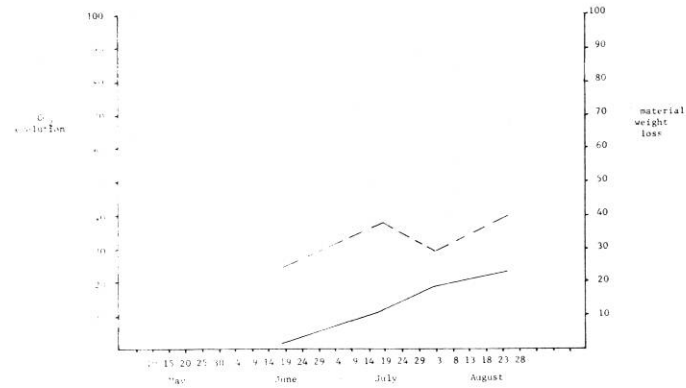

Figure 22. Percentage loss based on weight loss (---) and CO_2 evolution on May buried root tissue, 1973.

Ammonia Volatilization

Although readings were taken throughout the season very little, if any, NH_3 was volatilized from the soil during this examination period. The one day when measurable readings were obtained occurred in the early spring. Greater attention will have to be focused on the late fall and early spring activities.

Other Observations

Upon opening the plant tissue litter bags, it was noted that there was a preponderance of fungi on the organic material. This observation was further substantiated by additional examination using the side-field stereoscope and the research microscope. Fungi were tested (Moore, 1971) and found to effectively utilize starch, cellulose, hemicellulose, and conidendrun (lignin) as substrates for metabolism. Presently, bacteria isolated from the Jornada soils are being similarly tested. To date they do not exhibit the capacity to utilize these substrates in the same fashion as fungi. If these observations continue, the bacteria will have to be relegated to a much lower order of importance than they now possess.

DISCUSSION

Soil temperature is probably a very important variable to the decomposition process at many sites, but it does not appear to be as important as moisture at the Jornada site. This may be due to favorable temperatures for the growth of microorganisms throughout most of the year. Low temperatures that exist in December, January and February are not maintained continuously throughout these months. During the afternoons of many days, temperatures conducive to microbial growth prevail. Soil moisture, on the

other hand, reaches extremes that would drastically inhibit microbial activity. These dry conditions occur during the winter, spring, summer, and fall. The soil temperatures measured at the 10 cm depth during this investigation did not vary appreciably and would not cause stresses on the microbial activity. Much greater variation was associated with the soil moisture and lack of available moisture caused stresses on the activity of these organisms.

Rainfalls of 12.5 mm or less (Bailey, 1967) have been shown to be ineffective in inducing normal activity in plant growth. Moisture additions of 6 mm in June have been shown in this study to drastically influence the soil-moisture regime (Fig. 4). This was accompanied by increased microbial activity and increased CO_2 evolution (Figs. 7, 12 and 14). Rainfall of 5 mm on July 1 (Fig. 4) did not influence the soil moisture level, but did initiate increased CO_2 evolution (Figs. 7, 12 and 14). As mentioned in the Results section, it might be very important to obtain information on other parameters such as cloud cover, wind speed and direction, the level and persistence of relative humidity, and the evaporation rate.

Asbestos plastic tubes used in this experiment did not conduct heat as metal tubes had previously. The temperatures inside the tube did not differ appreciably from the temperatures outside the tube (Table 1). These tubes still retain soil moisture for periods longer than desired (Table 2). Other materials could be utilized and tested, but it is doubtful whether they would be superior in lowering condensates or allowing the soil within the tube to dry out more rapidly.

Substantial quantities of CO_2 were evolved from the soil as measured in g/24 hr/m^2. This evolution of CO_2 appeared to be directly related to the soil moisture availability.

