GROWTH AND FLOWERING OF SUGARCANE IN RELATION TO PHOTOPERIOD AND AIR HUMIDITY

M. H. Amin, E. S. Kassem, N. M. Bayoumi and Z. A. Menshawi
Assiut University and Egyptian Sugar and Distillation Company (U.A.R.)

ABSTRACT

This investigation was carried out in the 1966-67 season to study the effect of photoperiod and relative humidity on the growth and flowering of sugarcane. Thirty-four cane varieties, replicated 3 times, were potted on Aug 1, 1965. The first group was left, as control, to grow under natural conditions. The second was given the excess darkness treatment, whereas the third was treated with excess darkness plus misting during the daytime. The photoperiod treatment started on July 9th and continued for 85 cycles, with decreasing daylengths from 12 hr 23 min to 11 hr 55 min. Following this treatment the plants were kept under natural daylength. Night temperature inside the dark rooms was maintained above 70 F. From Aug 3rd to Oct 5th, 1966, the third group was given the high air humidity treatment in which maximum relative humidity was maintained around 93% by applying water in the form of a fine mist spray. The results indicated that either excess darkness or excess darkness plus misting during daytime promoted growth and flowering of canes compared to the control, the latter treatment being more effective. It was also observed that varieties differed in their optimum photoperiod and moisture requirements.

INTRODUCTION

Growth is largely a process of cell elongation associated with water intake; accordingly a close relationship has been found to exist between moisture and rate of cane elongation. Varma (14) claimed that high humidity, moderately high temperature, and a well distributed water supply are optimum for maximum cane growth. Bayoumi (3) found that canes subjected to excess darkness ranging from 12 hr 43 min to 11 hr 55 min were taller and had a higher number and longer internodes per stalk than those untreated. Kassem and Menshawi (9) reported that raising air humidity induced more linear growth in sugarcane. Moreover, various ranges of daylength have been found conducive to cane flowering. Chilton and Morcland (5), Chilton and Paliatseas (6), and Buzacott (4) were able to induce flowering by subjecting the plants to a day-length of 12 hr 44 min with a daily gradual decrease of 1 and 1.5 min. Paliatseas (12) induced floral initiation with a daylength ranging between 12 hr 30 min and 12 hr. Bayoumi (5) induced flowering in some cane varieties by subjecting the plants to the excess darkness treatment previously mentioned. Besides being primarily a photoperiod response, cane flowering is greatly conditioned by other factors, among which moisture and temperature are especially important. Rölsig, Ellis and Arceneaux (13), Daniels (7), and Menshawi (11) reported that a relative humidity of approximately 95% promoted flowering. Arceneaux and Kassem (2) claimed that low soil moisture
and low air humidity were probably the major deterrents to sugarcane arrowing in the U.A.R. High daytime temperatures and low night temperatures, in September, were also considered unfavorable.

Accordingly, this investigation was carried out in the 1966-67 season at Assiut, U.A.R. at 27°—11' N lat, and 31°—19' E long, with an elevation of 183 feet above sea level, to study the effect of day length and air humidity on the growth and flowering of sugarcane.

MATERIALS AND METHODS

Thirty-four cane varieties of different origin, were planted on Aug 1, 1965, in pots of about 5 gal capacity. The plants were watered daily and given monthly doses of a complete fertilizer till they had formed in June 1966 at least 5 to 6 mature internodes.

The canes were divided into three similar groups. The first was left to grow under natural conditions to be used as control. The second was treated with excess darkness, while the third was subjected to excess darkness plus misting during the daytime.

To initiate flowering, the second and third groups were each mounted on a separate wagon which was daily rolled in and out a dark room. They were subjected to the experimental photoperiod for 85 cycles, from July 9 to Oct 1, 1966. The dark treatment was given daily in continuation of the night period. It started with a daylength of 12 hr 23 min decreasing at a rate of 1 min every 3 days, and ended with a daylength of 11 hr 55 min, excluding twilight. From Oct 1 onwards, the plants were left to grow under natural daylengths, the wagons being pushed inside the dark heated rooms 45 min after sunset and moved outside at sunrise. Night temperature inside the dark rooms was maintained above 70 F, using appropriate electrical heaters.

Air humidity was raised by applying tap water in the form of a fine mist spray, Fig. 1. The canes in the third group, when pushed outside the

Fig. 1. Canes treated with excess darkness, right, and treated with excess darkness plus misting during daytime, left.
photoperiod chamber and left on the concrete platform, were positioned directly under 12 water sprays fixed atop a wooden framing at a height of approx. 5 meters above the ground level. Each nozzle delivered about 2.04 gal/hr at 45 lb/sq in. Water sprays operated daily from 8am to 6pm, from Aug 3 to Oct 5, 1966, Fig. 2.

Fig. 2. Nozzles spraying a fine water mist spray over the canes.

Air temperature, relative humidity, and the visible flowering symptoms, i.e., flag and emergence dates, were recorded.

At harvest time, on May 1967, stalk and internode lengths were measured and the number of internodes per stalk for each variety was counted. In addition, the canes were longitudinally dissected to determine the terminal bud condition.

EXPERIMENTAL RESULTS

The September average outdoor maximum and daytime air humidity were 79.4 and 41.4%, respectively, whereas the mean maximum and daytime air temperature were 37.5 C and 31.6 C, respectively.

Misting during daytime resulted in an increase in the mean maximum and daytime relative humidity of 13.9 and 14.1%, respectively, and a decrease
in the mean maximum and daytime air temperature of 6.7 °C and 4.3 °C, respectively (Table 1).

Table 1. Mean maximum and daytime air temperature and relative humidity in September.

