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Distribution of Microorganisms in Desert Soil

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DISTRIBUTION OF MICROORGANISMS IN DESERT SOIL

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ABSTRACT

Population estimates of fungi, bacteria and actinomycetes in desert soil were determined with respect to soil depth and distance to shrubs. In general, the highest number of microbes was found at the shrub base and the lowest number in the interspaces.

INTRODUCTION

The numbers and activities of soil microflora are important in desert soils in the processes of root and litter decomposition, and for the timing and release of nutrients tied up in organic matter. For this study, we are determining microbial populations of the major groups of fungi and bacteria from soil samples during the middle of the plant growing season, March-April 1973.

These soil samples are aliquots of those used in other studies of below-ground activity for root biomass and ATP activity (Bamberg et al. 1974), soil invertebrates (Edney et al. 1974) and soil nematodes (Freckman et al. 1974) at the Rock Valley Validation Site, Nye County, Nevada (Turner and McBrayer 1974).

OBJECTIVE

To relate microbial populations to root biomass.

METHODS

Soil samples were collected around the shrub species, *Lycium andersonii*, from nine locations. The soil was collected from three depths (0-10, 10-20, 20-30 cm) at each of three distances from the shrub: the shrub base (samples 1, 2 and 3, starting at the surface); at the canopy edge or one shrub radius (samples 4, 5 and 6); and in the shrub interspace or three canopy radii from the plant base (samples 7, 8 and 9).

Soil microbial populations were determined by dilution plate count method for soil collected during weeks 12, 13, 15 and 16 of 1973 (between March 18 and April 19). A soil solution was obtained by the addition of 100 g of sterile, distilled water to 20 g of oven-dry soil. Quintuplicate samples of serial dilutions of 1:500, 1:5,000 and 1:500,000 were plated to enumerate and differentiate the fungi and bacteria in the above soil samples. The molds were counted after 2 days of incubation on Cooke's rose bengal agar (Difco) which contained 35 μ g Aureomycin/ml; bacterial counts were made after 14 days on sodium albuminate agar. All plates were incubated at room temperature. Commonly found soil fungi, as well as *Streptomyces*, were differentiated and their percentages of occurrence reported. Microbial population data are stored in the Data Bank under DSCODE A3UBD30.

Soil pH was determined using a 1:5 soil solution. Soil moisture percentage was calculated after the soil was oven-dried at 105-110 C for 24 hr. Total numbers of organisms per gram of oven-dry soil are calculated according to the method of Clark (1965).

RESULTS

Soil microbial populations, pH, temperature and moisture are presented in Tables 1-4 for samples collected between weeks 12 and 16 of 1973 from Rock Valley. Results are summarized according to location.

Shrub Base

At the plant base the mold numbers in the top 20 cm almost doubled from 25,000 to 50,000/g DW soil before dropping in week 16. As the spring progressed, the number of molds decreased at the 20-30 cm level from 30,800 to 16,800/g DW soil. *Penicillium* was the dominant fungal genus underneath the shrub throughout the 5-week period. *Aspergillus* was moderately abundant in early spring but its importance dropped off during weeks 15 and 16.

Populations of bacteria and actinomycetes were much higher than those of the fungi. In April, the numbers of bacteria-actinomycetes decreased by 50%. *Streptomyces* increased its dominance under the shrub from 50 to 80% even though actual numbers declined. Bacterial population size did not seem to be related to sample depth.

Canopy Edge

Soil from the canopy edge (locations 4, 5 and 6) yielded mold populations which remained relatively constant in size until week 16. At this time, a decrease occurred at the 0-10 and 10-20 cm levels. Mold numbers from location 6 (20-30 cm), while lower than from shallower soils, did not change radically during the spring. *Penicillium* remained dominant, but the importance of *Aspergillus* increased compared to the shrub base.

Bacteria-actinomycetes numbers were lower at the canopy edge than underneath the shrub. Population size and species dominance trends of the bacteria followed those found at the plant base.

Interspaces

The lowest total number of molds was found in the shrub interspace. Mold densities in April were highest at the 0-10 cm level. In the shrub interspaces, *Aspergillus* replaced *Penicillium* as the dominant genus.

At three canopy radii from the shrub base, the populations of bacteria and actinomycetes were slightly lower than those at the canopy edge. With the exception of week 13, there was little difference in population size with time or depth. *Streptomyces* continued its strong dominant role.

