WATER USE OF KENTUCKY BLUEGRASS GROWN FOR SEED


Abstract

Kentucky bluegrass (Poa pratensis) grown for seed in the Northwest is irrigated until late spring and harvested in earlier summer. Daily crop water use was measured for both aggressive ('Glade') and nonaggressive ('South Dakota') bluegrass by the changes in soil water content from soil sensors. There was no significant difference in crop water use between cultivars that had differing seed and dry matter yield. Cumulative water use to harvest was 365 and 257 mm in 1994 and 1996, respectively. The crop coefficient (Kc) for bluegrass had a midseason stage that began very early in the season, followed by a decline after anthesis. A system of multiplexing soil moisture sensors was used to measure water use by changes in soil water content, and compared favorably to estimates of seasonal water use in 1994. In 1996, the sensors measured less water use, possibly due to the cool spring and ample irrigation that keep the soil wet.

Introduction

Kentucky bluegrass (Poa pratensis) is grown for seed in many areas of the Pacific Northwest in both irrigated and non-irrigated regions. The water requirements for Kentucky bluegrass seed have not been directly studied as far as we know. Published estimates of crop water use, or evapotranspiration (ET), do not agree. Using three sources of data for central Oregon as examples, bluegrass seed yearly water use was listed as 912 mm (35.9 inches) by Cuenca et al. (1992), while the Bureau of Reclamation's AgriMet system calculated a five-year average as 371 mm (14.6 inches) (Bureau of Reclamation, 1995), and Watts et al. (1968) listed 151 mm 5.95 inches. The discrepancy makes it imperative that field measurements substantiate water use of Kentucky bluegrass seed.

Cultivars of Kentucky bluegrass have been classified as aggressive and non-aggressive according to their tillering characteristics. Aggressive cultivars have more active rhizomes, and typically produce more seed at an earlier date, than the nonaggressive cultivars. Because this growth characteristic may influence ET, it should be measured for both aggressive and non-aggressive types.

The objectives of this study were to determine the crop water use of Kentucky bluegrass seed for aggressive and nonaggressive cultivars. Indexing ET to potential evaporation is a valuable means of transferring crop ET to other locales and years. A secondary objective is to develop a crop coefficient (Kc) relationship for Kentucky bluegrass seed.

Materials And Methods

Water use was measured on Kentucky bluegrass seed experiments located at the Central Oregon Agricultural Research Center, Madras, Oregon. The two cultivar treatments used here were part of a larger nitrogen-source experiment, consisting of eight cultivars and two nitrogen fertilizer types, that will be reported elsewhere. Two cultivars were selected based on their aggressivity; 'Glade' the most aggressive, and 'South Dakota' the least. The soil was a Madras loam (fine-loamy, mixed, mesic, Xerollic Duragid).

The trial was conducted according to standard practices for planting, weed control, pest control, irrigation, and fertilizer application. Irrigation is typically halted in mid-June to dry the crop preparatory to harvest. Harvest occurred on 5 July 1994 and 2 and 10 July 1996 for 'South Dakota' and 'Glade', respectively. Harvest was accomplished by taking 1 m² sections of each plot. Samples were weighed for dry matter, and stored for later threshing of the seed. Seed threshing was done at the USDA-ARS National Forage Seed Production Research Laboratory, Corvallis, Oregon.
Plant above-ground dry matter between ‘Glade’ and ‘South Dakota’ was not significantly different in 1994 or 1996, whereas the first-year seed yield (1994) was greater in ‘South Dakota’ compared to ‘Glade’. In contrast, third-year (1996) seed yield was not significantly different between cultivars.

Figure 2. Cumulative Kentucky bluegrass seed ETsensor and Epenman, Madras, OR, 1994.

![Graph of cumulative water use for 1994 and 1996.]

The total (through July 1) ETsensor value is compared against the Penman evaporation of both years in Figures 2 and 3. In 1994 and 1996, the ETsensor was 66 and 53 percent of Epenman. The lower 1996 ETsensor value may have occurred because of the cool spring, and ample irrigation that kept the soil in the wet range of soil water content, where sensors are not sensitive to water content changes. Another possibility is the powdery mildew that infested the bluegrass in 1996 and likely reduced growth and plant transpiration in late May and early June. This reduction can be observed in the Kc curve of 1996 (Figure 4).

The general form of Kc curves consists of initial, crop development, mid-season, and at-harvest stages (Doorenbos and Pruitt, 1977). As Figure 4 shows, the Kc values for both years started relatively high (0.7), meaning that the grass did not experience the low value of the initial growth stage as do most field crops (Doorenbos and Pruitt, 1977). This is not surprising since bluegrass was already established when it began growth in late winter. The midseason Kc remained at 0.8 until late May in both years, then began declining during the second week of June in both years, which corresponds precisely with the anthesis of the bluegrass and its reproductive stage. After that, Kc declined as irrigation ceased two weeks prior to harvest in early July (Figure 4).

Figure 3. Cumulative Kentucky bluegrass seed ETsensor and Epenman, Madras, OR, 1996.

![Graph of cumulative water use for 1994 and 1996.]

Discussion
The various estimates of Kentucky bluegrass seed water use in the literature differ from our field measurements due to disagreement about the Kc during different cropping periods. Watts et al. (1968) used the Blaney-Criddle monthly ET estimates with an equation-specific Kc. They assumed the growing period to be from mid April to mid June, which has been shown to start earlier (Figures 2 and 3 above.) Cuenca et al. (1993) used the modified Blaney-Criddle method (Doorenbos and Pruitt, 1977) and assumed the growing season was the entire year, which also is not accurate. The 12-month growing season and the high grass seed Kc
An automated weather station located within 30 m of the experimental plots provided hourly weather data for precipitation and potential ET calculation. The Kimberly-modified Penman equation was used to calculate potential ET (E_{Penman}) according to Dodder (1994). The weather station was managed by the US Bureau of Reclamation as part of their AgriMet network of weather stations.

