Technical Report No. 222

MICROBIAL DECOMPOSITION AND CARBON DIOXIDE EVOLUTION AT THE OSAGE SITE, 1972

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ABSTRACT

Part I

Soil temperature is a more important driving variable than soil water in the decomposition model for the Osage Site. Analysis of 1971 data supports this hypothesis.

Decomposition rates for cellulose and native litter and CO_2 evolution were higher in the grazed treatment than in the ungrazed treatment. Though other factors may influence these processes, temperature was always higher in the grazed treatment during the growing season.

Soil water at the Osage Site may have been high enough to decrease CO_2 evolution. This is especially true for the ungrazed treatment, where soil water averaged 3.3% greater than the grazed treatment.

The present method for measuring root decomposition is inadequate, making it difficult to distinguish between new roots which have entered the substrate bags and the initial sample.

Part II

Carbon dioxide evolution experiments made at the Osage Site from April through December 1972 showed a difference in CO_2 evolution between the grazed and ungrazed treatments. There were no significant differences between replicates within each treatment. Carbon dioxide evolution correlates significantly to temperature but not to soil water.

PART I

MICROBIAL DECOMPOSITION AND CARBON DIOXIDE EVOLUTION

OBSERVATIONS AND RESULTS

Abiotic Factors

Soil temperature and soil water were taken on each sampling date (Table 1) according to U.S. IBP Grassland Biome Technical Report No. 145 (Swift and French 1972). Soil water was higher in the ungrazed treatment than in the grazed treatment for the entire sampling season (Fig. 1). Soil temperature increased gradually through the summer and was always higher in the grazed treatment (Fig. 2).

CO_2 Evolution

CO_2 evolution was higher in the grazed treatment except for June (Table 2). This variation in CO_2 production does not correlate with changes in either soil temperature or soil water.

The total amount of CO_2 produced showed gradual increase throughout the season (Fig. 3) and was apparently influenced primarily by soil temperature. The data indicate that the lack of soil water was not a limiting factor in CO_2 evolution. The 3rd and 4th degree polynomial regression plots of CO_2 evolution vs. soil water (Fig. 4) show that CO_2 evolution decreased as soil water increased.

Decomposition

Surface and belowground samples of cellulose, litter, and roots were established on 22 April and recovered on 6 June, 7 July, and 8 August. The results are summarized in Table 3. The rate of decomposition in grams/month was higher for all substrates in the grazed treatment (Fig. 5). Cellulose, both above- and belowground, decomposed more rapidly than native litter.

Table 1. Soil temperature (°C) and percent soil water for each treatment at Osage, 1972.

Date	Parameter	Ungrazed	Grazed
22 April	Temperature	14.0	16.0
	Water	37.5	31.5
16 May	Temperature	15.0	17.5
	Water	30.1	26.1
6 June	Temperature	17.5	20.5
	Water	19.1	12.1
7 July	Temperature	18.5	19.7
	Water	24.9	24.4
8 August	Temperature	19.8	22.3
	Water	19.4	17.0
2 September	Temperature	19.3	22.5
	Water	29.3	26.5
4 November	Temperature	9.0	9.0
	Water	24.9	24.7

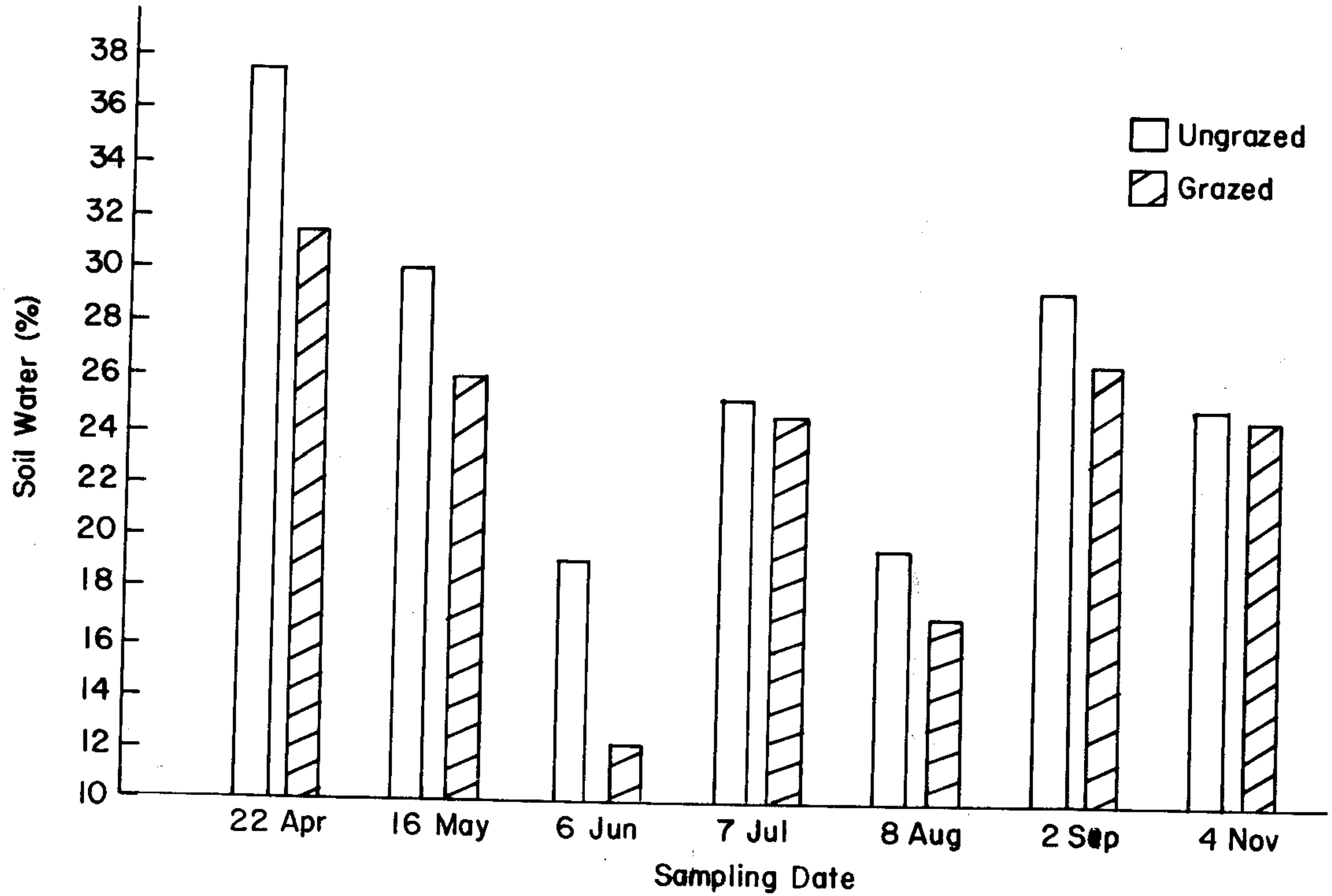

Fig. 1. Soil water vs. time, Osage, 1972.

