Dictyostelid cellular slime moulds in agricultural soils

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The distribution and occurrence of dictyostelid cellular slime moulds (dictyostelids) in agricultural soils was investigated in two plots (one with tilled soil and the other with untilled soil) on the Arkansas Agricultural Research and Extension Center at Fayetteville in northwestern Arkansas. Both the percentage of samples yielding dictyostelids and the number of colonies per gram of wet soil were higher in the plot with untilled soil. Just two species of dictyostelids (*Dictyostelium giganteum* and *D. sphaerocephalum*) were recovered from the two plots. Only *D. sphaerocephalum*, a species often associated with disturbed soils, was present in the plot with tilled soil. Both species were present in the plot with untilled soil, but *D. giganteum* was much more abundant and represented 84% of all colonies recovered from this plot.

Key words – Arkansas – biomonitors – *Dictyostelium* – ecology – microorganisms

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Introduction

Dictyostelid cellular slime moulds (dictyostelids) are single-celled, eukaryotic, phagotrophic bacterivores usually present and often abundant in terrestrial ecosystems. These organisms represent a normal component of the microflora in soils and apparently play a role in maintaining the natural balance that exists between bacteria and other microorganisms in the soil environment. For most of their life cycle, dictyostelids exist as independent, amoeboid cells (myxamoebae) that feed upon bacteria, grow, and multiply by binary fission. When the available food supply within a given microsite becomes depleted, numerous myxamoebae aggregate to form a structure called a pseudoplasmodium, within which each cell maintains its individual integrity. The pseudoplasmodium then produces one or more fruiting bodies (sorocarps) bearing spores. Dictyostelid fruiting bodies are microscopic and rarely observed except in laboratory culture. Under favorable conditions, the spores germinate to release myxamoebae, and the life cycle begins anew. Dictyostelids are most abundant in the surface humus layer of forest soils, where populations of bacteria are the highest and microenvironmental conditions appear to be the most suitable for dictyostelid growth and development (Raper 1984).

Approximately 140 species of dictyostelids have been formally described. Some species appear to be cosmopolitan, whereas others have a more restricted distribution (Raper 1984, Swanson et al. 1999). The primary objective of the present study, which was carried out on the Arkansas Agricultural Research and Extension Center at Fayetteville in northwestern Arkansas, was to determine the distribution and occurrence of dictyostelids in two different types of agricultural soils. The first of these was a plot with tilled soil and the second was a plot with untilled soil.

Methods

The Arkansas Agricultural Research and Extension Center at Fayetteville (36° 05' 47" N, 94° 10' 29" W) is located approximately 3 km north of the campus of the University of Arkansas. This region of northwestern Arkansas consists of rolling hills, with some areas of moderately level land. The predominant soil type is a silt loam, with 17 different soil series represented (USDA Soil Conservation Service and Forest Service 1969). Captina silt loam is the most common. These soils are moderately to well drained and slowly permeable. The tilled plot (A2A) used in the present study was planted with wheat in both 2002 and 2003 and then with canola in 2004. Each year a different pesticide treatment regime was used. Hoelon, Glean and Karte were applied in 2002; Harmony, Roundup and Glean in 2003; and Harmony and Treflan in 2004. The untilled plot (32B) was left fallow without any application of pesticides or fertilizer for this same period of time (V. Skinner, personal communication).

Twenty samples, each consisting of approximately 20–30 grams of wet soil and collected from a depth of < 3 cm, were obtained from each of the two plots in early January 2005. These samples were placed in sterile plastic bags and taken back to the laboratory to be processed for dictyostelids. Isolation procedures used were those described by Cavender and Raper (1965a). Each sample was weighed and enough sterile distilled water added to obtain a soil/water dilution of 1:10. This mixture was shaken to disperse the material and 0.5 ml samples of the resulting suspension added to each of three 100 × 15 mm culture plates prepared with hay infusion agar (Raper 1984). Approximately 0.4 ml of a heavy suspension of *E. coli* was added to each culture plate, and plates were incubated under diffuse light at 20–25 C. Each plate was examined at least once a day for several days following appearance of initial aggregations, and the location of each aggregate colony marked. When necessary, isolates were subcultured to facilitate identification. Nomenclature used herein follows Raper (1984).

