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Original article

Germination, survival, and growth of grass and forb seedlings: Effects of soil moisture variability

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ABSTRACT

Seed germination and seedling growth, survivorship, and final biomass and their responses to watering interval were studied in two grass and six forb species to assess germination and seedling growth responses to increased soil moisture variability as might occur with future increases in precipitation variability. Seeds were planted in prairie soil and watered at 1, 2, 4, or 7 d intervals (***I***). Seed germination peaked at $\boldsymbol{I} = 4$ d whereas leaf growth in grasses and forbs, and final biomass in grasses peaked at $\boldsymbol{I} = 7$ d, suggesting that growth and biomass were favored at greater soil moisture variability than seed germination. Biomass responses to ***I*** were stronger than the germination responses, suggesting that soil moisture variability more strongly influenced post germination growth. Individual species responses to ***I*** fell into three groups; those with responses to ***I*** for: (1) seed germination and seedling survival, (2) biomass, or (3) both germination and biomass production. These species groups may be more useful than life form (i.e., grass/forb) for understanding seed germination and seedling dynamics in grasslands during periods of soil moisture variability. Seed germination and early growth may assume more importance in grassland plant community dynamics under more variable precipitation patterns.

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Seed germination and seedling growth are critical stages of plant development leading to the establishment of new individuals in plant communities. These two aspects are highly sensitive to environmental variability, and require favorable conditions of soil moisture, which is rarely static. As a result, seeds in the soil in natural conditions routinely experience periods of alternating wet and dry conditions (Baskin and Baskin, 1982) caused by the episodic nature of precipitation. Tolerance of varying soil moisture also depends on the stage of plant development (Wilson et al., 1974). For example, in the C4 grass *Bouteloua gracilis*, levels of water stress which promoted high germination were unsuitable for seedling survival (Qi and Redmann, 1993). In shortgrass steppe, grass species that germinated well under a wide range of temperature and moisture conditions were intolerant of drought as established plants, whereas other grass species with narrow germination and establishment requirements survived drought when established (McGinnies, 1960). Thus, conditions that may favor germination may not favor continued growth and survival of seedlings or later stages (Lloret et al., 2004). Several studies have shown that differences in germination patterns associated with growth form or life history reflect adaptations to environmental variability (Matthews, 1976; Qi and Redmann, 1993; Dubrovsky, 1998; Perez-Fernandez et al., 2000; Flores and Briones, 2001).

Understanding how seeds and seedlings fare under varying soil moisture is important for determining how soil moisture variation may affect recruitment into plant communities. For example, several studies report that pulses of seed germination and seedling establishment in field populations follow pulses of precipitation (Wilson, 1973; Vincent and Cavers, 1978; Roberts and Potter, 1980). The timing of such events may have a marked effect on competitive success (Larsen et al., 2004; Weltzin and McPherson, 2000). The duration between precipitation inputs is a primary determinant of soil moisture variability. Most climate change scenarios forecast increasingly extreme precipitation patterns (Christensen and Hewitson, 2007). These will likely be manifest as longer droughts broken by large precipitation events. Increases in the frequency of extreme precipitation events have been documented (Groisman et al., 2005; IPCC, 2007). Knapp et al. (2002) reported that experimental rainfall applications that increased the occurrence of extreme events resulted in increased plant diversity and species turnover in grassland. Changes in plant community composition under more extreme precipitation patterns, particularly during spring, could arise in part from changes in seed and seedling success.

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