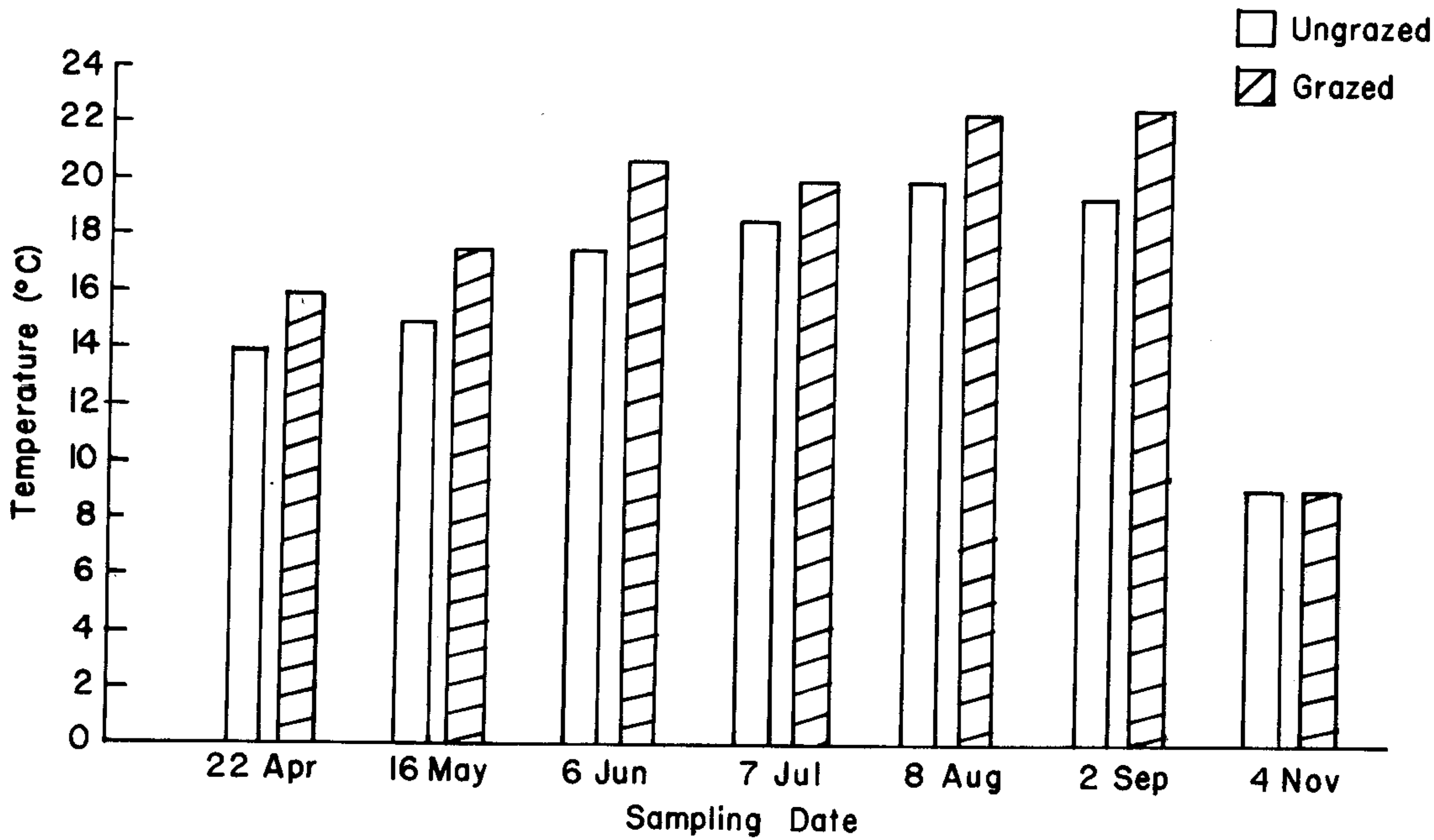

Fig. 2. Temperature vs. time, Osage, 1972.

Table 2. Summary of CO_2 evolution data.

Date	Treatment	g CO_2/24 hr/m^2	Soil Temperature (°C)	Soil Water (% dry wt)
22 April	Ungrazed	5.76	14.0	37.50
	Grazed	11.09	16.0	31.40
16 May	Ungrazed	4.44	15.0	30.10
	Grazed	10.01	17.5	26.08
6 June	Ungrazed	11.89	17.5	19.05
	Grazed	11.37	20.5	12.07
7 July	Ungrazed	9.23	18.5	24.90
	Grazed	9.75[a/]	19.7	24.35
8 August	Ungrazed	13.81	19.8	19.40
	Grazed	19.00	22.3	17.00
2 September	Ungrazed	15.21	19.3	30.05
	Grazed	24.58[a/]	22.5	26.50
4 November	Ungrazed	3.73	9.0	24.94
	Grazed	4.20	9.0	24.66

[a/] Data available for Replicate 1 only.

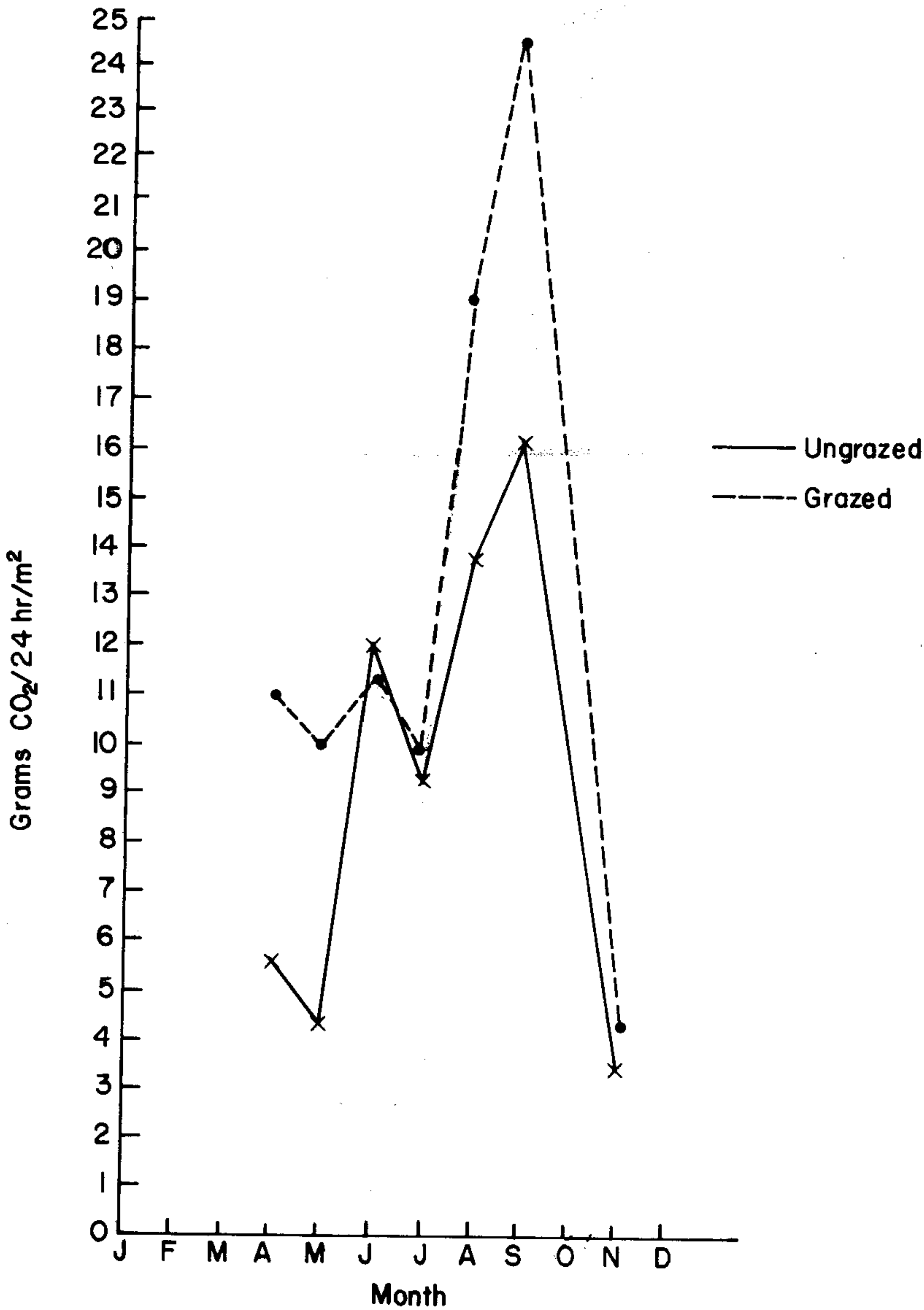

Fig. 3. CO_2 evolution per month, Osage, 1972.