Soil moisture availability also directly influenced the CO_2 evolution from most of the plant tissues placed into the field (Figs. 11, 12, 13, 14, and 15). Additional examination could benefit our understanding of the moisture effect on the February and May buried root tissue. Some part of the moisture effect could have been due to the precautions suggested by Coleman (1971), including:

1. Assure that $\geqslant 80\%$ of the alkali is unneutralized at the end of the experiment. This was not always possible.
2. The surface of the liquid-absorbing jar should be 15-20% of the total ground surface in the cylinder. This aspect was satisfied.
3. Any appreciable rainfall ($>$ 2-3 mm) is likely to flush the CO_2 into the ground and up into the cylinder, invalidating the results. It was assumed that this aspect would influence the soil respiration readings, but would not appreciably change the CO_2 evolution from tissue readings since the soil respiration was subtracted from these values.
4. Any marked changes in barometric pressure will alter the CO_2 evolution pattern. Determinations made at such times (as when a weather front is passing over) should be considered as suspect. Again, it was assumed that this CO_2 evolution would be included in the soil respiration values and not in the tissue CO_2 readings.

During this experiment, the CO_2 traps were in the tubes only once when rain fell on the plot. The amount of moisture was determined and added as distilled water to the tubes. It was fortunate that this aspect was maintained at a minimum, but this was not true for frontal systems that moved over the plot. It was hoped that the number of controls included in this experiment would maintain variations at a minimum.

It was felt that CO_2 evolution determinations from plant tissues yield better data than weight loss information. As mentioned earlier, there was a large discrepancy early in the decomposition process due to leaching from the tissue. Later in the test the weight loss data indicated an increase in tissue weight, or, as Dr. Francis Clark so aptly put it, "negative decomposition". If the percentage loss from the weight loss determinations are incorrect at the beginning of the experiment and are incorrect at the end of the experiment, then when are they correct so they can be used or how can they be corrected for use? These tendencies were not observed in the CO_2 evolution readings and it is believed that they more accurately express the field decomposition activity.

Percentage loss based on CO_2 evolution from leaf tissue (Fig. 23) shows that May and July tissue decomposed more rapidly than tissue placed in the field in February. This observation has been made in previous studies and it might be associated with the type of microbes initially colonizing the substrate under colder climatic conditions. After 65% of the leaf tissue was decomposed, the slope of the decomposition changed. It will be interesting to obtain the chemical analysis data to determine the type of substrate available at this time. Environmental conditions conducive for decomposition still prevailed at this time as can be seen by the slope of the curve for the July-introduced leaf tissue.

Percentage loss based on CO_2 evolution from stem tissue (Fig. 24) shows that tissue placed in the field in February decomposes at the same rate as tissue placed in May. Also the slopes of the curves of May tissues decomposing in August were parallel to the July tissues decomposing in August. When comparing the stem tissue decomposition with the leaf tissue decomposition, it can be seen that the leaf tissue placed in the field in May and July decomposed more rapidly than did the stem tissue placed at the same time. In contrast to this, the stem tissue placed in February decomposed more rapidly than leaf tissue added to the field in February.

Percentage loss based on CO_2 evolution from root tissue (Fig. 25) shows that tissue placed in the field in July decomposed most rapidly, followed by the May tissue; the February tissue was slowest to decompose. The decomposition of the root tissue added to the field in August basically equalled the decomposition of the stems added at the same time.

Losses based on CO_2 evolution from plant tissue are much more comprehensible than losses based on weight-loss determinations, as can be seen in Figures 26, 27 and 28. At

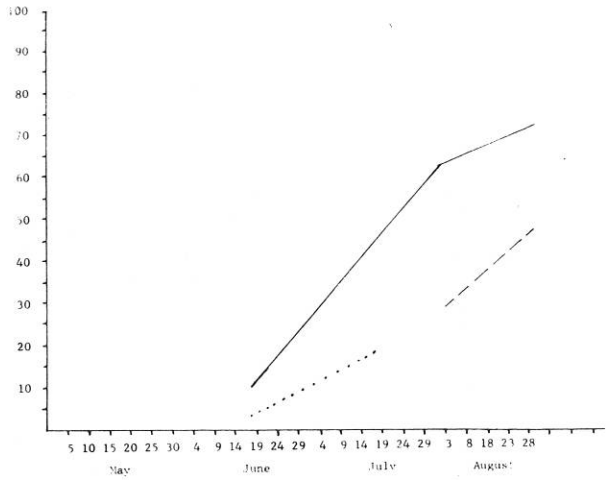

Figure 23. Percentage loss based on CO_2 evolution from leaf tissue buried in February (···), May (——), and July (---), 1973.