Soil Characteristics

Soil pH did not vary with either time or location. Temperatures, which were taken in the morning, showed

little variation in relation to sample location. But values for April averaged 5-6 C higher than those from March.

At the shrub base and the canopy edge, soil moisture dropped from about 15% during weeks 12 and 13 to about 5% during weeks 15 and 16. With the exception of week 13, little change in soil moisture was noticed with time at the interspace locations. The high moisture levels for week 13 were the result of 25 mm of rain which fell during the period between the first and second sampling dates. In the interspace, moisture content was nearly similar at week 12 and slightly higher at week 16 than in the other locations.

Shrub Characteristics

In general, root biomass under *Lycium andersonii* increased during the study, although there was considerable fluctuation (Table 5). Most of the roots were found under the shrub and the least in the interspaces. Root biomass usually decreased with depth. Flowering and continued growth occurred during this period, and fruit formation started at the end of the sampling period.

Table 1. Microbial populations of the soil under *Lycium andersonii* (March 18, 1973, week 12)

	SOIL			MOLDS				BACTERIA AND ACTINOMYCETES	
Sample location	Moisture %	Temp °C	pH	Organisms/g DW soil X 10^3	Aspergillus %	Penicillium %	Others %	Organisms/g DW soil X 10^6	Streptomyces %
1	15	8.5	8.9	25.5	13	17	70	8.6	60
2	15	9.0	9.3	24.9	15	54	31	16.6	44
3	16	9.5	9.5	30.8	4	93	3	14.6	46
4	14	9.0	9.0	23.0	10	23	67	7.2	63
5	15	9.0	9.3	24.5	42	48	10	13.0	51
6	15	9.5	9.2	8.5	12	40	48	6.8	80
7	9	10.0	9.0	9.9	62	6	32	2.9	67
8	10	9.0	9.1	13.1	61	21	18	4.3	68
9	13	8.5	9.0	3.9	10	13	77	3.7	91

Table 2. Microbial populations of the soil under *Lycium andersonii* (March 29, 1973, week 13)

	SOIL			MOLDS				BACTERIA AND ACTINOMYCETES	
Sample location	Moisture %	Temp °C	pH	Organisms/g DW soil X 10^3	Aspergillus %	Penicillium %	Others %	Organisms/g DW soil X 10^6	Streptomyces %
1	14	8.5	8.6	41.4	27	35	38	15.5	47
2	16	9.0	8.9	22.4	13	50	38	14.7	63
3	17	10.0	8.9	26.1	8	32	60	9.9	79
4	16	9.0	8.8	9.3	27	21	52	8.8	61
5	19	9.0	8.9	23.0	17	60	23	9.3	76
6	17	10.0	9.0	9.8	16	16	68	9.7	77
7	17	10.0	8.9	3.8	47	-	53	7.7	70
8	19	9.0	9.1	3.4	71	15	14	10.0	72
9	17	9.0	9.1	9.2	1	7	92	8.3	80

Table 3. Microbial populations of the soil under *Lycium andersonii* (April 12, 1973, week 15)

	SOIL			MOLDS				BACTERIA AND ACTINOMYCETES	
Sample location	Moisture %	Temp °C	pH	Organisms/g DW soil X 10^3	Aspergillus %	Penicillium %	Others %	Organisms/g DW soil X 10^6	Streptomyces %
1	5.0	18.0	8.9	44.7	2	71	27	4.5	87
2	5.9	16.5	9.1	50.3	3	72	25	6.5	74
3	5.5	16.0	9.3	16.3	3	58	37	2.3	80
4	5.0	17.0	8.9	20.1	4	50	46	4.7	75
5	6.4	15.0	9.1	23.5	4	50	46	3.9	76
6	6.4	15.0	9.3	12.3	2	29	59	3.7	69
7	6.8	24.0	8.9	13.2	78	14	9	5.4	66
8	7.3	18.0	8.9	9.0	57	19	24	3.7	71
9	7.3	16.0	9.1	5.2	64	29	7	3.8	65

Table 4. Microbial populations of the soil under *Lycium andersonii* (April 19, 1973, week 16)