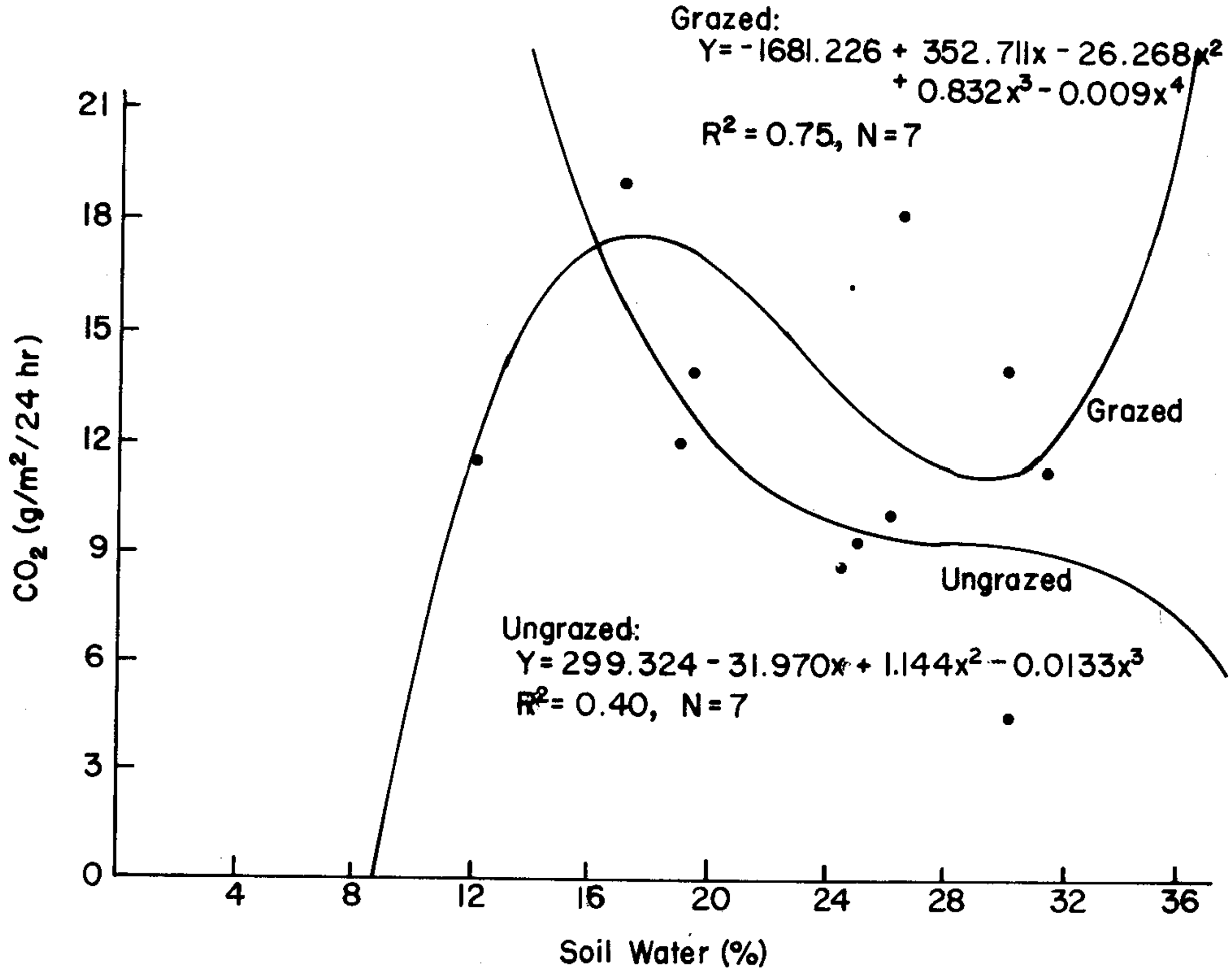

Fig. 4. Polynomial regressions of CO_2 evolution vs. soil water.

Table 3. Mean percent lost for each substrate, Osage, 1972.

Date	Treatment	Surface		Buried		
		Cellulose	Litter	Cellulose	Litter	Roots
6 June	Ungrazed	5.12	-3.82	35.10	7.09	-17.91
	Grazed	8.44	7.88	26.76	11.02	-15.73
7 July	Ungrazed	3.10	0.44	29.55	7.82	-7.12
	Grazed	3.98	2.38	31.01	12.73	-9.93
8 August	Ungrazed	2.25	2.80	26.83	8.03	-4.30
	Grazed	2.94	3.13	26.91	8.71	-2.35

