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Distribution and characteristics of cyanobacterial soil crusts in the Molopo Basin, South Africa

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Abstract

This paper provides an analysis of the physical and chemical characteristics of cyanobacterial soil crusts in the Molopo Basin, South Africa. It details the influence that soil type, livestock disturbance and shrubs have on the spatial distribution of crusts. Four morphologically distinct cyanobacterial crusts were identified and crust cover ranged from 24% to 55%. Crust cover was significantly higher and characterized by darkened type 3 and 4 crusts on Ironstone soils compared to Kalahari Sand. More frequently disturbed sites had the least crust cover and had predominantly type 1 and 2 crusts. Type 3 and 4 crusts are more common on the less disturbed sites and under the canopies of *Acacia mellifera* where soils are protected from livestock disturbance. Total nitrogen concentrations were significantly higher in crusts compared to unconsolidated soil. There is also a strong correlation between the pH and NH_4^+-N concentrations in crusts and the soil immediately below the crust, suggesting that crusts have an influence on some of the properties of the underlying soil. If the *A. mellifera* can utilize additional nitrogen from crusts it may provide a competitive advantage to their establishment in formerly grass-dominated grazing lands.

Keywords: Cyanobacterial soil crusts; Kalahari; Soil nutrients; Shrub encroachment; *Acacia mellifera*

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1. Introduction

Dryland soils are typically coarse and deficient in organic matter and nutrients, reflecting the lack of moisture for vegetation growth and nutrient mineralization. As a result they have been reported as fragile and easily degraded (e.g. Oldeman et al., 1990; Pimentel et al., 1995; UNEP, 1997). Despite this, there is a growing abundance of literature (e.g. Thomas and Middleton, 1994; Stocking, 1996; Warren et al., 2001) that emphasizes the resilience (a return to functional stable equilibrium) and resistance (the ability to maintain functional stability despite disturbances) of dryland soils. One important factor in this regard is biological soil crusts that typify many dryland soils (see Ullmann and Büdel, 2003 for review) but which have only been described at a few locations in the Kalahari (Skarpe and Henriksson, 1987; Aranibar et al., 2003; Dougill and Thomas, 2004). Biological crusts form from the association of soil particles and organic matter with varying proportions of cyanobacteria, algae, lichens and mosses (Belnap et al., 2003a). They have many important functions, including soil moisture retention, inhibition of weed growth, reduction of wind and water erosion, atmospheric nitrogen fixation and carbon sequestration.

A variety of environmental factors influence crust form and distribution on a range of scales. On a continental scale, temperature and rainfall are the greatest influences (Rogers, 1972). On a regional scale, soil type (especially texture) is the predominant control with biological crusts less likely to develop on sandy soils due to their surface mobility (Belnap and Gillette, 1997). On a localized scale, there appears to be an inverse relationship between biological crust cover and plant cover because they are in direct competition for light and moisture (Malam Issa et al., 1999). Shrub canopies can, however, provide protection from disturbance and create shade which can enhance microbiological growth (Belnap et al., 2003b). Consequently, crust–vegetation relationships are complex and scale- and site-specific. Crusts are also sensitive to physical disturbance. Belnap and Eldridge (2003) argue that frequently disturbed soils only support large filamentous cyanobacteria as later successional species are not able to develop, thus limiting microbial diversity and altering crust functioning. Marble and Harper (1989) also found biological crusts to be particularly susceptible to disturbance through mechanical damage when dry and thus livestock trampling to be one of the major inhibitors of crust development.

Consequently, there are numerous inter-dependent factors, notably soil type, shrub cover and disturbance influencing the development and distribution of biological soil crusts. This paper aims to provide an analysis of the distribution of biological soil crusts in the Molopo Basin, South Africa, and to assess their role in affecting nutrient characteristics. The objectives are to:

1. document the spatial extent, morphology and taxonomy of the different crust types;
2. determine the influence of soil type, disturbance and shrubs on the amount and type of crust cover; and