	SOIL			MOLDS				BACTERIA AND ACTINOMYCETES	
Sample location	Moisture %	Temp °C	pH	Organisms/g DW soil X 10^3	Aspergillus %	Penicillium %	Others %	Organisms/g DW soil X 10^6	Streptomyces %
1	4.6	14.5	8.8	39.8	1	73	26	5.2	70
2	5.5	12.5	9.1	27.8	6	25	69	8.3	76
3	4.6	13.0	9.1	16.8	21	36	43	6.9	85
4	5.3	13.0	9.0	18.3	8	44	48	3.7	81
5	5.0	12.0	9.1	15.1	9	75	90	4.3	77
6	7.3	13.0	9.1	10.3	22	56	22	4.5	85
7	6.9	16.0	8.9	7.3	71	3	26	3.4	49
8	9.6	15.0	9.0	3.6	39	6	55	3.0	84
9	12.6	13.0	8.9	4.7	19	4	77	2.7	78

Table 5. Root biomass (g DW/liter soil) in relation to sample location under *Lycium andersonii* in Rock Valley, 1973 (A3UBD22)

		Sample Location								
Date	Week #	1	2	3	4	5	6	7	8	9
March 18	12	[a]4.4	2.5	1.3	1.0	5.7	0.5	<0.1	<0.1	<0.1
		[b]1.1	0.4	1.5	0.1	0.6	1.2	0.3	0.5	0.3
March 29	13	0.4	7.7	0.4	3.8	0.4	0.4	<0.1	<0.1	<0.1
		1.0	1.2	1.1	2.2	1.2	2.2	0.2	<0.1	<0.3
April 12	15	1.6	0.8	2.5	0.7	0.5	0.1	0.6	0.2	0.1
		2.3	1.3	0.4	1.8	1.1	0.3	0.8	0.3	0.2
April 19	16	8.4	4.3	7.8	0.4	0.4	4.3	<0.1	0.1	1.4
		6.5	4.5	2.5	1.3	0.7	0.9	0.2	0.2	0.5

[a]Large and medium roots (diameter >2 mm).

[b]Fine roots (0.5 mm < diameter < 2 mm).

DISCUSSION

Generally both root biomass and total number of microbes were highest at the shrub base. This relationship indicates that the soil microflora utilize the roots or root exudates as a substrate (Starkey 1958; Clark 1967). It must be pointed out, however, that other types of organic matter, e.g., litter, in the soil show similar trends (Bamberg et al. 1974).

Mold populations remained stable or increased as the season progressed. Bacteria, however, decreased with time. These changes in the microbial community are probably related to soil moisture. In April, soil water potentials reached about —25 bars in Rock Valley. Bacterial activity is known to decline rapidly when the soil water potential drops below —5 bars, while many fungi and actinomycetes can tolerate much lower water potentials (Griffin 1972). Increases in streptomycetes and molds may be partially attributable to reduced competition by bacteria. The percentage of *Streptomyces* increased in April which may indicate the beginning of a more active decomposition role assumed by this group. This increase is particularly evident at the shrub base and canopy edge.

Penicillium was the dominant mold genus close to the plant, but *Aspergillus* also was common in the warmer surface soils and was dominant in the drier interspace zone. These findings agree with Peyronel (1956, in Griffin 1972) who reported that *Aspergillus* was a more xerothermic genus than *Penicillium*.

As mentioned previously, roots, root exudates and other substrate matter influence the soil microflora. Mold populations were found to decline in deeper soil, while *Streptomyces* dominance increased with soil depth. These differences may have resulted because the availability of preferred nutrient sources varied with soil depth. Most of the roots were located in the upper 20 cm of the soil. Siu (1951) reported that actinomycetes were generally poor cellulose utilizers, while fungi were highly cellulolytic. Distribution differences between molds and actinomycetes may also be due in part to different dispersal mechanisms.

Alexander (1971) states that the prevailing conditions in a habitat will dictate that only one, or a few, of the indigenous species actually will exploit an energy source. That seasonal variation in the soil environment will cause a shift in the relative numbers of various microbial populations is seen by the higher percentage of *Streptomyces* in week 16 over week 12 at the shrub base location. This response corresponds with a decrease in moisture and an increase in temperature during that time interval. The dominance of *Streptomyces* in this study may be attributable to the warm, dry nature of our desert soils.

Throughout the sampling period, mold numbers were much lower than those of the bacteria and actinomycetes. Interspecific relationships are important ecologically in microbial communities. Alexander (1971) pointed out that

Streptomyces species produce antifungal and mycolytic agents which could keep mold populations low.

It must be kept in mind that plate counts alone do not necessarily indicate activity patterns, since an organism, though present, may be dormant or play a small role in microbial processes.

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