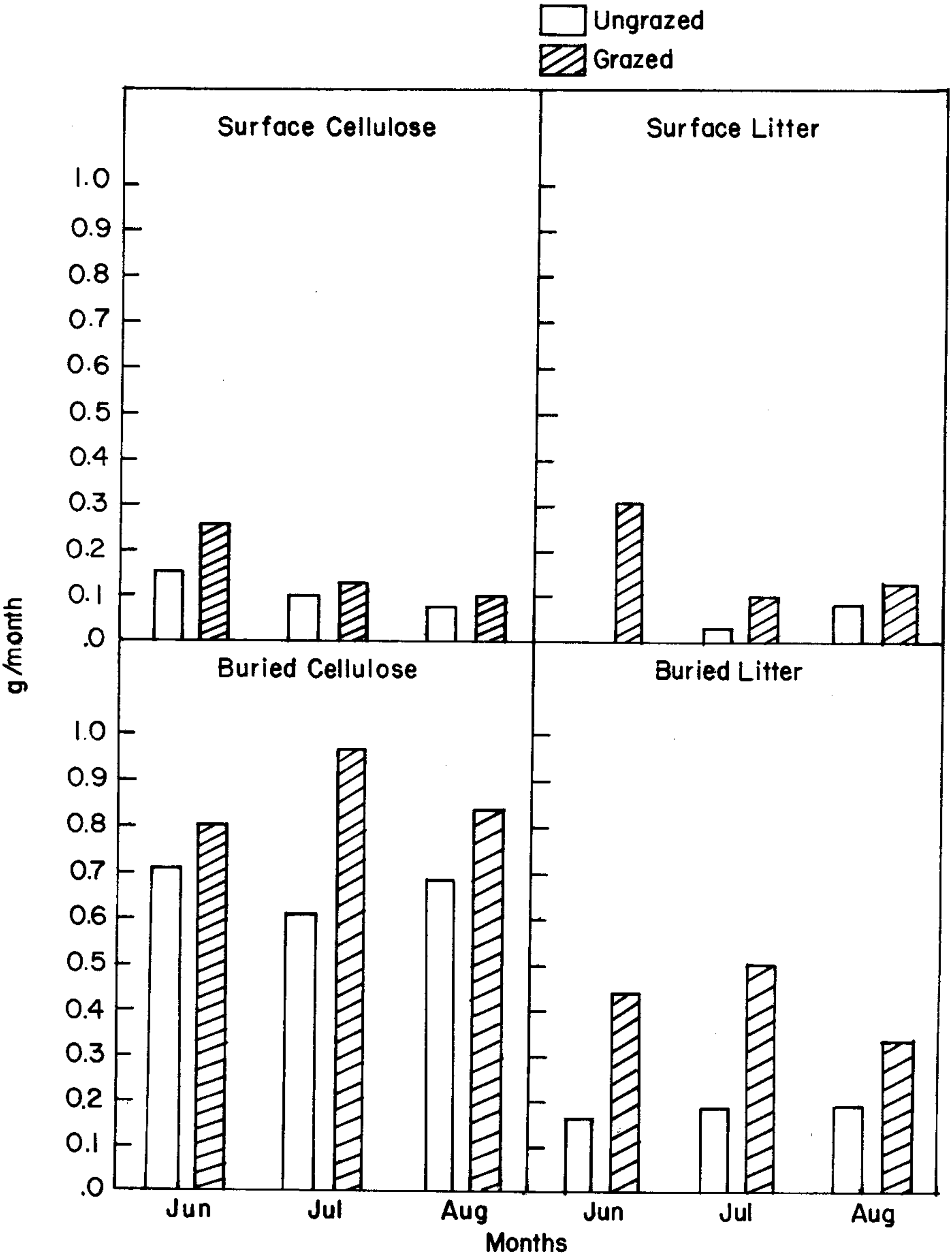

Fig. 5. Comparison of the decomposition rates, Osage Site, Summber 1972.

Data on root decomposition were inconclusive, showing a "negative loss," apparently because living material penetrated the samples. New roots growing into the sample bags were not easily distinguishable from the substrate and thus were not removed from the samples. (Control bags containing an inert inorganic filler such as fiberglass, or empty bags, placed in the ground and removed with the substrate bags may facilitate measurement of the amount of new root growth into each substrate sample.) Fig. 6, 7, and 8 show mean percent loss for buried cellulose, litter, and roots.

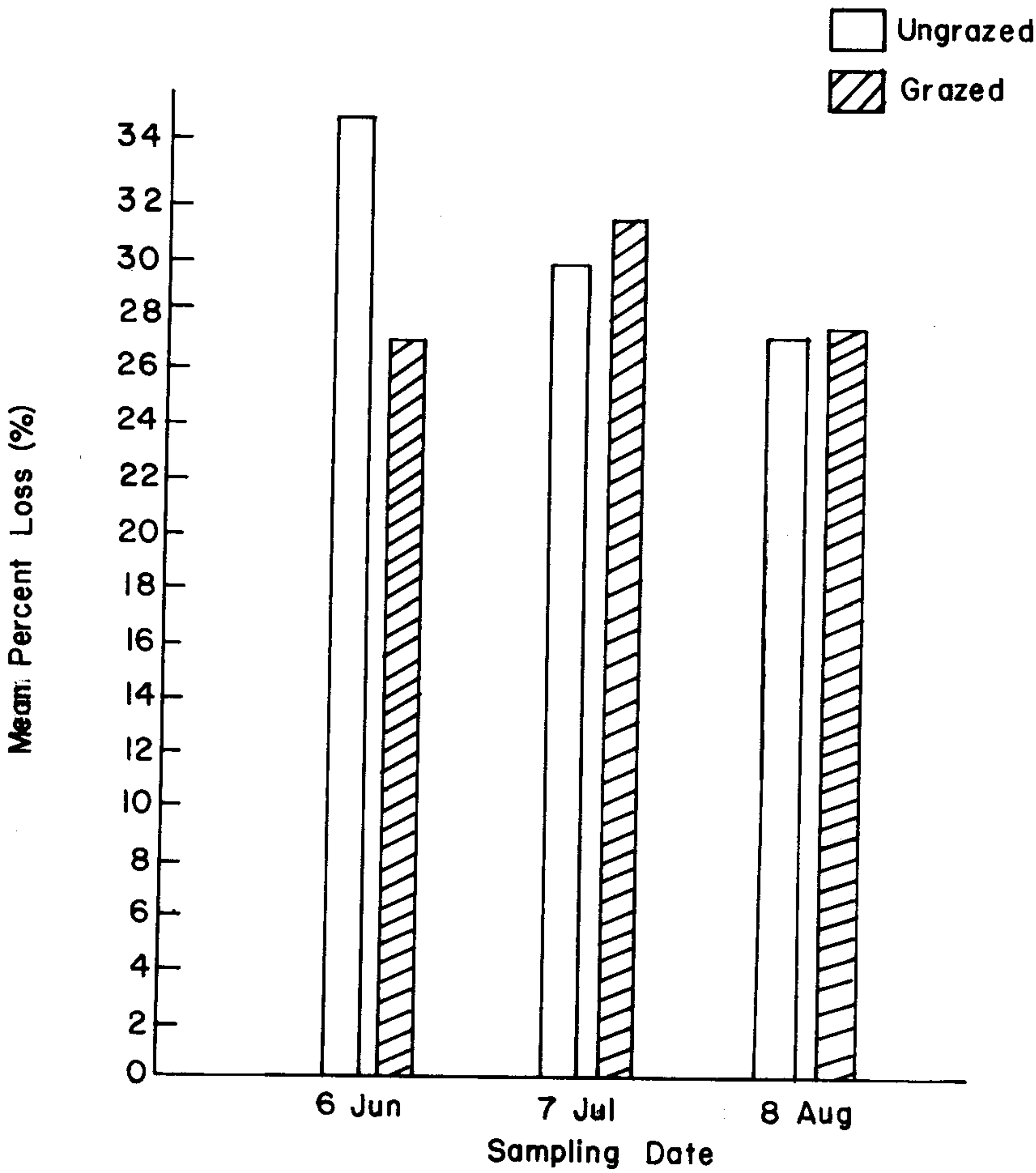

Fig. 6. Buried cellulose decomposition, Osage, 1972.