Results

Eleven of the 20 samples (55%) from the plot with tilled soil yielded colonies of dictyostelids. The number of colonies per gram of wet soil ranged from 0 to 30, with an average of 11 colonies per gram for all samples. All of the colonies recovered could be assigned to a single species, *Dicytostelium sphaerocephalum* (Oudem.) Sacc., Marchal & É.J. Marchal. In constrast, 14 of the 20 samples (70%) from the plot with untilled soil yielded dictyostelids. The number of colonies per gram of wet soil ranged from 0 to 230, with an average of 31 clones per gram for all samples. Two species of dictyostelids (*D. giganteum* B.N. Singh and *D. sphaerocephalum*) were recovered, but the former was much more abundant and represented 84% of all colonies.

Discussion

The two dictyostelids recovered in the present study might have been expected, based on results from previous studies. Both are cosmopolitan species that have been reported from many different localities throughout the world (Raper 1984). Moreover, both are commonly associated with disturbed soils (Swanson et al. 1999). This seems particularly true for *D. sphaerocephalum*. For example, in a study carried out in central Alaska, Landolt et al. (1992) found *D. sphaerocephalum* to be the overwhelming dominant in a series of restoration plots with disturbed soil, but this species was much less common in soils associated with natural vegetation in the same general study area. Their results are consistent with those obtained in several other studies (e.g., Cavender 1983, Hammer 1984, Cavender & Hopka 1986), which seem to indicate that *D. sphaerocephalum* is favored by the microenvironmental conditions associated with disturbed soils. *Dictyostelium giganteum*, which was described originally from a compost pile on an Experimental Farm in England (Singh 1947), has been recovered from various kinds of soils (e.g., forest, grassland and agricultural) but occurs more frequently in disturbed soils (Raper 1984).

Hammer (1984), who compared the dictyostelids of agricultural soils and forest soils, reported that both overall diversity and abundance of these organisms in agricultural soils were appreciably lower than in forest soils. However, the dictyostelids associated with old fields that had not been subject to recent distur-

bance were relatively more similar to forests. In an earlier study of the occurrence of dictyostelids along an ecological gradient that extended from tall grass prairie to forest in southern Wisconsin (Cavender & Raper 1965b), both diversity and total numbers increased as one moved from prairie through open woodland to closed canopy forest. Only two species were recovered from prairie soils, but nine were present in samples collected from the closed canopy forest. The pattern that emerges from a consideration of these data is that relatively low diversity and abundance of dictyostelids in agricultural soils would be expected. However, the difference noted between the two plots sampled in the present study is striking. Clearly, the two different treatments (tilled versus untilled) result in soils that support quite distinct assemblages of dictyostelids.

Bacteria represent the primary food resource for dictyostelids (Raper 1984), and the diversity and abundance of bacteria in soils at a particular site have a considerable influence upon the numbers and species of dictyostelids present. Kuserk (1980), who examined relationships of bacteria and dictyostelids in a hardwood forest in Delaware, found that populations of the two were strongly correlated. For example, populations of dictyostelids peaked in the spring and fall, when natural populations of bacteria were highest. However, several studies (e.g., Raper 1937, Horn 1971) have shown that dictyostelids do not utilize all bacteria equally. When offered a choice of different types of bacteria as food, certain species of dictyostelids consume some and avoid others. Consequently, the differences we observed in the two plots could reflect differences in the populations of soil bacteria present as much or more than differences in populations of dictyostelids.

In summary, our results suggest that dictyostelids, which are relatively easy to culture and quantify, would seem to have considerable potential value as biomonitors of soil conditions at a particular site. Although the factors responsible for the differences noted in the two plots we sampled remain problematic, the dictyostelid data do provide a starting point for further studies of the microbial ecology of agricultural soils.

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