<table>
<thead>
<tr>
<th>Date</th>
<th>Air temperature (°C)</th>
<th></th>
<th>Air humidity (%)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mist.</td>
<td>Outdoor</td>
<td>Mist.</td>
<td>Outdoor</td>
</tr>
<tr>
<td>Sept 1-10</td>
<td>36.5</td>
<td>36.8</td>
<td>27.3</td>
<td>31.5</td>
</tr>
<tr>
<td>Sept 11-20</td>
<td>29.6</td>
<td>39.6</td>
<td>26.4</td>
<td>31.1</td>
</tr>
<tr>
<td>Sept 21-30</td>
<td>32.3</td>
<td>39.0</td>
<td>28.2</td>
<td>32.3</td>
</tr>
<tr>
<td>Mean</td>
<td>30.8</td>
<td>37.5</td>
<td>27.3</td>
<td>31.6</td>
</tr>
</tbody>
</table>

The mean stalk length, mean number of internodes per stalk and the mean length of internodes for both the treated and untreated canes, were statistically analysed using the paired t-test (Table 2).

Table 2. Mean stalk length, number of internodes per stalk, and mean length of internodes.

<table>
<thead>
<tr>
<th>Statistical values</th>
<th>Stalk length (m)</th>
<th>No. of internodes/stalk</th>
<th>Length of internode (cm)</th>
<th>Exc dark + Un-treated</th>
<th>Exc dark + misting</th>
<th>Exc dark + misting</th>
<th>Exc dark + misting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean t</td>
<td>2.90</td>
<td>3.13</td>
<td>1.76</td>
<td>41.00</td>
<td>40.00</td>
<td>34.00</td>
<td>6.30</td>
</tr>
<tr>
<td>t</td>
<td>7.02**</td>
<td>8.10**</td>
<td>1.40</td>
<td>3.25**</td>
<td>3.24**b</td>
<td>0.46**</td>
<td>8.18**</td>
</tr>
</tbody>
</table>

a Exc dark vs Untreated
b Exc dark + mist vs Untreated
* Significant at 5% level
** Highly significant at 1% level

Canes treated with excess darkness and excess darkness plus misting during the daytime were respectively, 65 and 78% taller, had 21 and 18% more internodes per stalk, and their internodes were 54 and 73% longer than the control. Differences in these characters were highly significant.

The 34 untreated varieties remained vegetative. When treated with excess darkness, 22 remained vegetative, 7 were initiated, 3 flowered and 2 varieties exhibited dead terminal buds. With excess darkness plus misting during the daytime 20 varieties remained vegetative, 6 were initiated and 8 flowered. Differences due to treatments were observed between and within varieties.

Comparison between individual plants showed that, in the case of excess darkness, the initiated and flowering plants constituted 23 and 9% of the total canes, respectively. With excess darkness plus misting during daytime they constituted 15 and 23%, respectively, whereas only 2% of the stalks exhibited dead terminal buds (Table 3).

With excess darkness, 3 varieties, 43F89, 54B480 and 59A1129, reached the flag stage and only 59A1129 emerged; whereas with excess darkness plus
Table 3. Percentage of plants with the different terminal bud conditions.

<table>
<thead>
<tr>
<th>State</th>
<th>Exc dark</th>
<th>Exc dark + misting</th>
<th>Untreated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetative</td>
<td>60</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>Initiated</td>
<td>23</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>Flowering</td>
<td>9</td>
<td>23</td>
<td>0</td>
</tr>
<tr>
<td>Dead</td>
<td>8</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

misting during daytime 8 varieties, namely 54B469, 54B480, 54B889, CL 47-83, 59A36, 59A76, 59A506 and 59A1129, reached the flag stage and all emerged.

Comparison between treatments showed that excess darkness plus misting during the daytime was more effective in promoting flowering than excess darkness alone. The former treatment resulted in 14.5 and 20.5% increases in the flagged and arrowing varieties. It also advanced the time of blooming by 34 days in the case of the variety 59A1129, which arrowed in response to both treatments.

DISCUSSION

Since all the untreated canes remained vegetative, whereas some varieties were induced to flower when subjected to a gradually decreasing day length ranging from 12 hr 23 min to 11 hr 55 min, it can be concluded that the flowering process of sugarcane can be photoperiodically controlled. Similar results were obtained by other workers.

It may be concluded that other environmental factors, such as relative humidity and maximum air temperature condition the sugarcane plant to respond favorably to the photoperiodical treatments. This conclusion is supported by the increase in percentage of flowering plants and by the advancement of blooming date when the plants were misted during daytime. Such phenomena were observed by other investigators. The flowering promotion due to specific daylengths in this study, as well as in others, may have been stimulated by the reduction in daily maximum and daytime temperatures within the misted canes. This observation is confirmed by the smaller percentage of plants with dead terminal buds in the misted canes where it reached 2% compared to 8% in the case of the varieties treated with excess darkness only.

The failure of some of the initiated canes to proceed through the subsequent flowering stages is due mostly to other unfavorable environmental factors, such as the natural daylengths that prevail at Assiut following Oct 1; such plants may require shorter days. Unfavorable temperature, as reported by Arceneaux and Kassem (2) and Daniels (7), may also be considered another obstacle. The dead terminal buds observed in this experiment as well as in others might be considered as an indication of adverse conditions prevailing after initiation.

Varietal differences in photoperiod requirements and the capricious
flowering behaviour within the plants of the same variety similarly treated in the experiment are in agreement with those observed by others.

The growth promotion in canes treated with either excess darkness or excess darkness plus misting during daytime is also in agreement with results reported by other investigators.

REFERENCES