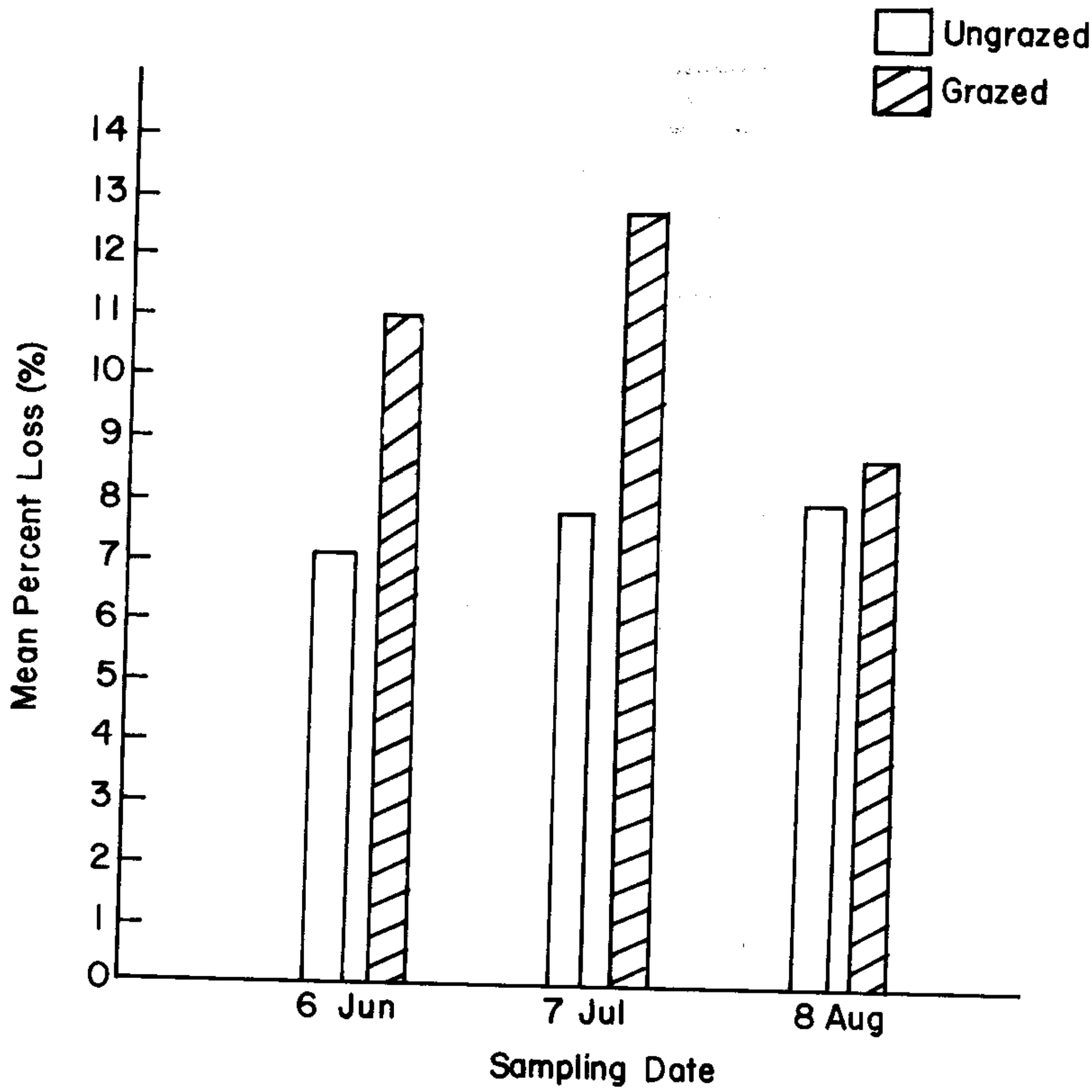

Fig. 7. Buried litter decomposition, Osage, 1972.

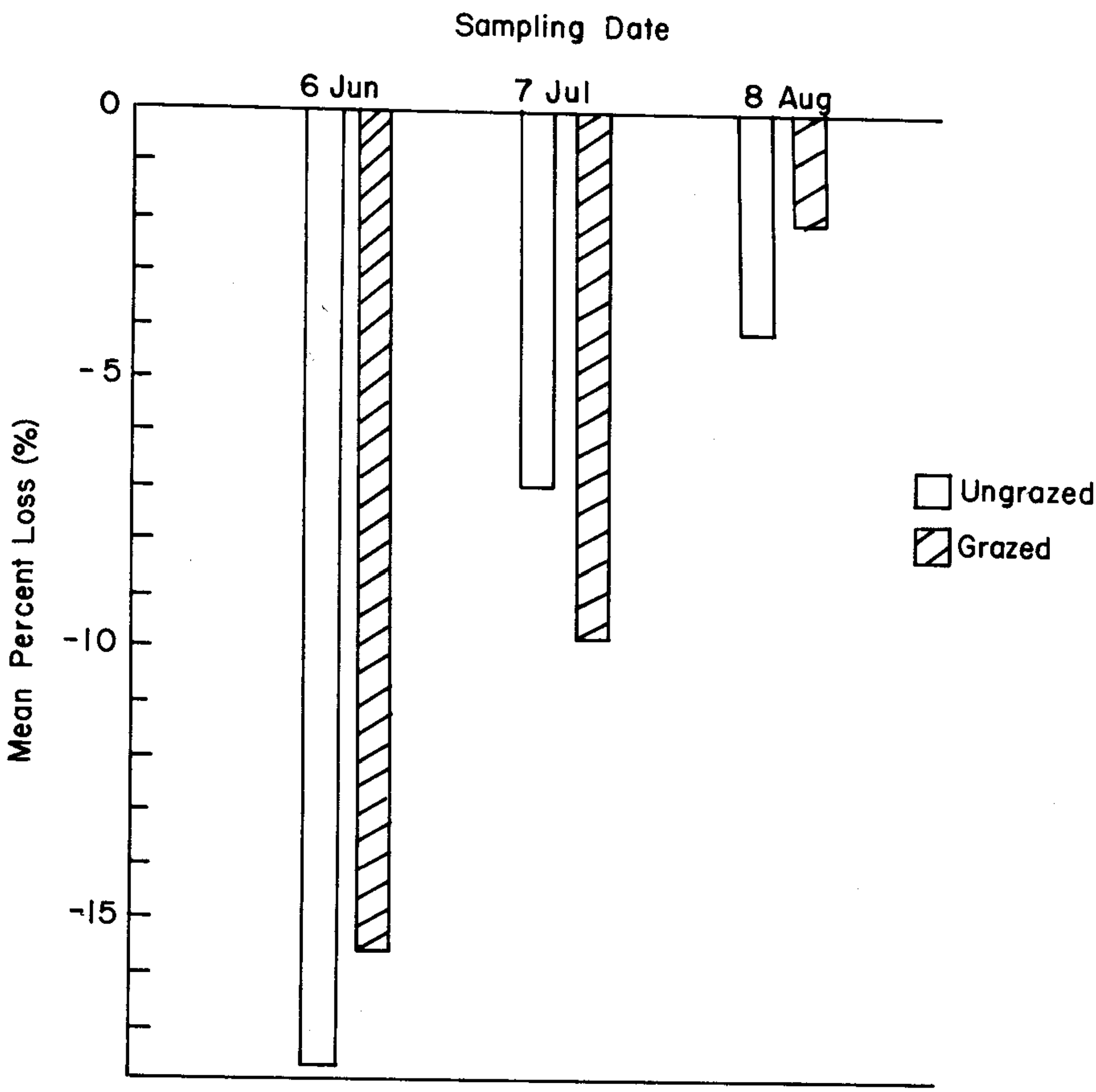

Fig. 8. Root decomposition, Osage, 1972.

PART II

AN EVALUATION OF THE EFFECT OF SOIL WATER AND TEMPERATURE ON CO_2 EVOLUTION

CARBON DIOXIDE EVOLUTION IN THE UNGRAZED AND GRAZED TREATMENTS

Carbon dioxide evolution experiments at the Osage were designed to detect any differences in rates of CO_2 evolution in the ungrazed and grazed treatments. Each treatment was composed of two replicates. On all but one date where a statistical test was possible, the grazed treatment demonstrated a significantly higher rate of CO_2 evolution (t test, $p \leq 0.1$). There were no significant differences for CO_2 evolution (Table 4) between the two replicates in each treatment. The rates from the grazed treatment were more variable throughout most of the season (Table 5).

CORRELATION BETWEEN CO_2, TEMPERATURE, AND SOIL WATER IN THE UNGRAZED AND GRAZED TREATMENTS

We have reported that CO_2 evolution seemed to be more highly correlated with temperature than with soil water at the Osage, and a closer look at our 1972 data supports this opinion. Table 2 contains a revised summary of CO_2 evolution, temperature, and soil water for each treatment. Table 6 summarizes the correlation for these parameters in each treatment. Correlation between temperature and CO_2 evolution was significant in both treatments at the 0.05 level. Correlation between the other parameters was not significant. The dynamics between CO_2 evolution and temperature follows a second degree polynomial regression curve (Fig. 9). The correlation of the curve to the data and the equations are shown on the graph.

Table 4. Carbon dioxide (g/24 hr/m^2) and temperature (°C) for replicates 1 and 2 in each treatment. Simple correlation between CO_2 and temperature shown for each replicate.

