Evaluation of Crested Wheatgrass Managed as Turfgrass

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Abstract

Typical turfgrass species often receive substantial inputs of water, fertilizer, chemicals, and cultural management, particularly in the Intermountain U.S. Plant materials that do not require these inputs and that also maintain acceptable levels of turf quality and performance are desirable in low-maintenance/limited irrigation situations. However, there is a lack of plant material that fits this description. Crested wheatgrass is a potential source of turf varieties for semi-arid regions and is the focus of current breeding efforts to improve its turf characteristics. This study examined implications of irrigation interval, mowing height, nitrogen fertilization, and cultivar selection on the performance of crested wheatgrass turf. While irrigation interval, mowing height, and cultivar affected performance, the application of nitrogen fertilization was the critical factor for maintaining the quality of crested wheatgrass turf under the conditions of this study. Regardless of the treatments imposed, crested wheatgrass turf performance declines during the hot summer months.

Introduction

Maintenance costs in many areas could be reduced by planting persistent, low-maintenance turf grasses that require limited irrigation and mowing (9). One of the main limitations to the use of low-maintenance turf is the availability of appropriate plant material. Common turfgrasses, such as Kentucky bluegrass (Poa pratensis L.) and perennial ryegrass (Lolium perenne L.), are genetically improved for turf quality, resistance to plant pests, and other characteristics, and perform well in many areas of the world. However, in more arid regions, such as the Intermountain U.S., these species often require large inputs of water, fertilizer, chemicals, and cultural management. As urban expansion continues, the amount of water available for high-maintenance landscapes will be reduced or even eliminated, generating a need to develop plant materials designed for low-maintenance landscapes (9). In addition to improving grass cultivars for low-maintenance situations, the adoption of cultural practices that reduce evapotranspiration rates has the potential to decrease water-use rates (5).

A potential source of turf germplasm for the Intermountain U.S. and other semi-arid regions is crested wheatgrass (Agropyron cristatum). Crested wheatgrass is indigenous to the Steppe region of European Russia and southwestern Siberia (13). Crested wheatgrass is a persistent, long-lived perennial. Characteristics include excellent seed production, ease of seed harvesting, seedling vigor, drought resistance, and adaptability to the harsh conditions often encountered in water-limited environments. Crested wheatgrass exhibits three ploidy levels (diploid, tetraploid, and hexaploid) with the tetraploid form being the most common (1,6,7,18). Although crested wheatgrass is normally caespitose (bunch-type growth habit), accessions with varying degrees of rhizome development have been acquired from Iran and Turkey. These introductions are shorter in stature and have finer leaves than...
typical crested wheatgrass. Breeding programs are underway with these and other plant materials to develop cultivars for arid turf, primarily for use in water-limited environments for lawns, golf course fairways, roadsides, and similar settings (1).

The objectives of this study were to compare management practices for crested wheatgrass turf and to compare the potential of experimental populations with currently available crested wheatgrass cultivars for turf applications (2) in the Intermountain U.S.

**Establishment of Crested Wheatgrass Turf**

Seeding of the experiment occurred on 10 September 1993 at the Utah State University Evans Research Farm (2 km south of Logan, UT). The soil is a Nibley silty, clay loam (mesic Aquic Argiustoll), and the site receives 430 mm of average annual precipitation. The soil has a field capacity of 0.34 mm water per mm soil and an available water capacity of 0.18 mm water per mm soil (19). Soil samples were taken on 31 March 1994 to determine nutrient nitrogen levels at the study location prior to initiation of the treatments. Sample results from the Utah State University Soil Testing Lab were 3.5 ppm N.

Plant materials consisted of the crested wheatgrass cultivars 'Ephraim' (17), 'Fairway' (13, 15), and 'Ruff' (USDA Extension Service, 1978) and experimental crested wheatgrass strains 'CWG-F' (from Turkey), 'CWG-R' (from Iran), and 'CWG-T' (from Turkey).

The grasses were broadcast seeded in 1-x-1.5-m plots at a rate of 80 kg/ha in a firm weed-free seedbed. Plots were hand raked and rolled with a push-type roller to improve contact between the seed and soil. A semi-permanent PVC irrigation system (5-cm PVC pipes placed along the plot borders using Hunter S-type sprinkler heads with an adjustable 1° to 335° circular spray pattern and a 4.6-m radius) provided irrigation water for the plots. Irrigation occurred, as needed, during the establishment year to maintain a wet soil surface during seedling emergence and to insure stands of all entries.

