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Effects of inorganic amendments (urea, gypsum) on seed germination and seedling recruitment of 20 native plant species used in dryland restoration

Amber Bateman (1,2), Todd E Erickson (1,2), David J Merritt (1,2), Miriam Muñoz-Rojas (1,2)

(1) University of Western Australia, Plant Biology, Crawley, 6009, WA, Australia, (2) Kings Park and Botanic Garden, Kings Park, Perth 6005, WA, Australia (miriam.munozrojas@bgpa.wa.gov.au)

Introduction

Soil health and functionality are major determining factors for restoration of degraded arid and semi-arid ecosystems. These highly nutrient impoverished soil substrates with low water retention capabilities dictate plant growth and survival in these landscapes that are subject to variable rainfall event and high temperatures (Muñoz-Rojas et al., 2016). Anthropogenic disturbances derived from mining activities have contributed to the degradation of soil functionality and have altered plant-soil-water interactions. With unknown positive or negative rehabilitation outcomes, inorganic amendments in the form of urea and gypsum are commonly added to reconstructed soil substrates disturbed by mining to replenish soil nutrients (nitrogen) and improve soil water holding capacity to improve seedling establishment and survival.

Methods

Using existing protocols for amendment addition to soil substrates, two experiments assessed the effects of urea and gypsum at multiple doses in reconstructed soil substrates (topsoil (TS), waste (W) and, 50:50 blend of both materials (TW) to evaluate its effectiveness as a supplement to improve seed germination, seedling recruitment and plant growth. In the first experiment, 20 species native to the resource-rich biodiverse Pilbara region of Western Australia were grown in 30 °C glasshouse facilities under well-watered conditions for three weeks with seedling emergence scored daily. At the end of the trial, seedlings were harvested and biomass was assessed. In the second experiment, five of the original 20 species (e.g. Acacia bivenosa, Gossypium robinsonii, Eucalyptus gamophylla, Triodia wiseana and, Senna notabilis) were assessed for germination in amended soils by burying nylon sachets in the reconstructed substrates. After three weeks, the sachets were retrieved and seeds were assessed for germination (i.e. radicle emergence was evident).

Results and Discussion

Total emergence and biomass of seedlings was negatively affected by higher doses of gypsum and urea amendments. In the lower dose treatments, however, the total biomass of seedlings showed a positive effect for species from the Amaranthaceae. There was no apparent effect on species from the Fabaceae, Malvaeceae, Myrtaceae, and Poaceae families. Small doses of the amendments had a positive impact on the seed germination for three of the five evaluated species (Acacia bivenosa, Triodia wiseana and, Senna notabilis). Yet, despite the addition of soil amendments there was a high rate of mortality between the germination and emergence phases, a common occurrence in arid zone species subject to extreme environmental conditions (James et al., 2011). Seedling emergence of Acacia bivenosa and Triodia wiseana in TW and W substrates with low doses of urea achieved levels comparable to emergence in topsoil. Overall, responses to the inorganic amendments varied considerably across species and long-term field studies are required to assess plant responses in a restoration setting. Nevertheless, the findings of this suggest that the addition of these N-based inorganic amendments at low concentrations will benefit some plant species and improve arid zone restoration.

References

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Muñoz-Rojas M, Erickson TE, Martini D, Dixon KW, Merritt DJ. 2016. Climate and soil factors influencing seedling recruitment of plant species used for dryland restoration. SOIL, 2, 1–11, DOI: 10.5194/soil-2016-25