Abstract

Methanol applied to the foliage has been reported to reduce water use of C3 crops. A field experiment on peppermint measured plant performance and soil water depletion for methanol and an untreated control. No differences were found in dry matter yield, oil yield, plant height, leaf weight, or water use. Preliminary phytotoxicity studies showed no toxicity or necrosis at concentrations up to 99 percent methanol.

Introduction

Last fall 1992, Drs. Arthur M. Nonomura and A.A. Benson announced the results of field trials that claimed that foliar-applied methanol can increase crop production of C3 plants (Benson and Nonomura, 1992; Nonomura and Benson, 1992a, b, c). Methanol, commonly called wood alcohol, can reportedly reduce the photorespiration of C3 plants, which occurs under high light intensity, making them as efficient as C4 plants. In Arizona, methanol in aqueous solution was found to increase crop yield of plants under high light intensity, although species and cultivars of plants differed in their response. Also, phytotoxicity was reported between about 15 and 50 percent methanol, depending on the plant species. For this reason, methanol concentrations were reduced for sub-phytotoxic levels for field applications.

Methanol responses have been associated with high light intensities. Peppermint growth in central Oregon that contributes to oil yield primarily occurs in June, July, and early August. During these months, total daylight hours exceed those in Arizona, which suggests that peppermint might respond well to methanol.

According to Dr. Nonomura, treated plants appeared to require less water both during the growing period and near harvest because the plants matured sooner (Nonomura and Benson, 1992c; Mauney, 1993; L. A. Times, 1992). The potential for water conservation is important in drought-stricken areas, such as central Oregon. Water use for irrigation is increasingly debated throughout the West. If methanol does in fact reduce water requirements, then this may be a partial solution to increasing the water-use efficiency of crops.

We conducted exploratory research on the water conservation potential of methanol, using potatoes and peppermint, in addition to monitoring plant growth and yield. These crops should have a potential for yield increases because they exhibit wilting in the field during hot summer days (Nonomura, personal communication). Both crops are important to the agricultural economy of central Oregon. The objective of the experiments was to compare...
crop water use under methanol-treated and non-treated plots. Only the peppermint results are available at this time and will be reported.

Materials and Methods

Two preliminary studies on methanol toxicity took place in May. In the first, eight treatments of methanol concentrations in water in regular 10 percent intervals from 0 to 70 percent were applied to three replications in a randomized block design. A hand-held spray bottle was used to apply methanol solution to ten 1-ft \textsuperscript{2} plots. Application rate was 20 gal/ac. The second trial two weeks later was done in the same manner, with the additional concentrations of 80, 90, and 99 percent methanol, and to 4-ft \textsuperscript{2} plots. At the time of application, it was sunny and warm (approximately 70°F).

The water-use measurements were part of two larger studies. Methanol was applied in three replications in a randomized complete block design. The plots measured 9 x 30 ft. The initial methanol application rate was 20 gal/ac of solution that included a nutrient minimal enhancement media of 1 g/1 urea, 1 g/1 Triton, a surfactant. As experimental control comparisons, other treatments included totally untreated plots, and plots treated with a minimal enhancement media (MEM) consisting of 1 g/1 and 0.05 g/1 Triton X100. A glycine-phosphate treatment, as shown in Table 1, also was included as an alternative to methanol. Peppermint plots were sprayed on June 24, July 8, 23, and 29, and August 5. Because of the lack phytotoxicity and lack of discernable difference in plant growth, the last two applications were increased to 40 gal/ac of 75 percent methanol solution. Harvest was August 9 and 10-lb samples were distilled at a research distillery on location. Oil quality was tested by A.M. Todd, Kalamazoo, MI.

Due to cost, not all methanol treatments had the crop water use tested. Crop water use was tested for the treatments designated in Table 1.

