The Diazotroph Community of Biological Soil Crusts

Joseph Dean , Shannon Siart, and Shannon Johnson
Joseph01@cableaz.com, ssiart@msn.com, shannon.johnson@asu.edu

ARIZONA STATE UNIVERSITY

Southwest Center for Education and the Natural Environment

Abstract

Deserts are known to be limited in nitrogen. In a desert, the largest supply of nitrogen comes from nitrogen fixing cyanobacteria that reside in biological soil crusts. These biological soil crusts cover large areas of the deserts and are vital in maintaining the ecological system. Previous research has shown that cyanobacteria can only survive and fix nitrogen at the photic zone of the soil crusts. However, it was found that nitrogen fixation is still occurring below the photic zone suggesting diazotrophic microbes. In our experiment, we looked at soil crusts at two different maturity stages from the Colorado Plateau. We enumerated dinitrogen-fixing bacteria concentrations in the first centimeter of the soil crusts, which we divided into six horizons. For every horizon, we used MPN (most probable number) micro-well plates in order to determine the location and concentration of the nitrogen-fixers. The plates use a nitrogen-free media therefore allowing only the nitrogen-fixers to survive. From these micro-well plates, we chose a few interesting bacterial colonies. We obtained a total of three morphologically different isolates. Our MPN data shows that most of the nitrogen-fixers existed at the top few millimeters of the soil crusts. This is true for both the light soil crust and dark soil crust, however it appears there are greater concentration variations in the light soil crust. At the beginning of our experiment, we predicted that we would find most of the nitrogen-fixers in the upper millimeters of the soil crust.

Introduction

Biological soil crusts are common millimeter to centimeter topsoil layers in arid lands. Globally these soils cover at least 70% of arid lands. These layers are made by filamentous cyanobacteria, which give them resistance to erosion, increase soil fertility. Over long periods of time these crusts mature and develop diverse communities of microbial life. Among these communities are many dinitrogen fixers, which play a major role in the nitrogen cycle worldwide. In these crusts dinitrogen fixers are ecologically important. Recent work has shown that greater than 95% of the cyanobacteria in the crust are restricted to the top three millimeters, which is the photic zone. However, nitrogen fixing can be found below this depth.

We considered samples from Colorado Plateau, of two different successional stages. These have been labeled light and dark, the light consisting of only non-heterocystous cyanobacteria, and the dark containing both non-heterocystous and heterocystous cyanobacteria. We anticipated that a greater percentage of the nitrogen fixing activity would be due to cyanobacteria in the dark rather than the light crusts.

Materials and Methods

Soil cores were embedded a 1.5% agar solution and the 1cm was sliced into 1-3mm horizons (1). Each horizon was used to inoculate (3) one micro-well plate with each well containing 100µL of the Burke media (2). The samples were then incubated for two weeks at room temperature in the dark. Positive wells were determined by examination under a dissecting microscope. We isolated three distinct morphotypes from the cultures and have described them based on colony and cellular morphology.