**Treatments**

The experimental design was a split-split-split plot design with overall blocks replicated four times. Whole plots consisted of two irrigation intervals: every 7 or 14 days. Subplots consisted of two mowing heights (mowing): 75 and 100 mm. Sub-subplots consisted of two nitrogen fertilization levels (N fertilization): 0 and 150 kg N per ha/year. Sub-sub-subplots consisted of the six previously mentioned crested wheatgrass sources (entries).

The N fertilization treatments were applied after the establishment year. For the 150-kg/ha/year N fertilization treatment, split application of N at 50 kg/ha as ammonium nitrate (34-0-0) occurred on 16 May 1994, 13 June 1994, and 12 September 1994, and then on 26 May 1995, 30 June 1995, and 28 August 1995. Irrigation treatments began in the spring of 1994 and consisted of irrigation of the plots to field capacity every 7 or 14 days, as verified by gravimetric soil-moisture determinations (Fig. 1). During the evaluation period, mowing treatments occurred on a weekly basis.
Maintenance recommendations in Logan, UT for typical home lawns (i.e., Kentucky bluegrass and tall fescue) during the months of May to September are application of 13 mm irrigation water every 3 to 4 days, mowing to a height of 50 to 100 mm, and application of N fertilizer at 150 to 200 kg/ha \((12,14)\). Thus all management treatments included in this study represented low to moderate maintenance recommendations for this region of the Intermountain U.S.

**Data Collection and Analysis**

Data collection occurred weekly during the growing seasons of 1994 (16 May to 17 September) and 1995 (19 May to 15 September) for turf color (color), turf regrowth (regrowth), and turf quality (quality). Color data was not collected in May 1994. Visual ratings combining color intensity, leaf texture, and tiller density comprised the evaluation of quality \((10,16)\). Quality ratings followed a 1-to-9 scale \((1 = \text{brown color, coarse leaves, and open canopy}; 9 = \text{green color, fine leaves, and dense sod})\). Color values also followed a 1-to-9 scale \((1 = \text{brown dormant turf} \text{ and } 9 = \text{green turf})\). The 5GY hue (based on the Munsell charts) most closely matched the range in colors of the entries included in the experiment. Measurement of average regrowth (height in mm minus the height of the mowing treatment) per plot occurred prior to each mowing. Percent ground cover (ground cover) was the estimate of the percent of the total plot area covered with live, actively-growing grass on 26 and 30 August 1994 and 22 June 1995 \((16)\). The two ratings made in 1994 were averaged. With the exception of ground cover, which had only one value per year, data are presented based on the month in which they were collected.

Treatment effects were analyzed across years and within months (May, June, July, August, and September) using the GLM procedure of SAS (SAS Institute, Inc., Cary, NC, 1999). Irrigation, mowing, N fertilization, and entry were fixed effects while blocks and years were random effects.

**Effect of Irrigation Interval**

There were no differences between irrigation levels for quality, in any of the months (Table 1), or for ground cover \((\text{data not shown})\). The 14-day interval resulted in better color than the 7-day interval in June, but there was no effect on color during the other months (Table 1). The 14-day interval resulted in more regrowth in May than did the 7-day interval, but the 7-day interval resulted in more regrowth in July and August. There was no effect on regrowth in June or September (Table 1).
Table 1. Mean values associated with irrigation interval, mowing height, nitrogen fertilization, and crested wheatgrass entry quality, regrowth, and color measured weekly from May to September of 1994 and 1995.

