Response of drip-irrigated native spearmint to different water stress levels applied at different times

Prossie Nakawuka & Dr. Troy Peters
Biosystems Engineering Dept’, Washington State University, Pullman WA

Introduction

Nearly 40% of food and agricultural commodities are produced through irrigated agriculture on about 17% of agricultural land (FAO, 2002). Irrigation uses take almost 60% of all the world’s freshwater withdrawals (Kenny et al., 2009). Increasing municipal and industrial demands for water plus climate change have already decreased water allocated for agriculture. The challenge now is to increase food production with less water. Scheduling irrigations below the maximum crop requirement and allowing some extent of water stress either during a particular growth stage or throughout the entire growing season can improve water use efficiency and increase water productivity. The aim of this study was to quantify the effect of different stress levels applied at different times during the growing season on native spearmint’s oil yield and quality.

Materials and methods

The field experiment was conducted at the WSU UAREC, Prosser WA during the growing season of 2011. The mint field which was planted in 2010 is a completely randomized block design with 4 replications of each treatment.

The two factors under study included level of irrigation (or stress) and timing of the stress. Four levels of irrigation were considered, 100, 80, 54, and 40% of the crop water requirement. Timing also had four levels T1, T2, T3, and T4. For T1, the stress levels were applied throughout the growing season. For T2, T3, and T4, the plants were fully irrigated and the stress levels only applied 21, 14, and 7 days before harvest.

Results

Fresh hay yields

Table 2. Fresh hay yields per cutting for 2011

<table>
<thead>
<tr>
<th>Cutting</th>
<th>Fresh hay yield (tons/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>19.85a</td>
</tr>
<tr>
<td>2</td>
<td>11.03b</td>
</tr>
</tbody>
</table>

SE mean 0.315

Fig. 2. Changes in fresh hay yields due to irrigation amounts applied

Materials and methods

The field experiment was conducted at the WSU UAREC, Prosser WA during the growing season of 2011. The mint field which was planted in 2010 is a completely randomized block design with 4 replications of each treatment.

The two factors under study included level of irrigation (or stress) and timing of the stress. Four levels of irrigation were considered, 100, 80, 54, and 40% of the crop water requirement. Timing also had four levels T1, T2, T3, and T4. For T1, the stress levels were applied throughout the growing season. For T2, T3, and T4, the plants were fully irrigated and the stress levels only applied 21, 14, and 7 days before harvest.

Results

Fresh hay yields

Table 2. Fresh hay yields per cutting for 2011

<table>
<thead>
<tr>
<th>Cutting</th>
<th>Fresh hay yield (tons/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>19.85a</td>
</tr>
<tr>
<td>2</td>
<td>11.03b</td>
</tr>
</tbody>
</table>

SE mean 0.315

Fig. 2. Changes in fresh hay yields due to irrigation amounts applied

Oil yield

Table 3. Mean oil yield per cutting for 2011

<table>
<thead>
<tr>
<th>Irrigation level</th>
<th>Oil yield (µg/ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>67.61a</td>
</tr>
<tr>
<td>80</td>
<td>68.81a</td>
</tr>
<tr>
<td>100</td>
<td>70.62a</td>
</tr>
</tbody>
</table>

SE mean 2.537

Fig. 3. Variation of water use efficiency among irrigation levels

OIL CONCENTRATION

Table 4. Mean oil concentration for each treatment for 2011

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Oil concentration (µg/ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>0.265ab</td>
</tr>
<tr>
<td>80</td>
<td>0.217a</td>
</tr>
<tr>
<td>100</td>
<td>0.218a</td>
</tr>
</tbody>
</table>

SE mean 0.081

Fig. 5. Changes in oil concentration with changes in irrigation amounts applied

Discussion

The significant differences (p < 0.001) in irrigation and crop water use amounts indicate that treatments were effective in providing a wide range of soil water deficits. Interaction between irrigation levels and timing was significant for fresh hay yields (p = 0.0399), and there were also significant differences among treatments and cuttings. Fresh hay yields increased linearly with increase in the amount of irrigation applied.

There was no interaction between irrigation levels and timing for oil yield (p = 0.125). There were also no significant differences in oil yield among irrigation levels (p = 0.554), timing (p = 0.656), and cuttings (p = 0.277). This implies that considerable water can be saved by allowing some level of water stress to native spearmint plants, either throughout their growing period or within three weeks prior to harvest without affecting oil yields.

Temperature regulates flowering in mint, the timing of which is important since oil composition and yield are at optimum levels at flowering (Biggs and Leopold, 1955). This explains why hay yields for the second cutting were almost half those for the first cutting yet the oil yield for the second cutting was slightly higher than that for the first cutting. The EDD prior to the first harvest and second harvest were 1547.1 and 1898.2 respectively (40°F Base).

Fresh hay yield per acre decreased with increasing water stress although oil yield per acre didn’t significantly change as water stress increased, therefore less biomass had to be harvested during harvesting and distillation which might translate to reduction in costs of producing mint oil.

Both water use efficiency and oil concentration increased with increasing water stress, suggesting that water stress may induce early flowering in native spearmint since oil yields are optimum at flowering. Also, since less biomass is produced as water stress increases, shading of the lower leaves is minimized and the plant is therefore able to retain the more mature leaves. Oil quality and quantity is a result of both old and young leaves (Loomis, 1978).

The oil component analysis didn’t show significant differences among treatments for the major native spearmint constituents.

Conclusions

Water stress reduces biomass production in native spearmint.

Same oil yield with less water suggests that water stress may have encouraged essential oil accumulation.

Deficit irrigation can improve on water productivity of native spearmint.

On going work

An economic analysis is also underway to determine whether deficit irrigation can improve on farmers’ net income through saving on irrigation water costs and pumping costs.

The experiment is to be repeated in the 2012 growing season.

Acknowledgements

This work is supported by the USDA SCRI grant. We thank Ray Baker for his assistance in establishing and maintaining the mint field, harvesting and distilling the mint oil, and also acknowledge Romulus Okwany for his help during field establishment and harvesting.

Literature cited


For further information

Prossie Nakawuka
Research Assistant, Biosystems Engineering Dep’t', Washington State University, Pullman WA 21406 N Bunn Rd, Prosser WA 99350

Dr. Troy Peters
Associate Professor, Biosystems Engineering Dep’t, Washington State University, Pullman WA 21406 N Bunn Rd, Prosser WA 99350

Phone: 509-768-2226 Email: troy_peters@wsu.edu

Website: http://irrigation.wsu.edu