References

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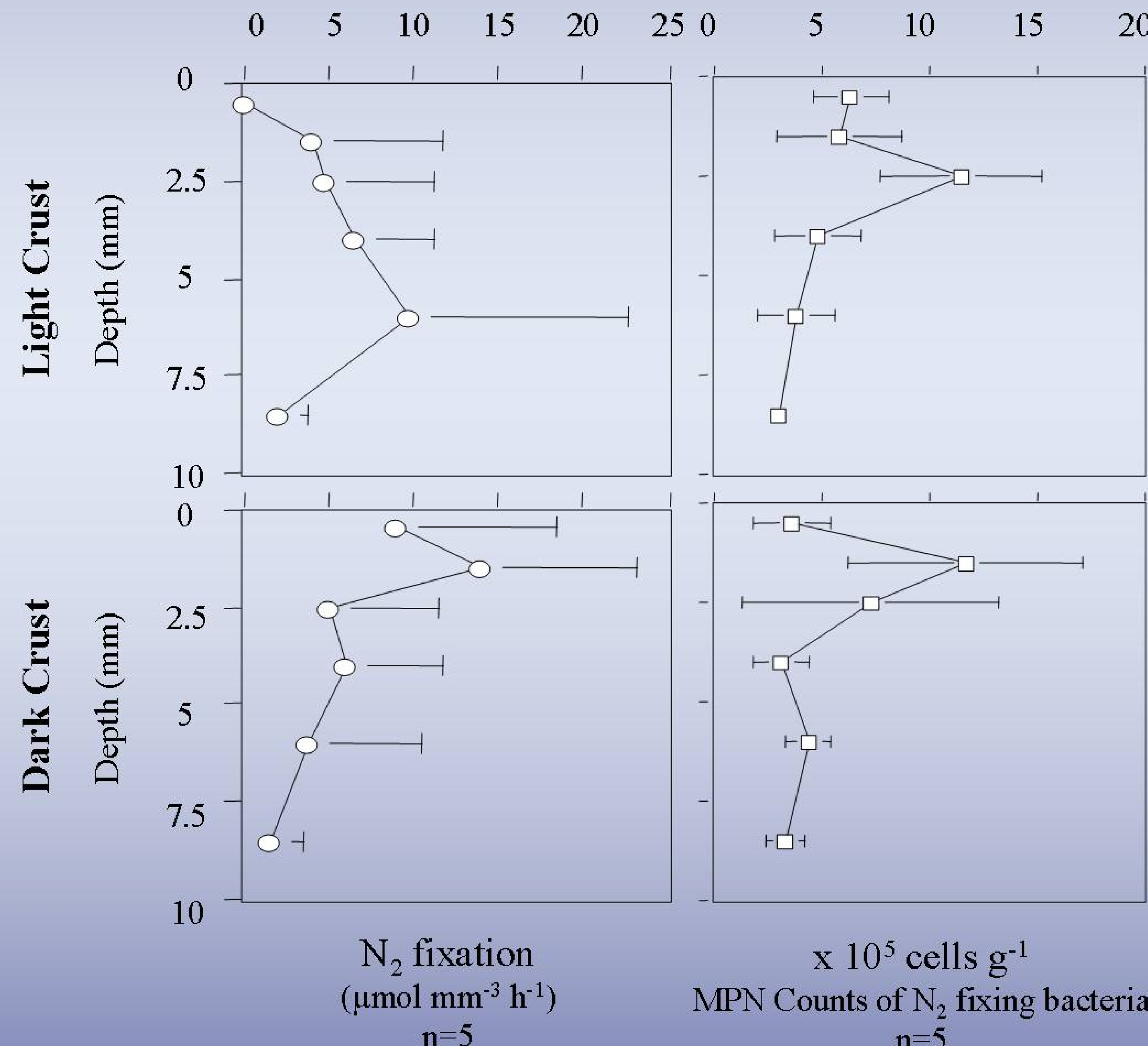