<table>
<thead>
<tr>
<th></th>
<th>Quality (1-9)</th>
<th>Regrowth (mm)</th>
<th>Color (1-9)</th>
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<tbody>
<tr>
<td></td>
<td>May</td>
<td>June</td>
<td>July</td>
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<tr>
<td>Irrigation interval (days)</td>
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<tr>
<td>7 day</td>
<td>4.7</td>
<td>3.7</td>
<td>3.8</td>
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<td>14 day</td>
<td>4.9</td>
<td>3.7</td>
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<tr>
<td>Mowing height (mm)</td>
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<tr>
<td>75 mm</td>
<td>4.7</td>
<td>3.5b</td>
<td>3.7b</td>
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<tr>
<td>100 mm</td>
<td>4.8</td>
<td>3.9a</td>
<td>3.9a</td>
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<td>Nitrogen fertilization (kg/ha/year)</td>
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</tr>
<tr>
<td>0</td>
<td>3.9b</td>
<td>2.9b</td>
<td>3.1b</td>
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<td>150</td>
<td>5.6a</td>
<td>4.5a</td>
<td>4.6a</td>
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<td>Entry</td>
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<tr>
<td>CWG-F</td>
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<td>4.0c</td>
<td>3.9b</td>
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<tr>
<td>CWG-R</td>
<td>4.9b</td>
<td>3.5e</td>
<td>3.6c</td>
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<td>4.2b</td>
<td>3.9b</td>
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<tr>
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<td>3.7d</td>
<td>3.9b</td>
</tr>
<tr>
<td>Fairway</td>
<td>5.5a</td>
<td>4.4a</td>
<td>4.8a</td>
</tr>
<tr>
<td>Ruff</td>
<td>2.7c</td>
<td>2.3f</td>
<td>2.9d</td>
</tr>
</tbody>
</table>

Means for a given trait and treatment followed by different letters are statistically different; Protected LSD (0.05).

X Quality: 1 = brown color, coarse leaves, and open canopy; 9 = green color, fine leaves, and dense sod.

Y Color: 1 = brown dormant turf; 9 = green turf.

Effect of Mowing Height

The 100-mm mowing treatment resulted in better quality than the 75-mm mowing treatment during June, July, and September, but there was no effect during the other months (Table 1). Color was better in June and July with the 100-mm treatment than with the 75-mm treatment. However, color in August was better with the 75-mm treatment (Table 1). The 100-mm treatment gave more regrowth in May and June than did the 75-mm treatment, but the opposite was true for regrowth in July and August (Table 1). Mowing height had no effect on ground cover (data not shown).

Effect of Nitrogen Fertilization

N fertilization was the most important crested wheatgrass turf management factor, resulting in differences between the nitrogen treatments for each measured trait in each month (Table 1). In all cases the effect of fertilization was consistent with the 150-kg/ha/year N treatment resulting in larger values than the 0-kg/ha/year N treatment. Turf quality and color were low during the summer and fall months under the 0-kg/ha/year N treatment (Table 1). The 150-kg/ha/year N treatment had 78% ground cover compared to the 45% ground cover value of the 0-kg/ha/year N treatment (data not shown).

Effect of Crested Wheatgrass Entry

Fairway had the best quality during each month (Table 1) and also had the highest ground cover (data not shown). CWG-T and CWG-F did not differ from Fairway for May quality and consistently had high quality values during each month. CWG-T also had high ground cover values. Ruff had the lowest quality during each month and also had the lowest ground cover values.

Results for entry color values were not as consistent as those for the other traits (Table 1). Differences were contingent on the month being analyzed. Ephraim had the highest color values in May and June while Fairway and Ruff
had the lowest values in May and June. In July, entries all performed similarly for color with the exception of CWG-R, which had a lower value than the other entries. In August, Fairway and Ruff had the highest color values with little difference among the other entries. There was no difference among entries for September color. When compared to earlier summer months, the higher color values of Fairway and Ruff during the later summer months were not attributable to improved performance. Rather the performance of these two declined less than the values of the other entries. Ruff had the most regrowth during each month of the study while CWG-F and CWG-T had the least (Table 1).

**Interactions between Treatment Factors**

The split-split-split plot design of this study resulted in different levels of precision for the estimation of main effects and also complicated the interpretation of significant interactions between main effects. The analysis of variance identified a number of statistically significant interactions (*data not shown*). The majority were interactions either with either year or entry. In general, these interactions were due to changes in magnitude rather than changes in rank. Although statistically significant, the significance either had no practical application or did not aid in the determination of best overall management practices of crested wheatgrass turf. For these reasons, further discussion is focused solely on the main effects included in this study.

**Management Implications**

Differences between irrigation intervals occurred for some color and regrowth values, but for none of the quality or ground cover values. In general, these differences were small (very close to the LSD value for the trait). Although additional information across more years would be useful for determining the importance of irrigation interval on quality, the lack of difference between intervals for quality and ground cover suggested the sufficiency of a 14-day interval for crested wheatgrass turf.

