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Growth performance of some grasses in cattle dungpats in a greenhouse study

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ABSTRACT

This study investigated the effects of dungpat thicknesses and water regimes on the emergence, shoot development, and survival of seedlings of bluebunch wheatgrass [*Psuedoroegneria spicata* (Pursh) A. Love], Sandberg bluegrass (*Poa secunda* L.), and Hycrest crested wheatgrass [*Agropyron desertorum* (Fisch. Ex Link) Schult. X *Agropyron cristatum* (L.) Gaert.]. Pre-germinated seeds of each species were planted separately in the center and periphery of artificially prepared dungpats at heights of 0.5 cm for 1 cm-thick dungpats, 0.5 and 1.5 cm for 2 cm-thick dungpats, and 0.5, 2.0, and 3.5 cm for 4 cm-thick dungpats. In order to simulate natural drying conditions in the soil profile, half of the replications for each dungpat treatments received supplemental water, while the other half received no supplemental water during the study. Seedling emergence, development, and survival for all species were greatest when seeds were planted 0.5 cm from the bottom of dungpats and planted in 1 cm-thick dungpats. Supplemental watering enhanced seedling emergence and survival for all species. Hycrest crested wheatgrass had a greater seedling emergence than bluebunch wheatgrass and Sandberg bluegrass; and Hycrest crested wheatgrass and bluebunch wheatgrass had a greater seedling survival than for Sandberg bluegrass.

1. Introduction

The revegetation of degraded rangelands in arid areas is a complicated task due to poor soil conditions, topographic constraints, and high costs associated with plant materials and equipment. Additionally, using the mechanical methods for revegetation of degraded rangelands is expensive and often unsuccessful (Barrow and Havstad, 1992), and existing desirable plant species can be disrupted by seedbed preparation equipment. Therefore, since fecal seeding can be a less costly, less disruptive, and more environmental friendly method for revegetation works in degraded rangelands compared to the mechanical seeding techniques, many researchers have been looking for alternative methods for revegetating degraded rangelands in arid areas and investigating seed germination, seedling emergence, and growth of range plants in cattle dung (Akbar, 1994; Auman et al., 1998; Brown and Archer, 1987; Gökbulak and Call, 2004; Malo and Suarez, 1995a, b; Ocumpaugh et al., 1996; Shinderman and Call, 2001; Welch, 1985). In another words, a potentially significant percentage of seeds ingested by domestic and wild ungulates could be deposited in a moist, nutrient-rich medium that may facilitate germination and establishment (Archer and Pyke, 1991; Shinderman and Call, 2001). When compared to soil seedbeds in many rangeland environments, recently deposited cattle dungpats often have higher fertility and water holding capacity, and they can reduce competition with existing vegetation (Auman et al., 1998; Ocumpaugh et al., 1996; Shinderman and

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Call, 2001). For instance, Ocumpaugh et al. (1996) observed that fecal seeding of switchgrass (*Panicum virgatum* L.) had significant advantages over broadcast seeding of the same species in terms of seedling emergence, establishment, and growth in a subtropical grassland in southern Texas. In a similar small-plot trial, Akbar et al. (1995) found that moisture and temperature conditions in cattle dungpats were favorable for germination and establishment of passed seeds of crested wheatgrass [*Agropyron desertorum* (Fisch. ex Link) Schult. X *Agropyron cristatum* (L.)] during late spring and early summer in a sagebrush (*Artemisia tridentata* Nutt.) steppe in northern Utah. Wilson and Hennessy (1977) reported that the establishment of kikuyu grass (*Pennisetum clandestinum* cv. Whittet) was good in cattle dungpats. On the other hand, Shinderman and Call (2001) compared fecal seeding with broadcast seeding in a sagebrush dominated steppe and suggested that fecal seeding may be used as a tool for revegetating degraded rangelands in the long term, but may not be an option in the short term.

Akbar (1994) and Auman et al. (1998), working with Hycrest crested wheatgrass in artificially deposited dungpats, observed that the seedling establishment was strongly influenced by the location of passed seeds in dungpats. Seedlings emerged in all regions of dungpats in both studies, but those emerged at the periphery had the greatest survival and development. In a field study working with the same grass species in the naturally and artificially deposited dungpats, Gökbulak and Call (2004) observed higher seedling recruitment in thin dungpats than thick ones.

