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REVIEW ARTICLE

Establishing woody perennials on hostile soils in arid and semi-arid regions – A review

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Abstract
Background and aims Woody perennials can be difficult to establish on harsh soils in arid and semi-arid regions. Historically, technological advances have focussed on methods to improve transplanting and direct-seeding but the available information on these advances remains fragmented and the edaphic factors have been largely ignored. This review explores the literature on plant establishment and identifies soil properties that limit plant response in harsh environments.
Conclusions We reveal that some woody perennials are particularly well-adapted to dry conditions and can also help reclaim degraded landscapes. Furthermore, the environmental and phenological factors that limit the success of direct seeding are well understood but the edaphic factors are not. For example, seedbed preparation and subsoil amelioration before seeding have not been evaluated in dry regions. Seed-priming and seed-placement are also poorly understood, as is the tolerance of woody perennials to different salt types in waterlogged soils of extreme pH and high soil strength. The reason why woody perennials can penetrate strong, hard soils is not obvious from the literature. They apparently cannot exert root growth pressures of the same magnitude as domesticated plants, so they must be able to exploit soil biopores and cracks more efficiently. Other gaps in our understanding of the soil factors that limit woody perennial establishment on hostile soils are identified.

Keywords Direct seeding · Transplanting · Soil-root interactions · Hard soils · Low rainfall · Native plants

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Introduction

Interest in establishing deep-rooted woody perennials has increased in efforts to mitigate global warming (e.g. Graham et al. 2009; De Deyn et al 2008; Kell 2011), to contain or reverse land degradation (e.g. Barrett-Lennard 2002; Marcar 2009; Schofield 1992; Stirzaker 2002), to conserve biodiversity (e.g. Salt and Freudenberger 2009), and to meet escalating demand for raw materials in the wood and biofuel industries of Asia (Fumikazu 2001; Minsheng 2003) , Australia (Nuberg et al. 2009; Schofield 1992; Wu et al. 2008), India (Shankarnarayan et al. 1987), and South America (Diaz-Balteiro and Rodriguez 2006). Planting woody