The inconsistent results from the mowing treatments indicated the potential of a seasonal approach to mowing. Earlier in the year, there was indication that the 100-mm treatment achieved improved quality and color. In July and August there was evidence that the 75-mm treatment gave improved color and resulted in more regrowth, suggesting that the shorter mowing height may induce more growth during the hotter months of summer. Mowing at a higher height resulted in a better crested wheatgrass turf and should be the practice during the early and middle summer months. However, giving consideration to a lower mowing height in the later months may be beneficial.

Interestingly, data coming out after the completion of this study suggested that higher mowing heights may be more appropriate for crested wheatgrasses and that the mowing heights used in this study might adversely affect the persistence of crested wheatgrass (8). This is a possible explanation for the low ground cover values (*data not shown*). Another possible explanation for the low ground cover was weed coverage. Weeds were not viewed as problem in 1994 and data was not collected. Weed coverage was higher in 1995 and data was collected, but overall weed coverage was low (*data not shown*). The 1995 weed data suggested that the 7-day irrigation interval and the 75-mm mowing height encouraged weed coverage. It was unclear whether the increased weeds from 1994 to 1995 arose due to the lower ground cover values due to less competition or played a role in lowering the ground cover values. These results suggest the need for additional studies specifically aimed at identifying the best mowing height for crested wheatgrass and for breeding efforts aimed at developing crested wheatgrass adapted to lower mowing heights.

The crested wheatgrass turf entries required inputs of nitrogen fertilization to maintain trait values. This was particularly true for quality and ground cover. Saving resources by not having to purchase nitrogen fertilizer and lessening environmental impacts by not applying fertilizer may justify lower values for some traits. However, the loss of ground cover (78% with N fertilization compared to 47% without N fertilization) was large. A follow-up study is
necessary to test intermediate levels of nitrogen fertilization which might give comparable results to the 150-kg/ha/year N treatment and still result in savings on N fertilization, beneficial in a low-maintenance situation. It would also be important to analyze different types of nitrogen fertilizers that have slower release rates than ammonium nitrate. Although nitrogen was low in this soil, crested wheatgrass turf is likely to be used in lower-quality soil conditions and thus results were reflective of likely management conditions.

Fairway was consistently one the best-performing entries for the key quality and ground traits. Additionally, it was one of slower regrowing entries leading to less mowing frequency. Fairway also has the benefit of being a diploid entry. All the other entries – with the exception of Ruff which was selected from Fairway (3) – are tetraploids. Selection and gain from selection are faster in a diploid organism than in a tetraploid organism, and Fairway would be a promising candidate for further turfgrass breeding goals based on its overall performance and diploid nature. Its main drawbacks were its low color values and caespitose growth habit.

As mentioned, a rhizomatous-type growth habit is preferable, and all the entries – with the exceptions of Fairway and Ruff – are rhizomatous. Ephraim had good color and low regrowth, but was lacking in quality and ground cover. The entries CWG-F and CWG-T were very comparable to Fairway for most traits and comparable to or better than Ephraim for all traits. These two entries also have the benefit of lower regrowth. Based on this study, Fairway was the most promising entry. However, due to their rhizomatous growth habit and overall good performance across traits, CWG-F and CWG-T exhibit promise as potential turf entries in a low-maintenance turfgrass management effort. Ruff was the worst overall entry and would be a poor choice for crested wheatgrass turf. RoadCrest is a newer cultivar developed by the USDA-ARS in Logan, UT for low-maintenance turfgrass situations (4), but was unavailable during the implementation of this study.

Conclusions
It is difficult to make comparisons between different species. However, the quality and color characteristics of the included crested wheatgrass entries did not perform near the expected performance of conventional turfgrasses, i.e. Kentucky bluegrass and tall fescue. Of greater concern was the inability of the entries to maintain ground cover over both years. Crested wheatgrass is not, at this point, a good option for areas requiring high quality, but it might have promise for low maintenance/irrigation situations. While results for irrigation and mowing treatments were inconclusive, it was clear that nitrogen fertilization is required for quality and ground cover and that Fairway with CWG-F and CWG-T, due to their rhizomatous natures, were the most promising entries.

A clear result was the decline of quality and color of crested wheatgrass during the hot summer months. These traits decline as the summer progresses resulting in overall low performance. Breeding efforts are ongoing to improve these and other turf traits in crested wheatgrass turf (1,11), and will be the key to future acceptability of crested wheatgrass as an acceptable turf option.

Literature Cited