Temperature	CO_2 1	CO_2 2
	Ungrazed	
14.0	6.04	5.52
15.0	3.52	5.35
17.5	11.92	11.85
18.5	10.06	8.58
19.8	14.00	13.62
19.3	15.30	15.10
9.0	3.60	4.06
r	0.86	0.85
	Grazed	
16.0	11.49	10.75
17.5	11.56	8.46
20.5	11.79	10.95
19.7	9.75	--
22.3	16.79	21.20
22.5	24.58	--
9.0	4.30	4.12
r	0.79	0.83

Table 5. Coefficient of variation for CO_2 evolution in the ungrazed and grazed treatments, Osage Site.

Date	Ungrazed	Grazed
April 4	21.53	24.98
May 16	59.91	44.66
June 6	14.38	32.89
July 4	17.34	27.08
August 8	11.51	28.37
September 2	28.34	5.80

Table 6. Simple correlation for data from 1972 growing season. Upper right shows grazed, lower left ungrazed.

Grazed

	Temp	H_2O	CO_2
Temp		−0.37	0.80
H_2O	−0.30		−0.08
CO_2	0.86	−0.43	

Ungrazed

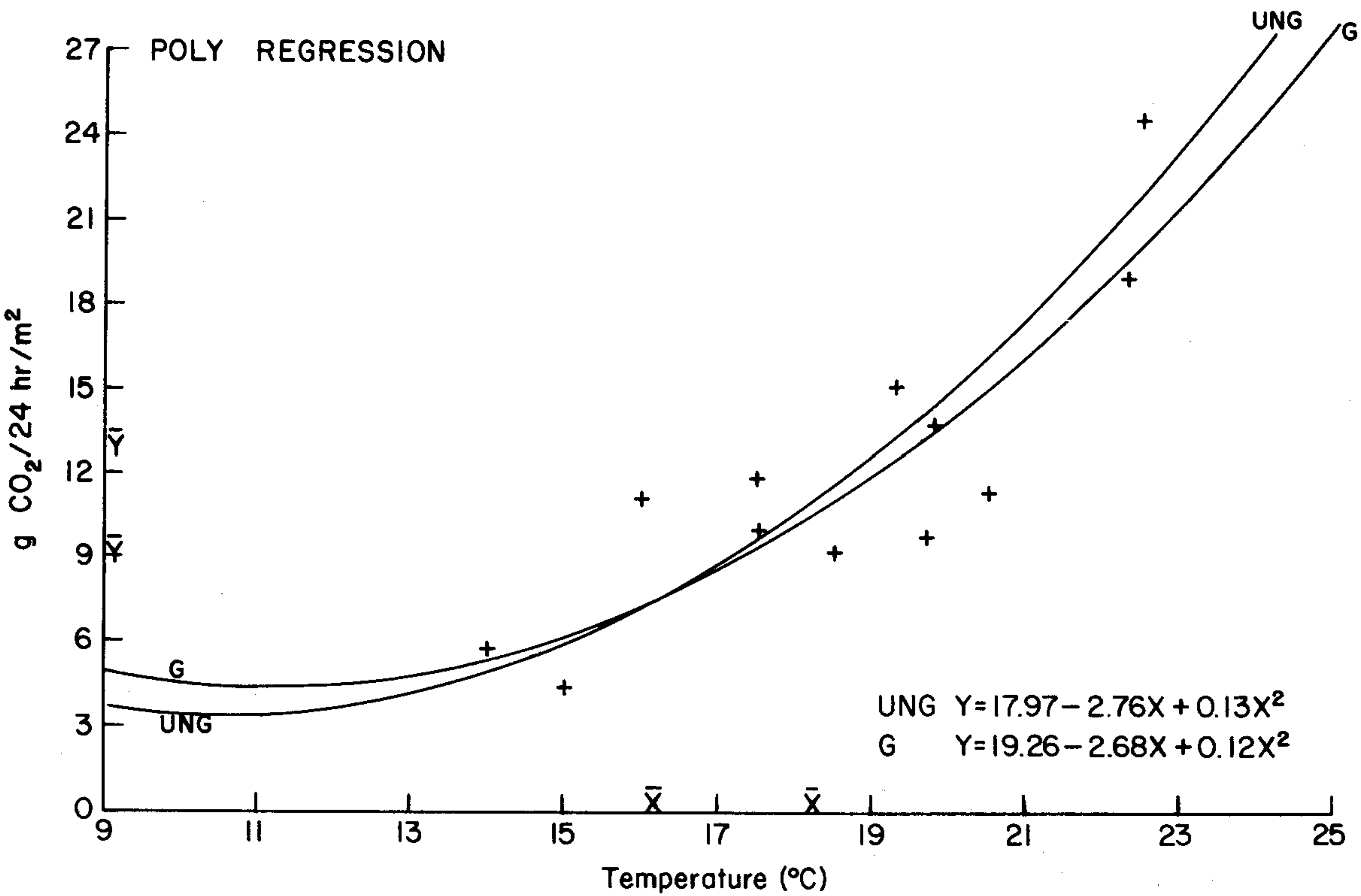

Fig. 9. CO_2 evolution vs. temperature for ungrazed and grazed treatments. Correlation of graph to data: R^2 = 0.86, ungrazed; R^2 = 0.77, grazed.

When CO_2 evolution, temperature, and soil water were submitted to a multiple linear regression with two independent variables ($Z = A_0 + A_1X + A_2Y$), 77% of the variance of CO_2 evolution was accounted for by the data in the ungrazed treatment and 70% in the grazed treatment. When $Z = CO_2$, $X = HOH$, and $Y = °C$, the equation for the ungrazed treatment is $Z = -3.12 - 0.13X + 0.98Y$ and the equation for the grazed treatment is $Z = -16.74 + 0.26X + 1.29Y$.

CORRELATION BETWEEN CO_2 AND TEMPERATURE BETWEEN REPLICATES IN EACH TREATMENT

Table 4 shows the data for each replicate and the simple correlation between CO_2 and temperature. In all cases the correlation is significant to the 0.05 level.

Fig. 10 and 11 show second degree polynominal regression curves for the ungrazed and grazed replicates respectively. Correlation between the data and the curve as well as the equation for each regression are shown on each graph.

