Soil moisture patterns below mounds of harvester ants

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Abstract

Harvester ants are a major component of western rangeland. Little is known about ants' role in soil water dynamics. Annual patterns of soil moisture under mounds of the harvester ant (*Pogonomyrmex owyheei,* Cole) were studied in southeastern Idaho. Soil moisture at 20-cm intervals to a depth of 100 cm was estimated monthly with a neutron probe. Between 60 and 100 cm, higher levels of moisture were found below mounds than in control areas. The amount of water added to the soil during spring recharge was greater in control areas at 20 cm but greater under ant mounds at depths below 60 cm. Under ant mounds, approximately 1.3 cm more water was added to the soil between 60 and 100 cm.

Key Words: *Pogonomyrmex owyheei,* Idaho, infiltration, recharge

Harvester ants (*Pogonomyrmex owyheei,* Cole) are common mound builders in Idaho. Mound densities can be in excess of 16 mounds per hectare (Sharp and Barr 1960) and can be a dominant visual component of the range ecosystem (Porter and Jorgensen 1988). Mound-building ants have a long-recognized, active role in soil processes. They contribute significantly to mixing of soils and concentrating of soil minerals (Mandel and Sorenson 1982, Levan and Stone 1983). Ant burrows also increase soil porosity which is thought to enhance water infiltration (Mandel and Sorenson 1982). Rogers and Lavigne (1974) found higher levels of soil moisture below mounds of harvester ants *(P. occidentalis)* in Colorado. However, their samples were only from late summer. Little is known about annual soil moisture patterns under ant mounds, especially during spring recharge.

In northwestern semiarid areas, the majority of water infiltration into the soil occurs during the spring snow melt. If harvester ant burrows do affect water infiltration, they could enhance recharge and contribute to soil water reserves. To clarify the role of harvester ants in soil water movements, I documented the pattern of soil moisture below ant mounds and compared these soil water patterns to patterns in adjacent nonmound areas.

Methods

The study area was on the Idaho National Engineering Laboratory (INEL) site. The INEL is a National Environmental Research Park (NERP) operated by the U.S. Department of Energy and is located 65 km north of Pocatello, Idaho. The site receives an average of 20.6 cm precipitation per year. Vegetation is a mixture of sagebrush (*Artemisia* sp.) and grass. Detailed descriptions of vegetation on the site appear elsewhere (Harniss and West 1973, Anderson and Holte 1981).

Soil moisture the first year of the study was determined gravimetrically. Samples were taken with a veihmeyer tube at 20 and 60 cm depths below ground level under ant hill mounds and at the edge of the anthill clearing. Different anthills were chosen each month for sampling. To reduce the variability from sampling different anthills each month, soil moisture under 5 randomly selected hills was monitored with a neutron probe (Campbell Nuclear Pacific Corp, Pacheco, Calif.) for the remaining 2 years of the study. Aluminum access tubes were placed to a depth of 100 cm directly in the middle of the selected ant mounds (treatment tubes). Control tubes were placed toward the edge of mound clearings an average of 4.1 ± 0.24 m from the mounds. Moisture readings were taken at 20-cm intervals from 20 cm to 100 cm below the soil surface in mound and nonmound areas. Readings were taken once monthly. Estimates from each sample depth were used as representative of moisture levels for the soil profile 10 cm above to 10 cm below the sample depths. All moisture estimates are given in percent by volume.

Samples for soil texture analyses were taken at 30-cm depths in mound and control areas. Soil texture was determined gravimetrically by the hydrometer method described in Day (1965). Bulk density of the soil was calculated from core samples (Blake 1965) taken at 30 and 60 cm depths.

All statistical comparisons were paired t-test designs and the $P = 0.05$ level of significance, one-tailed, was used throughout. All percent data were arcsine transformed for statistical tests. All means are given ± standard errors.

