Soil fissures help in the restoration of vegetation on secondary bare alkali-saline soil patches on the Songnen Plain, China

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Fissures are a natural phenomenon of clay soils caused by shrinkage during dry or freezing conditions (Tian et al. 2003a; Vogel et al. 2005). The size and number of fissures is influenced by soil water content, temperature, clay content, and salinity (Lima and Grismer 1992; Tang et al. 2010). Fissures increase the rate of evaporation of soil moisture, can damage plant roots, and can trap seeds, resulting in local accumulations of seeds in the seed bank (Burmeier et al. 2010; Tian et al. 2003b). Some research concentrates on disadvantage of soil fissures, such as the destruction of grass roots (Tian et al. 2003a). However, fissures also act as natural seed traps that have significant positive implications for the restoration of secondary bare alkali-saline soil patches (Burmeier et al. 2010; Elberling 2000).

Songnen Plain is located in northeastern China (Hu et al. 2009). It is dominated by Chinese lyme grass (*Leymus chinensis*) and is one of the most grazed and mown grasslands in China (Zheng and Li 1993). The plain is surrounded by mountains and has very poor drainage, which contributes to the high clay and soil salinity content (Zheng and Li 1999). The plain also has many bare alkali-saline patches caused by overgrazing (Jiang et al. 2010; Zheng and Li 1999). The patches have a higher pH and salinity than surrounding areas where Chinese lyme grass is growing (table 1). However, the soil surface in alkali-saline patches is quite flat, it cannot trap seeds (He et al. 2004), and this makes restoration difficult. Soil fissures, however, provide a means by which seeds may be trapped and become incorporated into the seed bank.

There are two types of soil fissures. The first type is fissures formed by freezing from the end of November to March; the second type is fissures formed by desiccation from April to July (Tian et al. 2003a). Fissures are typically 2 to 5 cm (0.8 to 2 in) wide at the surface, 5 to 20 cm (2 to 8 in) deep, and can be many meters long. Seeds and plant litter are trapped by these fissures. The soil within fissures is significantly higher in soil organic matter and lower in electrical conductivity and pH, compared to fissure edges at soil depths from 0 to 20 cm (0 to 8 in) (Tian et al. 2003b). Therefore, soil fissures provide beneficial conditions for seed germination and establishment in secondary bare alkali-saline soil patches.

Feather fingergrass (*Chloris virgata*) is a high-protein annual grass that can survive on soils with a pH > 10 (Yang et al. 2008; Zheng and Li 1999). After successful establishment in fissures, feather fingergrass traps blowing sand, seeds, and litter; when it dies, it decomposes and contributes to improving soil conditions (figure 1).

Table 1

<table>
<thead>
<tr>
<th>Soil depth (cm)</th>
<th>Soil</th>
<th>pH</th>
<th>Electrical conductivity (µS/cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lyme grass</td>
<td>Soil patches</td>
<td>Lyme grass</td>
</tr>
<tr>
<td>0–20</td>
<td>9.7</td>
<td>10.4</td>
<td>497.5</td>
</tr>
<tr>
<td>20–40</td>
<td>10.1</td>
<td>10.3</td>
<td>639.8</td>
</tr>
<tr>
<td>40–60</td>
<td>9.8</td>
<td>10.3</td>
<td>423.2</td>
</tr>
<tr>
<td>60–80</td>
<td>9.4</td>
<td>10.3</td>
<td>279.3</td>
</tr>
<tr>
<td>80–100</td>
<td>9.1</td>
<td>10.1</td>
<td>198.7</td>
</tr>
</tbody>
</table>

Figure 1

Feather fingergrass grows from soil fissures on the secondary bare alkali-saline soil patches on the Songnen Plain, China.
in turn accelerates subsequent vegetation restoration (Jiang et al. 2010). The life history of this grass, and the conditions under which it is able to survive, provide an opportunity to test its suitability for more wide-scale reclamation and restoration of these heavily degraded grasslands.

Fissures are a natural feature occurring on bare alkali-saline patches in overgrazed grasslands. These fissures trap seeds and provide beneficial conditions for seed germination and establishment and consequently the restoration of vegetation on degraded grasslands. This provides a new perspective whereby we can accelerate vegetation recovery by artificially creating soil fissures, such as by drilling holes or otherwise fracturing the soil surface.

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