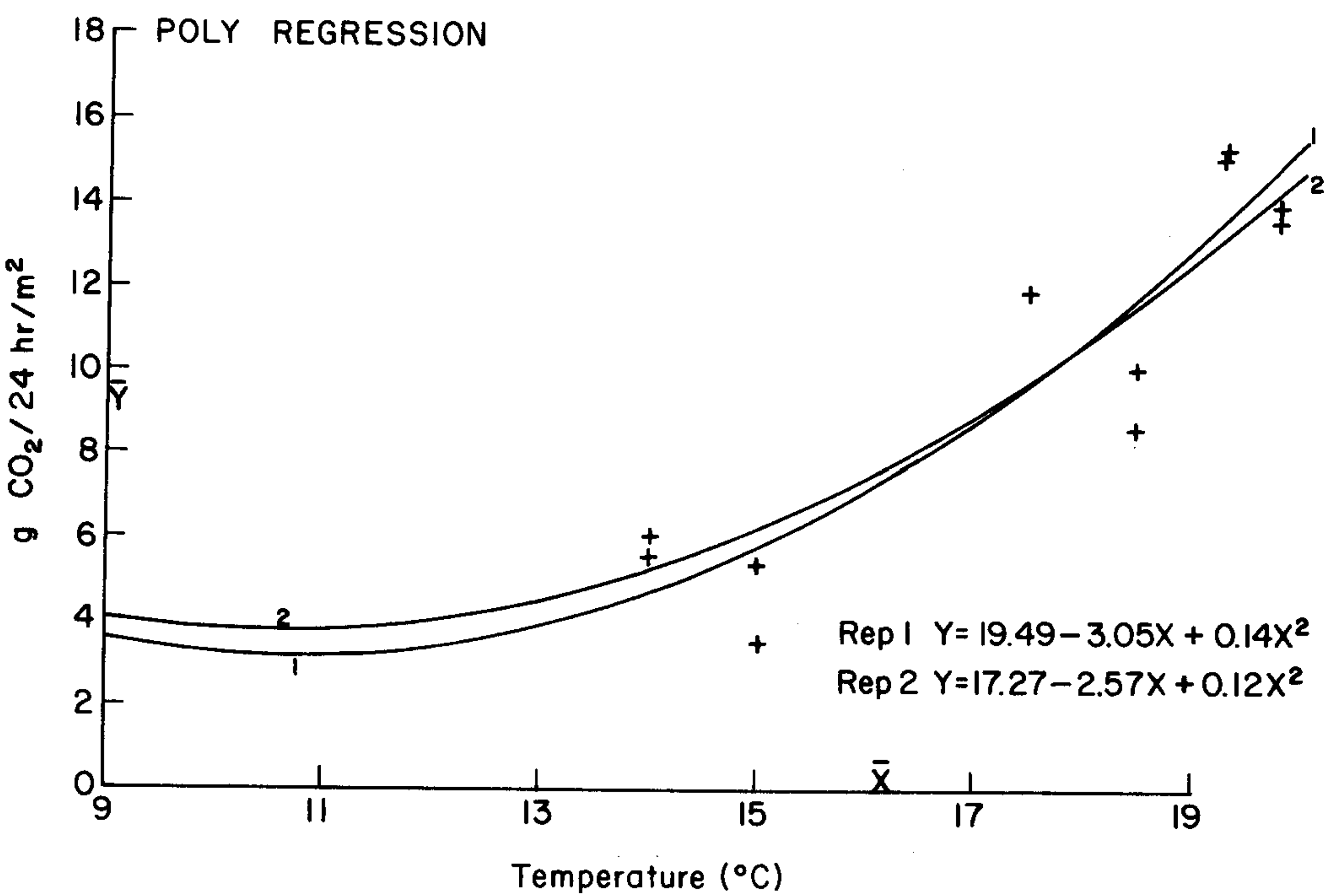

Fig. 10. CO_2 evolution vs. temperature for replicates 1 and 2 in the ungrazed treatment. Correlation (R^2) of graph to data: replicate 1 = 0.87, replicate 2 = 0.84.

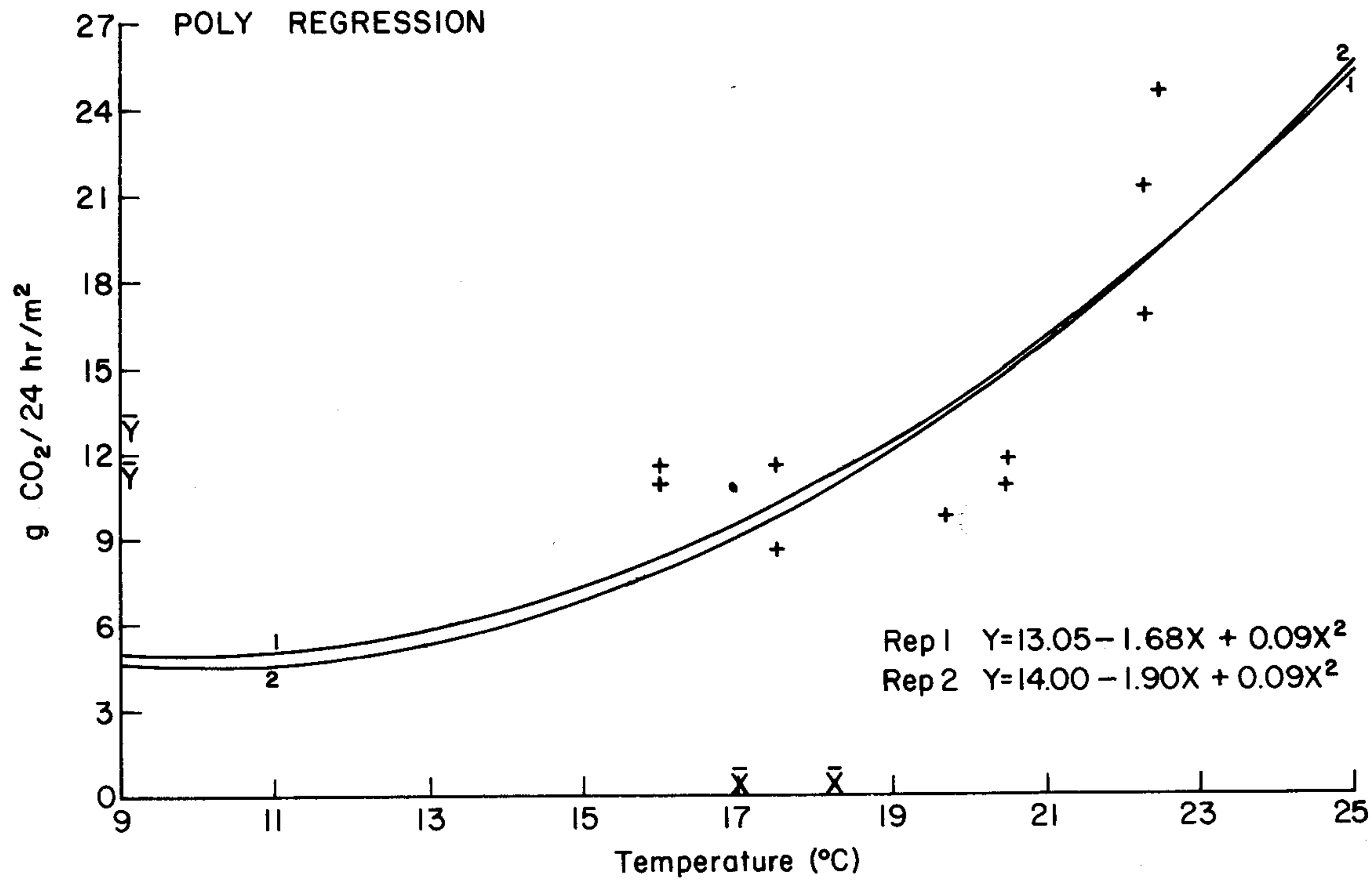

Fig. 11. CO_2 evolution vs. temperature for replicates 1 and 2 in the grazed treatment. Correlation (R^2) of graph to data: replicate 1 = 0.71, replicate 2 = 0.79.

SUMMARY

1. Carbon dioxide evolution at the Osage showed a difference between the ungrazed and grazed treatments significant at the 0.1 level. Replicate differences within each treatment were not significant.

2. Carbon dioxide evolution is more variable in the grazed treatment than in the ungrazed.

3. Soil temperature is more important than soil water in the prediction of decomposition rate at the Osage Site.

4. The dynamics for CO_2 evolution at the Osage follows a second degree regression curve suggesting the hypothesis that within the limits of soil water in the 1972 growing season, CO_2 evolution increased as soil temperature increased.

LITERATURE CITED

Swift, D. M., and N. R. French [Coordinators]. 1972. Basic field data collection procedures for the Grassland Biome 1972 season. U.S. IBP Grassland Biome Tech. Rep. No. 145. Colorado State Univ., Fort Collins. 86 p.

APPENDIX I

FIELD DATA

Microbial Decomposition Data

The microbial decomposition data were collected at the Osage Site on form NREL-4D in 1972. The IBP designation for this data set is A2U4009. Examples of the form and the data collected at the Osage Site follow.