Results

Soil texture of the study area averaged 43.1 ± 4.1% (n = 16) sand, 44.9 ± 3.4% (n = 16) silt, and 11.9 ± 1.2% (n = 16) clay and was classified as a loam. Bulk density did not differ significantly between mound and control areas for either 30 or 60 cm and averaged 1.3 ± 0.02 g/cm^3 (n = 30).

Maximum snow depths for each of the 3 years were 50 cm in 1985, 33 cm in 1986, and 5 cm in 1987. Maximum water contents of the snows equaled 9.4 cm in 1985, 7.1 cm in 1986, and <1.0 cm in 1987.

Figure 1 presents the monthly averages of soil moisture for the different sample depths. At 20 and 40 cm, patterns of moisture were similar between mound and control areas during the summer fall and winter of 1986 and 1987. At 60, 80, and 100 cm, mean water levels under ant mounds were higher in control areas during these times. As moisture patterns seemed similar, these 3 sample intervals were combined into 1 interval extending from 50–110 cm. In a manner similar to Rogers and Lavigne (1974), the mean soil moisture values for 60, 80, and 100 cm were used as 3 estimates of soil moisture for that interval and compared between burrow and control areas (Table 1). The mean soil moisture for the soil profile between 50–110 cm was significantly higher under ant burrows in both summers of the study.

Once infiltration began in the spring, 3 different patterns of recharge became evident. At the 20 cm level, peak recharge levels in non-mound areas were significantly higher than mound areas for all 3 years (1985: $t = 2.56$, $P = 0.03$; 1986: $t = 4.44$, $P = 0.01$; 1987: $t = 3.16$, $P = 0.02$). At the 40 cm level, peak recharge did not differ between the 2 areas (Fig. 1). At 60, 80, and 100 cm depths, mean soil moisture levels were higher under ant mounds than in control areas in 1986 (Fig. 1). Again, mean soil moisture for the 3 sample depths were used as 3 estimates of the soil moisture for the soil profile between 50–110 cm (Table 1). Soil moisture at peak recharge for the sample interval was significantly higher under ant

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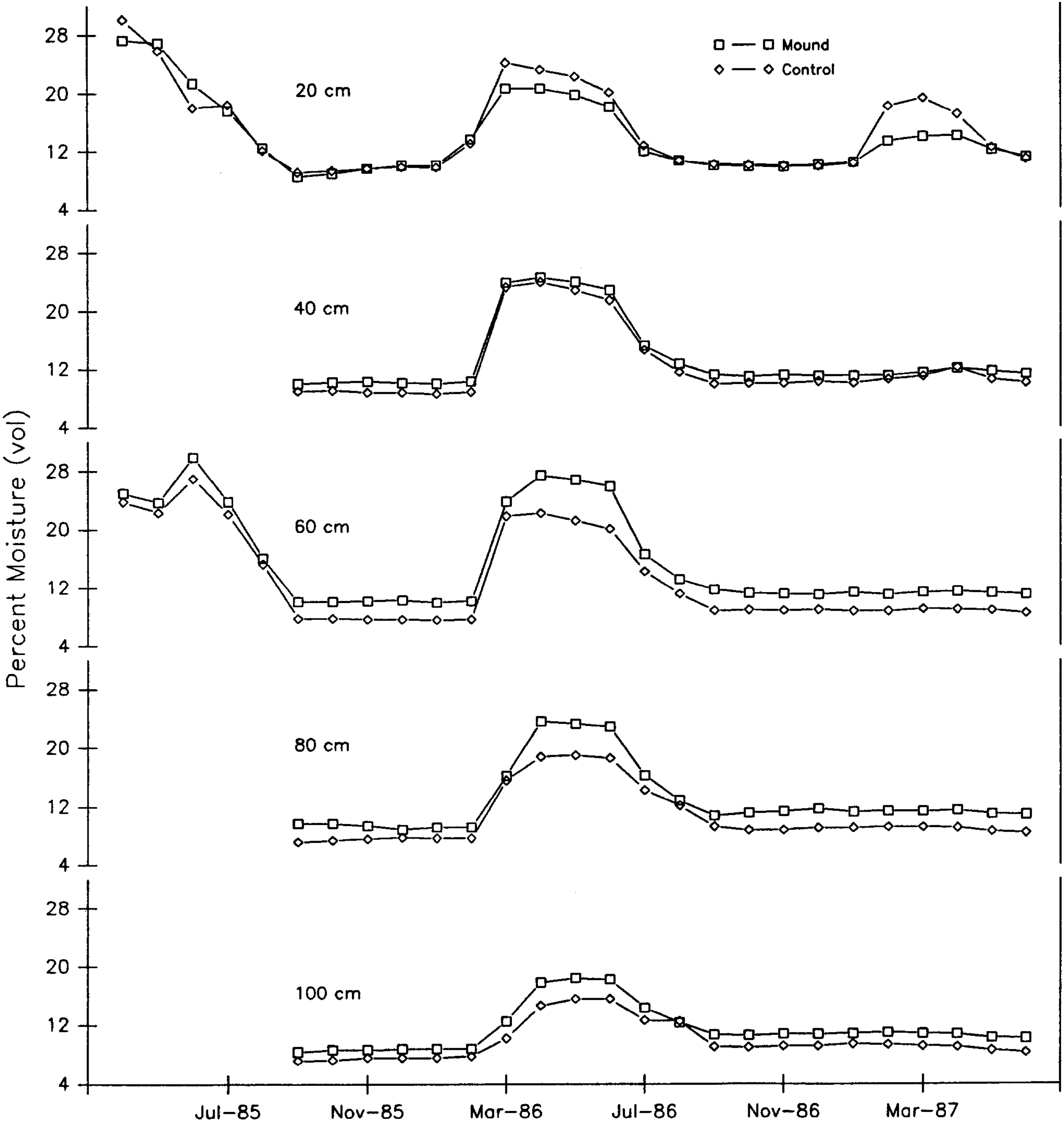

