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Discussions

Interactive comment on "Dew formation on the surface of biological soil crusts in central European sand ecosystems" *by* T. Fischer et al.

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We sincerely appreciate the overwhelmingly positive comments from Aaron Yair. He had three comments on the overall effects at the ecosystem scale, which we address below.

Aaron Yairs comment #1: Two important question, regarding the overall effects of data presented at the ecosystem scale, remain open:

1. Slight difference in microtopograpgy result in differences of BSCs over distances of few centimeters. How do such differences affect spatial differences in water infiltration and water availability for higher plants?

Response to Aaron Yairs comment #1: In our study we tried to explain the mechanism

of increased dew formation on better developed (i.e. thicker) BSCs. This refers to individual BSC patches, whatever their size might be. On a variety of scales, however, BSCs have been reported to increase, to reduce, or to have no effect on infiltration (Xiao et al., 2012): (1) Higher infiltration has been attributed to increased porosity, enhanced aggregate stability and to improved physical structure (Mager and Thomas, 2011; Menon et al., 2011; Rossi et al., 2012); (2) Reduced infiltration has been attributed to water repellency and pore clogging (Kidron et al., 1999, Issa et al., 2009) and (3) no influence has been attributed to the overwhelming action of interfering factors, e.g., the influence of BSCs on infiltration can be masked by some basic soil properties such as structure and texture (Williams et al., 1999).

We found that within BSC patch infiltration was inhibited, in particular due to water repellency and after swelling of extracellular polysaccharides (Fischer et al., 2010). Water running off individual BSC patches probably will be collected in BSC patch interspaces, possibly resulting in formation of flow channels in a hillslope situation, or in higher infiltration between BSC patches. Therefore, our answer to the first part of the question should be: BSC differences determine spatial differences in water infiltration on a BSC patch scale. This would also be true if BSCs increased infiltration.

Similar ambiguous results as with infiltration have been reported for plant settlement on BSCs: Soil crusts may help plants in germinating under harsh environmental conditions by creating micro safe sites (Zaady et al., 1997) or by nutrients release in the phase of establishment of juvenile or adult plants (Belnap & Harper, 1995, Belnap et al. 2001). Young BSCs may have a negative effect on the germination success of herbaceous key species on inland sand dunes, while senescing crusts have been reported to alter the micro-relief of the soil surface as well as the nitrogen availability of the sand (Steinlein & Wittland, 2006).

We believe that BSC mediated water redistribution is one of the key factors for plant settlement and growth. While there is little doubt that higher plants benefit from downslope run-on water, at least two scenarios seem plausible for crusted slopes: (I) BSC patch interspaces provide favourable conditions for plant germination, but plants progressively experience drought stress as they spread over the crusted surface. Seedlings of higher plants dry out. (II) Higher plants take over, resulting in an establishment of "islands of fertility" (see below) or in a replacement of the BSC cover.

Hence, it is one of our hypothesis that under the given climatic conditions BSCs stabilize through limiting water supply to higher plants. We emphasize the role of the climatic conditions in the revised manuscript.

Aaron Yairs comment #2: 2. Are dew amounts high enough to saturate the crusts and induce surface runoff?

Response to Aaron Yairs comment #2: No. The dawning water potentials decreased with BSC thickness and ranged between -2 MPa in crust 2 and -0.005 MPa in the substrate. We added this information to the manuscript. This is close to saturation in the substrate, but run-off generation is unlikely due to high infiltration rates there.

However, in temperate climate the soil atmosphere may contain considerable amounts of water vapour and dewfall plays an important role for lichens (Leisner et al. 1997). Ascending moisture may condense at the soil surface when it cools down. We discuss to this phenomenon in the manuscript.

Aaron Yairs comment #3: In the humid environmnet considered one would expect a high frequency of saturated crusts. Under such conditions a high frequency of surface runoff should be observed. This runoff may be absorbed at a downslope position where deep infiltration may occur. In other terms saturation of the BScs may reduce infiltration at a small scale (with negative effects on the vegetation) but increase infiltration at a larger scale with positive effects on the vegetation.

Response to Aaron Yairs comment #3: Yes, we absolutely agree with this position. It should also be taken into consideration that the establishment of higher vegetation most likely will stimulate pedogenesis, resulting in improved soil structure, formation of

humic horizons etc. This results in the formation of ‘islands of fertility’ under shrubs (Garner and Steinberger, 1989; Schlesinger et al., 1990; Zaady et al., 1996). These ‘islands’ are nutrient- and soil-rich patches, which support relatively high abundance, diversity and biomass of plants (Boeken and Shachak, 1994; Sarig et al., 1994). However, our study was limited to the BSC patch scale on sandy substrate, and further studies are needed to address this question on a landscape scale.

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