IBP

GRASSLAND BIOME

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FIELD DATA SHEET--MICROBIOLOGY - DECOMPOSITION

Data Type	Site	Initials	Date			Treatment	Replicate	Material	Percent O.M.	Location	Depth	Date Set Out			Number Days	Weight Original	Weight Retrieval	Weight Ignition	Soil Weight	Soil, Ignition
			Day	Month	Year							Day	Month	Year						
1-2	3-4	5-7	8-9	10-11	12-13	14	15	17	19-22	24	26-27	29-30	31-32	33-34	36-38	40-44	46-50	52-56	58-62	64-68
40																				

Data Type
40 Microbiology - decomposition

Site
01 ALE
02 Bison
03 Bridger
04 Cottonwood
05 Dickinson
06 Hays
07 San Joaquin
08 Jornada
09 Osage
10 Pantex
11 Pawnee
12

Treatment
1 Ungrazed
2 Lightly grazed
3 Moderately grazed
4 Heavily grazed
5 Ungrazed current year only
6
7
8
9

Sample Material
1 Cellulose
2 Native litter
3 Native roots

Location
1 Aboveground
2 Belowground

EXAMPLE OF DATA

```
               1         2         3         4         5         6
      1234567890123456789012345678901234567890123456789012345678901234567889

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4D09SWM06067252	1	1.00	2	05	220472	044	3.0	2.1	0.454	9.04	8.19
4D09SWM06067252	1	1.00	2	05	220472	044	3.0	3.2	0.864	9.04	8.19
4D09SWM06067252	1	1.00	2	05	220472	044	3.0	2.7	0.707	9.04	8.19
4D09SWM06067252	1	1.00	2	05	220472	044	3.0	2.1	0.435	9.04	8.19
4D09SWM06067251	2	.773	2	05	220472	044	5.0	4.8	1.791	5.40	5.15
4D09SWM06067251	2	.773	2	05	220472	044	5.0	4.5	1.224	5.40	5.15
4D09SWM06067251	2	.773	2	05	220472	044	5.0	4.3	1.103	5.40	5.15
4D09SWM06067251	2	.773	2	05	220472	044	5.0	3.9	0.906	5.40	5.15
4D09SWM06067251	2	.773	2	05	220472	044	5.0	4.6	1.457	5.40	5.15
4D09SWM06067252	2	.773	2	05	220472	044	5.0	4.2	1.121	9.04	8.19
4D09SWM06067252	2	.773	2	05	220472	044	5.0	4.4	1.040	9.04	8.19
4D09SWM06067252	2	.773	2	05	220472	044	5.0	4.7	1.266	9.04	8.19
4D09SWM06067252	2	.773	2	05	220472	044	5.0	4.8	1.319	9.04	8.19
4D09SWM06067252	2	.773	2	05	220472	044	5.0	4.7	1.320	9.04	8.19
4D09SWM06067251	3	.641	2	05	220472	044	5.0	4.5	0.455	5.40	5.15
4D09SWM06067251	3	.641	2	05	220472	044	5.0	4.6	0.823	5.40	5.15
4D09SWM06067251	3	.641	2	05	220472	044	5.0	4.5	0.443	5.40	5.15
4D09SWM06067251	3	.641	2	05	220472	044	5.0	4.3	0.501	5.40	5.15
4D09SWM06067251	3	.641	2	05	220472	044	5.0	4.3	0.474	5.40	5.15
4D09SWM06067252	3	.641	2	05	220472	044	5.0	4.8	0.838	9.04	8.19
4D09SWM06067252	3	.641	2	05	220472	044	5.0	5.2	1.005	9.04	8.19
4D09SWM06067252	3	.641	2	05	220472	044	5.0	4.6	0.503	9.04	8.19
4D09SWM06067252	3	.641	2	05	220472	044	5.0	4.5	0.802	9.04	8.19
4D09SWM06067252	3	.641	2	05	220472	044	5.0	4.5	0.453	9.04	8.19

CO_2 Evolution Data

The CO_2 evolution data were collected at the Osage Site on form NREL-4E for the year of 1972. The IBP designation for this data set is A2U4049. Examples of the form and data collected at the Osage Site follow.

IBP

GRASSLAND BIOME

U.S. INTERNATIONAL BIOLOGICAL PROGRAM

FIELD DATA SHEET--MICROBIOLOGY - CO_2 EVOLUTION

Data Type	Site	Initials	Date			Treatment	Replicate	Cylinder Area	Soil Temperature	Soil Water	Experimental	Hours CO_2 Trapped	Molarity HCl	Mean of Blanks	ml HCl	B-E	Mg CO_2	Mg CO_2/24 hr	g CO_2/24 hr/m^2
			Day	Month	Year														
1-2	3-4	5-7	8-9	10-11	12-13	14	15	17-19	20-23	25-28	30	32-35	37-41	43-47	49-53	55-59	61-65	67-71	73-77
4E																			

Data Type
4E CO_2 evolution

Site
01 ALE
02 Bison
03 Bridger
04 Cottonwood
05 Dickinson
06 Hays
07 San Joaquin
08 Jornada
09 Osage
10 Pantex
11 Pawnee
12

Treatment
1 Ungrazed
2 Lightly grazed
3 Moderately grazed
4 Heavily grazed
5 Ungrazed current year only
A Diet light
B Diet moderate
C Diet heavy
D ESA - O
E ESA - W
F ESA - N
G ESA - WN

Experimental
1 Experimental cylinder
2 Blank cylinder

****EXAMPLE OF DATA****

```
         1         2         3         4         5
123456789012345678901234567890123456789012345678901234567890

4E09SWM0606721178.517.519.05 1   22  1.08  8.79  4.50
4E09SWM0606721178.517.519.05 1   22  1.08  8.79  4.70
4E09SWM0606721178.517.519.05 1   22  1.08  8.79  4.75
4E09SWM0606721178.517.519.05 1   22  1.08  8.79  5.50
4E09SWM0606721178.517.519.05 1   22  1.08  8.79  5.75
4E09SWM0606721178.517.519.05 1   22  1.08  8.79  5.60
4E09SWM0606721178.517.519.05 1   22  1.08  8.79  4.85
4E09SWM0606721178.517.519.05 1   22  1.08  8.79  5.80
4E09SWM0606721278.517.519.05 1   22  1.08  8.79  5.50
4E09SWM0606721278.517.519.05 1   22  1.08  8.79  5.40
4E09SWM0606721278.517.519.05 1   22  1.08  8.79  5.35
4E09SWM0606721278.517.519.05 1   22  1.08  8.79  5.65
4E09SWM0606721278.517.519.05 1   22  1.08  8.79  4.70
4E09SWM0606721278.517.519.05 1   22  1.08  8.79  5.50
4E09SWM0606721278.517.519.05 1   22  1.08  8.79  4.30
4E09SWM0606725178.520.512.97 1   22  1.08  8.57  5.35
4E09SWM0606725178.520.512.97 1   22  1.08  8.57  6.35
4E09SWM0606725178.520.512.97 1   22  1.08  8.57  5.50
4E09SWM0606725178.520.512.97 1   22  1.08  8.57  4.75
4E09SWM0606725178.520.512.97 1   22  1.08  8.57  2.50
4E09SWM0606725178.520.512.97 1   22  1.08  8.57  4.75
4E09SWM0606725178.520.512.97 1   22  1.08  8.57  5.80
4E09SWM0606725278.520.511.17 1   22  1.08  8.83  5.90
4E09SWM0606725278.520.511.17 1   22  1.08  8.83  5.45
4E09SWM0606725278.520.511.17 1   22  1.08  8.83  5.75
4E09SWM0606725278.520.511.17 1   22  1.08  8.83  6.80
4E09SWM0606725278.520.511.17 1   22  1.08  8.83  3.45
4E09SWM0606725278.520.511.17 1   22  1.08  8.83  5.80
4E09SWM0606725278.520.511.17 1   22  1.08  8.83  5.45
```