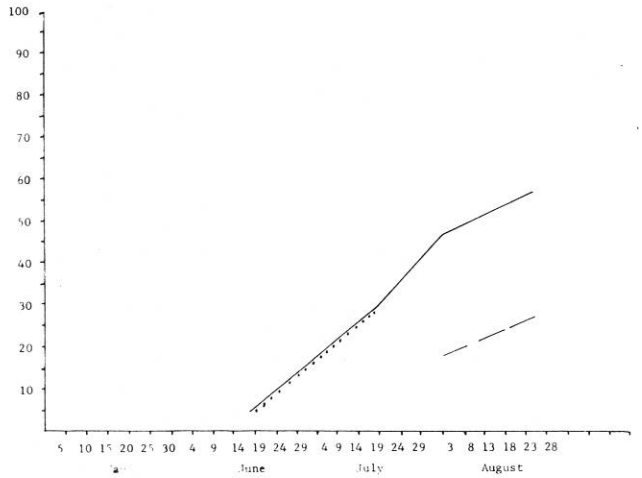

Figure 24. Percentage weight loss based on CO_2 evolution from stem tissue buried in February (···), May (——), and July (---), 1973.

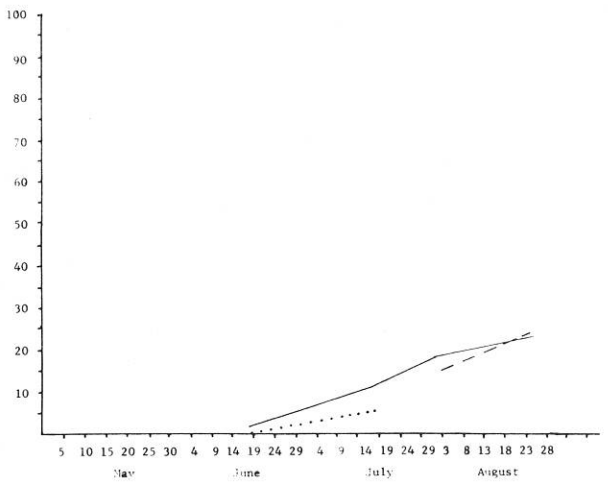

Figure 25. Percentage weight loss based on CO_2 evolution from root tissue buried in February (···), May (——), and July (---), 1973.

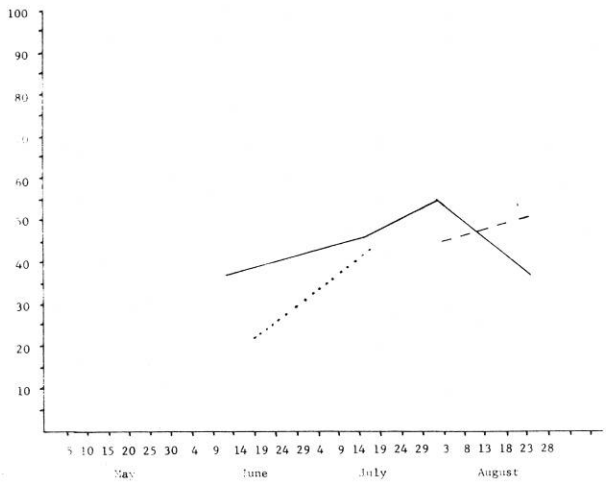

Figure 26. Percentage loss based on weight loss determinations from leaf tissue buried in February (···), May (——), and July (---), 1973.

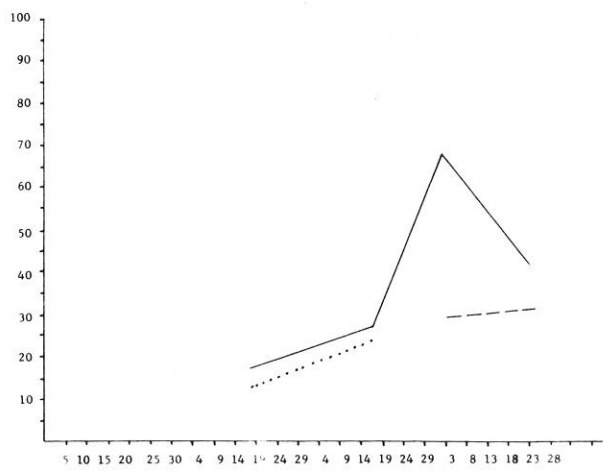

Figure 27. Percentage loss based on weight loss determinations from stem tissue buried in February (···), May (——), and July (---), 1973.