Table 1. Treatments of methanol trial test for crop water use, Madras, OR, 1993.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Spray mixtures applied at rate of 20 gal/ac</th>
</tr>
</thead>
<tbody>
<tr>
<td>untreated</td>
<td>none</td>
</tr>
<tr>
<td>MEM*</td>
<td>1 g/1 urea and 0.05 g/1 Triton X100</td>
</tr>
<tr>
<td>methanol+MEM*</td>
<td>25% methanol + 1 g/1 urea and 0.05 g/1 Triton X100**</td>
</tr>
<tr>
<td>glycine</td>
<td>1% glycine + 0.1% phosphate + 0.05 g/1 Triton X100</td>
</tr>
</tbody>
</table>

* Water use tested for these treatments
** Percentage of methanol upped to 75% and rate of application increased to 40 gal/ac, beginning July 8, 1993.
Crop water use was measured with a series of granular matrix sensors (GMS) that were buried at several soil depths and multiplexed to an automated datalogger as shown in Figure 1 for peppermint. The change in soil water content was integrated for the soil depths to arrive at crop water use for the period between irrigations, assuming deep percolation was negligible. All methanol treatments were sprinkler irrigated at the same rates. The GMS were previously calibrated for soil tension (Eldridge et al. 1993) and for soil water content for the Madras loam (fine-loamy, mixed, mesic, Xerollic Durargid) on which the study took place.

Plant height was measured on July 29, 1993. Leaf mass was measured on August 9, 1993 for 40 plants per replication. Peppermint was harvested on August 9, 1993. Yield was determined from a swath measuring 40 inches wide x 25 ft. long, from which a subsample (approximately 10 lb) was reserved for oil yield analysis. Sacked peppermint was immediately dried in the open air and stored indoors until distillation in a small scale research distillery on location.

Results

No leaf toxicity or necrosis was observed in either preliminary toxicity trial, even at concentrations above 90 percent. As far as we know, this is the first such result for methanol-treated crops. One explanation may lie in the nature of the peppermint plant that consists of up to 2 percent alcohol. Such plants may possess mechanisms that resist alcohols such as methanol. It is possible that methanol failed to be taken into the cells of the peppermint leaves.

Plant height measurements showed no significant difference between the four treatments ($P < 0.05$). The overall average was 64.4 ± 4.1 cm. Leaf mass measurements taken at harvest also showed no significant differences between treatments.

There were no yield differences for the methanol treatments for peppermint. Average peppermint dry matter yield was 4,855±600 lb/ac and oil yield was 53.7 ± 3.1 lb/ac. Oil quality constituents menthol, menthofuran, esters, and total head were all found to be unaffected by methanol treatment.

Water use of peppermint was not influenced by methanol treatment as tested by ANOVA. The daily change in profile water content is shown in Figure 2 for the average of both treatments. The treatment values match each other very well, which demonstrates that the GMS method of measuring water gave consistent results. The average ET from June 9 to harvest on August 12 was 5.0 mm/day for the methanol treatment and 5.1 mm/day for the control. These ET values compared favorably with neutron-meter data from an adjacent field that showed an average of 5.0 mm/day for the same period.
Figure 1. Design of GMS data collection for peppermint methanol trial, Madras, OR, 1993.

**Methanol Peppermint Trial**

Average of all replications

![Graph showing the change in profile water (mm) over time for methanol and control treatments.]

Figure 2. Daily water use by methol-treated peppermint compared to the untreated control, Madras, OR, 1993. Positive values are irrigation while negative are soil water depletion.
Conclusion

Water use of methanol-treated peppermint did not differ from the untreated control. This was probably the result of the inefficacy of the methanol in increasing plant growth or yield under our conditions. Peppermint showed no sign of toxicity to methanol, unlike other plants. The GMS method of measuring change in profile water gave consistent results, but no differences were observed under the methanol treatment. It is unknown at this time whether lack of response was due to lower temperatures than reported for trials conducted in Arizona, somewhat cloudy conditions early in this trial, or due to other reasons.

References