Fig. 1. Monthly soil moisture levels at the 5 sample depths under ant mounds and in control areas. The first 6 estimates for the 20 and 60 cm depths were determined gravimetrically. All the other estimates are based on neutron probe data.

mounds. At the sample depths of 60, 80, and 100 cm, no change in soil moisture was seen in 1987 because there was insufficient snow pack in 1987 for recharge beyond 40 cm. Average soil moisture in the spring of 1985 was higher under ant burrows at 60 cm but the difference was not significant.

Lavigne (1969) found a high number of storage chambers at and below 60 cm in burrows of the harvester ant *P. occidentalis*. The food stores and other organic material in those chambers would be detected by the neutron probe and could result in elevated estimates of soil moisture. If such stores exist for *P. owyheei*, they may account for the difference in average soil moisture between mound and control areas at and below 60 cm at the driest time of the year. This error in estimating soil moisture could bias comparisons of % moisture at peak recharge. To eliminate such bias, I determined the difference in soil moisture between the time of lowest soil moisture (late fall) to the time of peak recharge (early April) for 1986 and 1987. As before, mean differences in soil moisture for 60, 80, and 100 cm sample depths were used as 3 estimates of the soil profile between 50–110 cm. Analysis of the difference in moisture levels did not change the pattern seen (Table 1).

The difference in percent moisture represents the amount water added to the soil from the spring recharge. For 1986 and 1987,

Table 1. Average soil moisture levels, percent by volume, below mound and nonmound (control) areas for 60, 80, and 100 cm depths at end of withdrawal season in 1985 and at peak recharge in 1986. The third column is the average difference in soil moisture between the end of withdrawal season and peak recharge for the 60, 80 and 100 cm depths. All means are ± standard errors.