Rapid initial development of shoots and roots enables the seedlings to acquire necessary resources for growth in often-stressful rangeland environments (Coyne and Bradford, 1985; Newman and Moser, 1988). Aguirre and Johnson (1991) investigated the seedling development characteristics of four range grasses in a sandy loam soil in the greenhouse, and found that the rapid leaf and tiller development and greater leaf area were associated with greater total root length, earlier branching of the primary root, a greater number and order of branching of seminal roots, and earlier elongation and branching of adventitious roots. Seedling shoot development has not been quantified in cattle dungpats. Such information is necessary to more fully understand the potential of using fecal seeding as an alternative revegetation strategy on rangelands.

Little information is available about competitive interactions during plant establishment on dungpats. Akbar (1994) observed up to 70 seedlings of crested wheatgrass emerging from the artificial cattle dungpats during the first two weeks after dungpat deposition on bare soil in the field, but 1–5 seedlings survived on each dungpat by the end of the growing season. The majority of survivors were located on the periphery of dungpats. Auman (1996) noted the same trend while using cattle dungpats to create gaps in relatively sparse perennial vegetation [bottlebrush squirreltail (*Sitanion hystrix* Nutt.)] at the same field site. However, Akbar (1994) and Auman (1996) did not examine the effect of dungpat thickness and seed locations in dungpats on seedling establishment and survival.

Only a few experiments (Akbar et al., 1995; Auman et al., 1998; Ocumpaugh et al., 1996) have addressed the seedling emergence, establishment, and survival in mostly artificially deposited dungpats. More information is needed about how dungpat thickness and size, and seed locations in dungpats affect the seedling emergence, establishment, and survival in dungpats. It is needed to determine why the majority of seedlings die after emergence and why seedling survival is greater at the peripheral region of the dungpats than in the center of the dungpats. It is not known if the thinner dungpats may be suitable for the seedling emergence, but not for seedling survival due to lower moisture holding capacities, than thicker dungpats. It may be possible to adjust dungpat thickness by feeding animals with different diets.

Therefore, main objective of this study was to investigate how emergence, development (above-ground biomass production and number of tillers per plant), and survival of bluebunch wheatgrass [*Psuedoroegneria spicata* (Pursh) A. Love], Sandberg bluegrass (*Poa secunda* L.), and Hycrest crested wheatgrass seedlings were affected by dungpat thickness, seed location in dungpats, and water regimes in a greenhouse environment.

2. Materials and methods

Bluebunch wheatgrass [*P. spicata* (Pursh) A. Love], Sandberg bluegrass (*P. secunda* L.), and Hycrest crested wheatgrass [*A. desertorum* (Fisch. Ex Link) Schult. X *A. cristatum* (L.) Gaert.] were selected for this experiment based on their desirability as revegetation species and differences in their seedling establishment abilities. Hycrest crested wheatgrass is more vigorous, productive, and easier to establish than bluebunch wheatgrass and Sandberg bluegrass in most of the upland rangeland environments (Asay et al., 1991; Wasser, 1982).

Twelve Holstein heifers were kept in individual pens for feces collection at the Utah State University Caine Dairy Farm for 1 week and dung was collected in the last day of the week in order to ensure that no seeds from the previous diet remained in the digestive tract. Animals were fed a grass hay diet (*Bromus inermis* Leysser, *Dactylis glomerata* L., *Festuca arundinacea* Schreb., *Phleum pratense* L., *Juncus* spp.; 69% in vivo dry matter digestibility, 7.8% crude protein, 63.6% neutral detergent fiber, and 32.9% acid detergent fiber) that did not include seeds of the experimental grass species fed to the animals, in order to collect the maximum amount of seed-free dung for the preparation of artificial dungpats. Animals had continuous access to water and to grass hay during the feces collection.

Artificial dungpats were formed from seed-free dung and deposited on a sandy loam soil in large plastic containers (30 cm diameter, 50 cm deep) without drainage holes in the greenhouse. Dungpats had the same diameter (20 cm), but they had three different thicknesses (1.0, 2.0, and 4.0 cm). The soil was watered to field capacity (based on soil moisture release curves developed from the pressure plate analyses), the day before dungpat placement. During the experiment, half of the