Shoot and Root Characterization of *Rudbeckia hirta* L. Mowed at Different Heights

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Additional index words. black-eyed susan, wildflower sod, mowing height, root biomass, shoot biomass, sod production system

Abstract. Significant research has been conducted on wildflower sod, but the reasoning behind the production system methods is not clear. The purpose of this research was to determine the influence of mowing height on the subsequent leaf growth and root biomass distribution in a wildflower sod production system. *Rudbeckia hirta* was grown in sand in polyvinyl chloride (PVC) tubes in simulating field conditions. Plants were either not mowed (control) or hand-clipped to 5.1, 7.6, or 10.2 cm to simulate mowing. After the initial mowing, plants were mowed at ≈ 7 -day intervals. Total root depth, number of root axes in the top 2.5 cm, root:shoot ratio, total root dry weight, and root dry weight at depths of 0.0–2.5, 2.5–21.7, 21.7–40.8, and 40.8–60.0 cm were measured at the end of the study. Comparing the total root dry weight of all segments indicates that mowing significantly reduces root biomass. As mowing height increased, the depth of longest root increased linearly. Plants not mowed or plants mowed to 10.2 cm produced significantly more root axes in the top 2.5 cm of sand than did mowing heights of 5.1 or 7.6 cm. Root dry weight in the top 2.5 cm was considerably greater in nonmowed plants. Increased root axes in sod with higher mowing heights indicated a greater root density, which may also increase wildflower sod stability.

Wildflower sod has been researched since 1978 and was patented in 1990 (Milstein, 1990), but the reasoning behind the production system methods is not clear. One parameter of wildflower sod production that has been debated is the height at which plants are maintained. Shoot growth is managed to reduce damage to plants when undercut and to allow for ease of shipping. Johnson and Whitwell (1997) treated several species of wildflowers with three growth regulators to control shoot height; however, the effects were nonsignificant. The reduction of shoots by mowing is a more dependable alternative to the use of growth regulators, but optimal mowing height is unknown. Growers typically use a height of ≈ 7.6 cm because this is the maximum height allowed by many mowers. Chaieb et al. (1996) concluded that clipping the shoots of three perennial rangeland grasses reduced root biomass. Wildflowers may be influenced in the same manner. The purpose of this experiment was to determine the influence of mowing height on wildflower sod production.

Received for publication 12 Nov. 1999. Accepted for publication 27 Jan. 2000. Journal Series Number 12832, Univ. of Nebraska, Agricultural Research Division. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked advertisement solely to indicate this fact.

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Materials and Methods

Rudbeckia hirta L. was used as a representative wildflower species, seeded at a rate of 0.01 g Pure Live Seed (PLS) into 10.2-cm-

diameter polyvinyl chloride (PVC) tubes. Seeds were sown at triple the recommended rate (Stock Seed Farms, Murdock, Nebr.) to ensure a dense planting. Tubes were 76 cm deep, and coarse gravel (15-cm layer) was added to the bottom of the tubes to simulate field conditions. A layer of landscape fabric was placed on the top of the gravel to prevent roots from growing into the rocks. Masonry-washed fill sand, particle size 0.4 to 3.2 mm (Riemers-Kaufman Concrete Products Co., Lincoln, Nebr.), was used as the growing medium (60-cm layer). A 1-cm space was left as a lip at the top of the tube. A pH range of 6.0–7.0 was maintained by adding aluminum sulfate when pH levels were above 7. Seeds were germinated and removed from the mist when seedlings produced their first set of true leaves. Temperatures in the greenhouse ranged from 24 to 27 °C day/18 to 24 °C night. Metal halide lights were used to maintain a light level of ≈ 450 to $700 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ at 1400 HR for a 14-h daylength. Minimum critical daylength for *R. hirta* is 12 to 14.5 h (Kochankov and Chailakhyan, 1986). During weeks 2 to 4, plants were fertilized with N at $100 \text{ mg}\cdot\text{L}^{-1}$ [(20N–4.4P–16.6K) + micronutrients] and 200 $\text{mg}\cdot\text{L}^{-1}$ during weeks 5 to 13 (Peter's Fertilizer Products, Allentown, Pa.). Plants were either not mowed (control) or hand-clipped to simulate mowing. When initial heights of 7.6, 11.4, and 15.2 cm were reached, plants were mowed to 5.1, 7.6, and 10.2 cm, respectively (one-third of shoot growth removed). After initial mowing, plants were mowed at ≈ 7 -d intervals (seven mowings). Shoots were harvested after each mowing, dried at 65 °C for 48 h, and weighed. Root dry weight was measured at depths of 0.0–2.5, 2.5–21.7, 21.7–40.8, and 40.8–60.0 cm at the end of the study. Depth of longest root, number of root axes in the top 2.5

Fig. 1. Mowing height effects on (A) total root depth, (B) number of root axes in top 2.5 cm of sand, (C) root:shoot ratio, and (D) total root dry weight of *Rudbeckia hirta* in a wildflower sod production system. Bars indicate $\pm$ SE.

cm, and root : shoot ratios were also recorded at this time. The experimental design was a randomized complete block with four replications. Data were analyzed with the Mixed Models procedure in order to account for two sources of variability (SAS Institute, Cary, N.C.).

Results and Discussion

Mowing reduced depth of rooting, and plants that were mowed to 5.1 cm had significantly shorter roots than those mowed to 7.6 and 10.2 cm ($P \leq 0.05$) (Fig. 1A). Total depth of rooting increased linearly with mowing height ($y = 4.75x + 41.9$; $r^2 = 0.49$). Plants not mowed or plants mowed to 10.2 cm produced significantly more root axes ($P \leq 0.05$) in the top 2.5 cm of sand than did those mowed to 5.1 or 7.6 cm (Fig. 1B). The number of root axes in the top 2.5 cm increased linearly ($y = 5.31x + 4.98$; $r^2 = 0.36$) with mowing height.

Nonmowed plants had higher root : shoot ratios at time of harvest than did mowed plants (Fig. 1C); they also had a higher root than shoot biomass, while the opposite was true for mowed plants. Root dry weight in the top 2.5 cm, which is the segment used for wildflower sod, was considerably higher in nonmowed plants (Fig. 2). A similar trend was observed in the deeper root segments. Differences among mowing treatments were nonsignificant. Mowing significantly reduced total root biomass (Fig. 1D).

Increasing the mowing height of *R. hirta* sod would produce more root axes, thus creating a more dense sod. However, the increased

Fig. 2. Effects of mowing height on root dry weight of *Rudbeckia hirta* at various depths. Bars indicate $\pm$ SE.

mowing height may increase damage to shoots from shipping. If damage can be kept at a minimum, a 10.2-cm mowing height would increase the stability of wildflower sod for shipping and transplant handling.

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