The ET measured by the sensors (ET_{sensors}), was calculated according to the method outlined in Mitchell et al. (1994) and Mitchell and Shock (1996). Watermark Model 200SS sensors (Irrometer, Inc., Riverside, CA) were buried at several soil depths and multiplexed to a CR-10 datalogger (Campbell Scientific, Inc., Logan, UT) as shown in Figure 1. A set of eight sensors were placed in three locations within replications of the ‘Glade’ and ‘South Dakota’ treatments. Readings were taken at 6:00 am daily. The surface sensors were installed horizontally 1 cm below the surface to monitor changes in evaporation after irrigation. Surface soil water changes would not be easily detected if the sensor were placed vertically, which is the practice for installation at greater depths. When integrating water content changes for the whole profile, each sensor was assigned a weight corresponding to the relative volume of soil that it represented.

The data from the CR-10 was transformed to water content according to equations outlined in Mitchell and Shock (1996). Although the Watermark sensors measure the soil matric potential (Eldredge et al. 1993), they can be calibrated to soil water content directly for a specific soil, or alternately calibrated using the soil water characteristic to transform matric potential to water content (Mitchell and Shock, 1996). Precipitation events and sprinkler irrigation upset the calculation of ET by the sensors because they measure soil water changes that do not represent the evaporation of water on the leaf surface following irrigation. For this reason, we decided that it would be impossible to construct the ET on days with significant precipitation or irrigation. Instead, we assumed the magnitude of ET on those days to be equal to that of the previous day.

Total seasonal ET was estimated using water balance equation (ET_{wb}) from early March to July 1 according to

\[
ET_{wb} = I + P + \Delta S - D - R
\]

where I is irrigation, P is precipitation, and \(\Delta S\) is the difference in soil water storage between the initial and final measurement dates in March and July. Drainage from the profile, D, and runoff, R, were assumed to be negligible.

The crop coefficient (Kc) was calculated as the ratio of ET_{sensors} to E_{Penman}. We estimated Kc by fitting polynomial equations to the Kc data from five-day periods throughout the season.

Table 1. Total ET until July 1 as measured by sensors, water balance, AgriMet, and Epenman, and seed yield and dry matter for 1994 and 1995, Madras, OR.

<table>
<thead>
<tr>
<th></th>
<th>ET_{sensors} (mm)</th>
<th>ET_{wb} (mm)</th>
<th>ET AgriMet (mm)</th>
<th>Epenman (mm)</th>
<th>Seed Yield (kg ha(^{-1}))</th>
<th>Dry Matter (kg ha(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>1994</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glade</td>
<td>367</td>
<td>367</td>
<td>367</td>
<td>553</td>
<td>94*</td>
<td>9,919</td>
</tr>
<tr>
<td>South Dakota</td>
<td>364</td>
<td>368</td>
<td>376</td>
<td>553</td>
<td>376</td>
<td>11,610</td>
</tr>
<tr>
<td>Average</td>
<td>365</td>
<td>367</td>
<td>376</td>
<td>553</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glade</td>
<td>246</td>
<td>302</td>
<td>363</td>
<td>485</td>
<td>591</td>
<td>6,980</td>
</tr>
<tr>
<td>South Dakota</td>
<td>269</td>
<td>305</td>
<td>363</td>
<td>485</td>
<td>563</td>
<td>9,819</td>
</tr>
<tr>
<td>Average</td>
<td>257</td>
<td>303</td>
<td>363</td>
<td>485</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*=significant at the 0.05 level

Results
In 1994, the seasonal ET_{sensor} values for the two cultivars did not differ significantly and were virtually identical to each other and to the ET_{wb} calculation (Table 1). In 1996, the mean ET_{sensor} was 257 mm and the ET between treatments differed by 23 mm, which is only 9 percent of the total. The ET_{wb} was higher than ET_{sensor} in 1996, possibly from drainage that occurred in the abnormally wet spring months but was not accounted for in the ET_{wb} calculations.
combine to give high estimates of ET. All of the above crop water estimates appear to be based on Kc values of turfgrass, for which considerable research has been done (Carrow et al. 1990). Unlike grass seed, turfgrass is regularly cut and is at full cover, which gives it a high Kc near 1.0. However, grass seed followed the water-use pattern of grain, in which Kc decreases late in the season as the plant shifts from vegetative growth to reproductive growth and relocation of assimilates.

The Bureau of Reclamation’s AgriMet ET estimates out-performed the above in approximating ET. These estimates were from daily calculated Etpenman based on the weather station data, in conjunction with Kc values that started in early March and ended in mid June (Bureau of Reclamation, 1995). The largest discrepancy between the AgriMet estimates and our data is the rate at which the Kc increases in earlier spring.

Late season irrigation in September and October is necessary to produce fertile tillers in the dry autumn climate of the Northwest, although it was not included in our analysis, nor those of the Bureau (1995) and Watts et al. (1968). Like the spring season analysis here, there is a need for actual measurements of late season crop water use and irrigation requirements.

The good agreement between ETsensor and ETwb in 1994, indicates that the multiplexed Watermark sensors can be an accurate method for estimating water use. We believe the discrepancy between the estimates in 1996 can be explained by drainage not included in the ETwb. The Watermark system has additional advantages of being inexpensive and somewhat portable from year to year (Mitchell and Shock, 1996).

References
Bureau of Reclamation. 1994. AgriMet Crop Curves. USBR, Boise, ID.