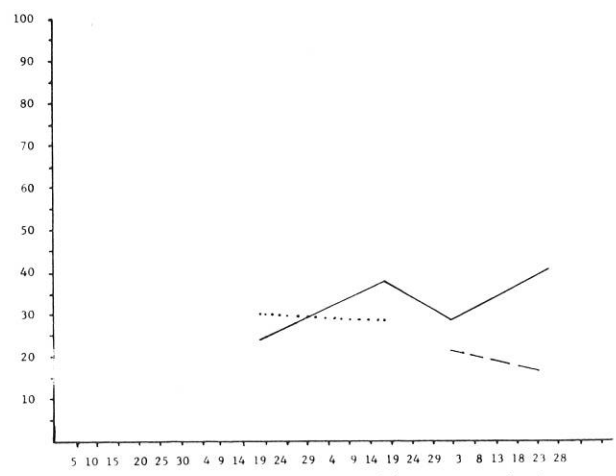

Figure 28. Percentage loss based on weight loss determinations from root tissue buried in February (···), May (——), and July (---), 1973.

least four and possibly five values (May-leaf, May-stem and February- May- and August-root) of the nine values obtained show this "negative decomposition" phenomenon. Since decomposition is a cumulative process it would be assumed that curves expressing this process should continue to show the utilization of the substrate. This is not shown in the weight-loss determinations. This same activity, "negative decomposition", has also been observed while utilizing filter paper as the decomposable substrate. At that time it was noted that organic carbon tended to accumulate on the filter paper as the soil was drying. It could be assumed that as the soil was drying the last thing to lose moisture was the filter paper. At the same time much of the microbial tissue was accumulating on the moist substrate. If the litter bag was weighed after the leachates had been removed (immediately following a rain) and later another, similar, litter bag weighed after microbial tissue had accumulated on it, the overall effect could be the accumulation of weight or "negative decomposition".

It is therefore suggested that weight loss from litter bags will yield data, but there is no assurance of the realm of accuracy of that data. Wherever possible the weight-loss data should be accompanied by, or better still replaced by, CO_2 evolution data when this information is collected from the field.

There was indication that no NH_3 was evolved during the course of this investigation. This does not mean that no NH_3 is volatilized, but possibly it was the wrong time to examine this aspect, or else conditions were not conducive to NH_3 volatilization.

As soon as the tissue analysis becomes available, it will be summarized and added as an addendum to this report. It is assumed that this information will augment and complement the ideas already expressed above.

EXPECTATIONS

This experimentation was conducted as a process study to establish a possible way of obtaining more dependable data on measurements of carbon and nitrogen changes occurring in the soil. Hopefully the techniques employed in this investigation will be adopted on the desert validation sites for the collection of decomposition data. It is suggested that further comparison between weight-loss data and CO_2-evolution-loss data be initiated to assure that weight loss from litter bags is inaccurate and in many instances difficult to explain as a true biological phenomenon.

ACKNOWLEDGEMENTS

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LITERATURE CITED

BAILEY, O. 1967. Water availability and grass root distribution in selected soils. Unpublished Master's thesis. N.M.S.U., Las Cruces, New Mexico. 67 p.

COLEMAN, D. 1971. Measurement of total soil respiration at IBP Grassland sites. Mimeo., IBP Grassland Biome. 4 p.

MOORE, S. 1971. Enzymatic activity of soil fungi. Unpublished Master's thesis. N.M.S.U., Las Cruces, New Mexico. 41 p.

WHITFORD, W.G. (COORDINATOR) and Collaborators. 1972. Jornada Validation Site report. US/IBP Desert Biome Res. Memo. RM 72-4.