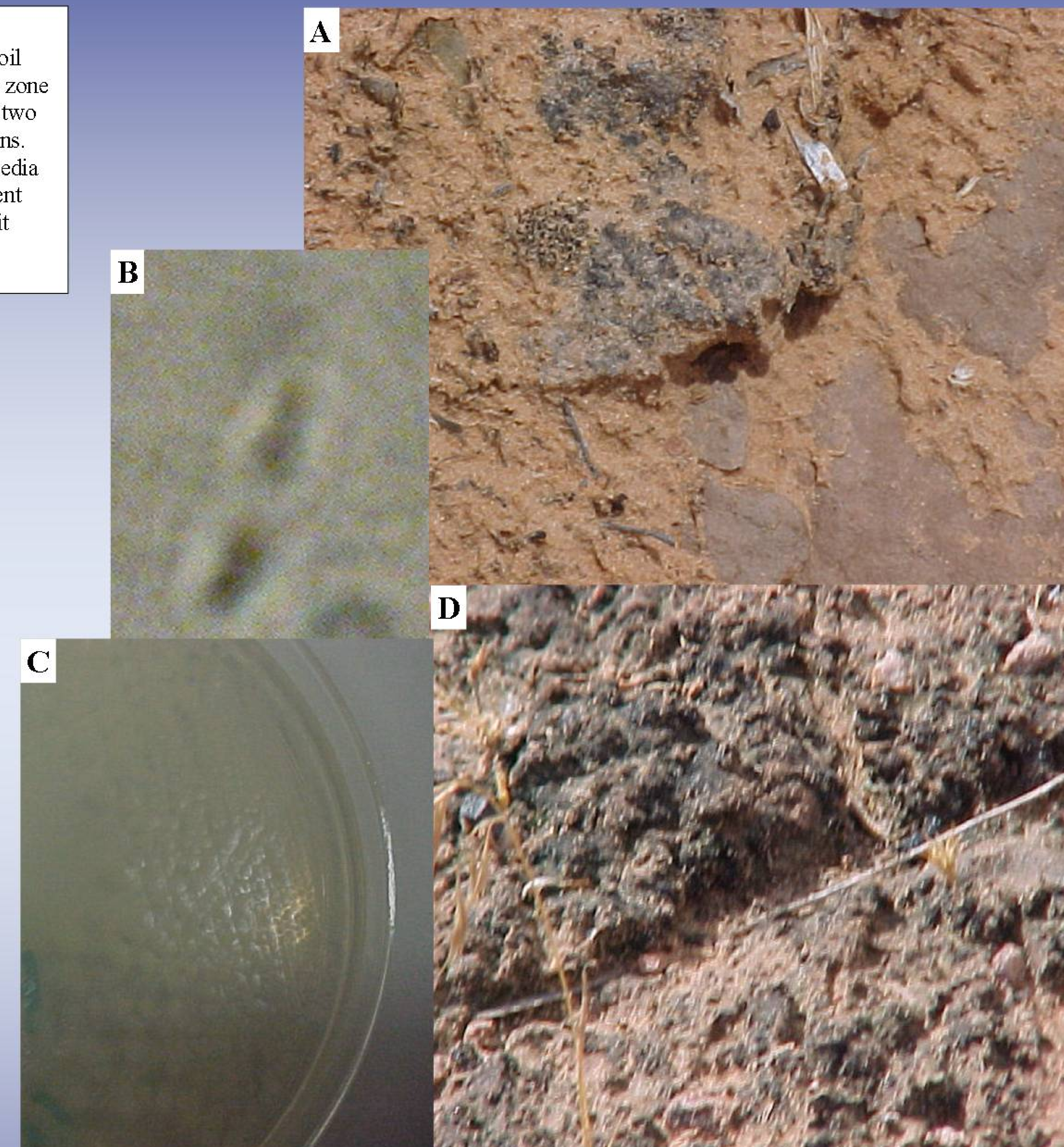

Photo Palette
A: Light BSC as found in field.
B: photomicrograph of isolate from MPN culturing (1000x).
C: Colony morphology of same isolate shown in B.
D: Dark BSC as found in field.

Results

Nitrogen fixation data found distinctive peaks in the rate of fixation between 5-7 mm in the light crust and between 1-2 mm in the dark crust. The light crust results indicated a non-cyanobacterial component of the nitrogen fixing community. MPN data revealed peaks in the number of diazotrophs in the light and dark crusts at 2.5 mm and 1.5 mm respectively. The peak in the light crust was at $11.5 \pm 3.78 \times 10^5$ cells g^{-1}, in the 2-3 mm range of soil. The peak in the dark crust was at $11.7 \pm 5.47 \times 10^5$ cells g^{-1}, in the 1-2 mm range of soil. Under the 3 mm mark both of the crusts were under 5.0×10^5 cells g^{-1}. In the light crusts the first two horizons had very similar concentrations of bacteria, which lead up to a major jump in concentration in the third horizon. However, in the dark crusts the concentrations of the first horizon was comparatively much lower than that of the second horizon.

Conclusion

Through our experimentation we showed that there are nitrogen fixers below the photic zone. We had substantial growth in our nitrogen-free micro-well plates showing that nitrogen-fixing heterotrophic bacteria exist in the first centimeter of soil crusts. When examining the concentrations of nitrogen-fixers in dark crusts, there is a peak at 1.5 mm. When examining the concentrations of nitrogen-fixers in light crusts, there is a peak at 2.5mm. These peaks in nitrogen-fixing bacteria concentrations are just under the areas of high cyanobacteria concentrations. This is most likely due to the high availability of carbon sources produced by the cyanobacteria. Also, the nitrogen-fixing bacteria probably would not survive closer to the surface of the soil crusts because of UV radiation.