	Withdrawal		Recharge		Difference	
	Mound	Control	Mound	Control	Mound	Control
60 cm	10.1 ± 1.0	7.8 ± 0.9	27.4 ± 1.6	22.2 ± 2.6	17.3 ± 1.1	14.4 ± 1.7
80 cm	9.7 ± 1.0	7.4 ± 1.5	23.7 ± 3.0	19.1 ± 5.0	14.0 ± 2.4	11.7 ± 3.6
100 cm	8.7 ± 1.8	7.3 ± 1.8	18.3 ± 4.5	15.5 ± 5.0	9.5 ± 2.8	7.8 ± 3.4
Mean	9.5 ± 0.42	7.5 ± 0.15	23.1 ± 2.6	18.9 ± 1.9	13.6 ± 2.3	10.7 ± 1.8
t	6.66		5.82		6.24	
P	0.01		0.01		0.01	

there was 3.0% and 4.8% more water added in the control area at 20 cm than under the ant mounds. Between 50–110 cm in 1986, there was an average of 2.2 + 0.4% (n = 3) more water added under the mounds. This percentage represents 1.3 cm more water added to the soil profile between the 50 and 110 cm depths under ant mounds as compared to control areas.

Discussion

During the summer and fall months of 1986 and 1987, soil moisture estimates 50–110 cm under ant mounds were higher than controls. Based on the work of Lavigne (1969), this difference can likely be attributed to organic material ants store in the high number of tunnels they build in this zone rather than actual differences in soil moisture. Because of this possible bias, comparisons between mound and non-mound areas were based on the difference in soil moisture between pre-recharge low and peak recharge high levels of soil moisture.

Data from the change in percent moisture between low and peak levels indicated that mounds of harvester ants altered water infiltration patterns during spring recharge. MacKay (1981) found that a majority of the burrow complex of *P. montanus* occurred in the top 30 cm of soil. Blom (pers. comm.) has found a similar structure for harvester ants in Idaho. Such burrowing reduces bulk density, changes soil texture (Rogers and Lavigne 1974), and subsequently field capacity. These changes would reduce the amount of water retained under mounds at these depths, allow more water to drain quickly through the upper strata, and result in the lower moisture levels noted at 20 cm in 1985 and 1986. The difference in moisture levels at the 20 cm depth in spring 1987 was likely the result of the low snow pack. In the mound areas, the little snow melt available was absorbed by organic matter in the ant mounds, reducing infiltration to the 20 cm depth as compared to nonmound areas where the snow melt went directly into the soil.

At 40 cm in 1986, sufficient water infiltrated in mound and nonmound areas to attain field capacity, approximately 25% (Foth 1978), for the soil type in the study area. Thus, no difference was seen between mound and nonmound areas at this depth. In 1985, the wettest year of the study, there was sufficient water to inundate the profile to field capacity to 60 cm in mound and mound areas. Unfortunately, no samples were taken deeper than 60 cm during this preliminary year of the study. With less snow pack in 1986, the effect of mounds became evident. At 60 cm, field capacity was attained under mounds but not in control areas and, in general, more water infiltrated to the 50–110 cm depth increment. The increased amount of water under mounds found in this study concurs with the findings of Rogers and Lavigne (1974) who found higher levels of soil moisture below mounds for *P. occidentalis* in northeastern Colorado.

The significance to the ants of the differences in water distribution between mound and control areas is unclear. Possibly the additional water could maintain higher levels of humidity in the burrows during the summer. However during the withdrawal season, the extra water under mounds is removed from the soil and moisture conditions are returned to pre-recharge levels as quickly as control areas.

Wight and Nichols (1966) and Rogers and Lavigne (1974) found increased plant productivity around the perimeter of mound clearings. They attributed this increased growth to water that infiltrates into the soil within the clearing. Presumably plants growing on the edge of mound clearings are extending their root systems into the clearing and depleting the water. Whether the additional water under the mounds would contribute significantly to this productivity is unknown. It was estimated that approximately 1.3 cm of extra water was added to the deep profile under the mound. However, this estimate applies only to the cylinder of soil below the mound, the approximate sampling sphere of the neutron probe. It is unknown how much, if any, water is added beyond that soil volume. If substantial amounts are added, especially in years of moderate precipitation, the extra water reserve may impact biomass production of these peripheral plants. Future work should center on determining the realm of influence ant burrows have on enhancing soil moisture and if such increases significantly affect biomass production.

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