WATER REQUIREMENT AND YIELD OF BANANA

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SUMMARY

The effect of the amount of irrigation water on the growth and yield of banana (Musa spp., cultivar Cavendish Dwarf) was investigated during a five-year period. Yields varied from year to year due to the occurrence of winter frost and strong winds. Monthly evapotranspiration increased from 50 mm in February to 220 mm in August, while its ratio to pan evaporation ranged from 0.6 in March-April to 1.0 in August-October. Seasonal irrigation with 1200 to 1300 mm of water proved sufficient. Under-irrigation delayed leaf growth, flowering and fruit maturity and reduced yield.

INTRODUCTION

Banana is mainly grown in the west coastal zone of Cyprus. It is cultivated in an area which increased from 54 ha in 1960 to 360 ha in 1990 and then decreased to 300 ha in 1996, while the value of its production was £0.04, 2.84 and 3.26 million, respectively (Papayiannis and Markou, 1998).

Banana requires an ample and frequent supply of good quality water. Regular irrigations at short intervals are needed over the entire growing season. There is little difference in crop reaction to water between different growth stages (Doorenbos and Kas-sam, 1979). Lahav et al. (1981) reported that drip irrigation advances flowering and shortens the flowering to maturation period. The drip system is considered as the most suitable for simulating soil moisture conditions typical of the tropics, to which banana reacts most favorably. It is expected that all banana plantations will eventually be irrigated by the drip method (Goldberg et al., 1976).

Due to the rapid development of the crop and its high water requirement, farmers generally irrigate at much higher levels than those derived from irrigation research (Lahav and Kalmar, 1987). Over-irrigation, however, results in waste of both water and fertilizers, since they are usually applied with the irrigation stream (fertigation). To avoid losses, a proper irrigation scheduling is needed. The objective of this study was to determine the irrigation requirement of banana and to examine the effect of suboptimal amounts of water on crop growth and yield.

MATERIALS AND METHODS

The experiment was conducted in the banana growing area (west coast of Cyprus) in 1989-94. The climate of the site is characterized by a wet winter followed by a long dry period. The average annual rainfall is 497 mm, 86% of which falls from October to March. Mean daily minimum and maximum air temperatures are 9.2 and 16.8 °C in February and 22.4 and 31.0 °C in August (Meteorological Service, 1984). Daily evaporation (screened USWB Class A pan) gradually increases from 4.5 mm in early spring to 7.5
mm during summer and decreases to 4.0 mm in late Autumn.

The soil up to a depth of 90 cm contains 45 to 50% clay, 25 to 30% silt and 20 to 25% sand. The CaCO3 content is 10 to 30% in the top 30 cm layer, increasing to 50 to 65% in deeper layers. Organic matter is generally low (0.5%) except in the 15 cm surface layer in which it is 1 to 2%. Dam water of good quality was used for irrigation (ECw=0.6 dS/m) containing 1.76 meq/l Cl ions.

The experimental orchard was planted to Cavendish Dwarf bananas at 3x3m in spring 1986. Excess suckers were removed every year so that three new pseudostems were left to develop at each plant position. These provided next year’s ratoon plants, following cutting of the old pseudostems at the end of the harvesting period (early April). Water was applied by drippers, spaced every 0.75 m on either side of the plant rows. Fertilizers (ammonium nitrate, monoammonium phosphate and potassium nitrate) were applied in constant concentration with the irrigation water at all irrigations. The nutrient concentrations were 40, 5 and 40 mg/l for N, P and K, respectively. In April and May each year, 20 kg Fe/ha in the EDTA chelated form (6% Fe) was applied with the irrigation water, in four applications at 15-day intervals. The irrigation requirement was calculated according to Doorenbos and Pruitt (1984) on the basis of Class A pan evaporation (Metochis, 1985). The coefficient used to relate pan evaporation to crop evapotranspiration ranged from 0.6 in April, when old pseudostems and excess suckers were removed, to 1.0 in August-October when the plants provided 100% ground cover. Irrigation was applied whenever 25 mm of the calculated requirement had accumulated, i.e. every two weeks in the early and late part of the irrigation season, every one week in May and October and twice a week during summer. Four irrigation treatments representing 60, 80, 100 and 120% of the irrigation requirement, corresponding, for a normal irrigation season, to 750, 1000, 1250 and 1500 mm, were tested. Each plot consisted of six plants (18 ratoons) and was replicated five times in randomized complete blocks.

At the end of each irrigation season soil samples were taken, below the drippers at 0.15 m increments to a depth of 1.2 m, for EC and Cl ions determinations on the satura-

**RESULTS AND DISCUSSION**

The derived values of the coefficients used to calculate evapotranspiration of banana from pan evaporation data, according to Doorenbos and Pruitt (1984), are presented in Fig. 1. Over the year these were: 0.85 in January, 0.65 in February, 0.60 in March-April, 0.65 in May, 0.75 in June, 0.90 in July, 1.00 in August-October and 0.95 in November-December. The above values agree with those suggested by Lahav and Kalmar (1987), reporting that evapotranspiration to pan evaporation ratio ranges from 0.50 in April to 1.00 in July-September. Robinson and Alberts (1989) also reported that for South Africa this ratio varied from 0.57 in winter to 1.01 in summer.

Calculated monthly banana evapotranspiration for a normal year increased gradually from 50 mm in February to 220 mm in August and declined, thereafter, almost linearly to reach 80 mm in December and January. Rainfall exceeded evapotranspiration only during the winter period (Fig. 1), therefore, irrigation every year started in early April and ended in late November-mid December, depending on the incidence of rainfall in late Autumn. In this way the calculated annual irrigation requirement during the 5-year experimental period ranged from 1200 to 1300 mm, which were applied in 48 to 52 irrigations. This amount of water exceeds by 100 to 200 mm the amount suggested by Lahav and Kalmar (1987), although pan evaporation and the coefficients used in the calculations were comparable. This was due to the longer irrigation season in Cyprus compared to that in Israel (240 to 260 vs 210 days).

Soil salinity at the end of each irrigation season was generally low, without any differences among treatments, due to the low concentration of salts in the irrigation water. Electrical conductivity and Cl ions content of the saturation extract ranged from 1.0 to
1.7 dS/m and 1.0 to 2.2 meq/l, respectively, throughout the soil profile. Salinity in the root zone over the five irrigation seasons remained the same from year to year. This was due to effective leaching of the low soil salinity by rainfall, which during winter exceeded the crop evapotranspiration (Fig. 1). Therefore, as was also found with grapefruit (Metochis, 1989) and olives (Metochis, 1998) under similar climatic conditions at the south coastal area of Cyprus, the application of water in excess of the crop requirement (intended for leaching) is not essential.

Regarding the nutritional status of the plants, as evidenced by leaf analysis, no differences were observed among treatments, while lime-induced chlorosis was prevented. During the study period, leaf N, P and K concentrations were 2.4 to 2.6, 0.18 to 0.22 and 2.5 to 3.0%. Micro elements, Fe, Zn, Mn and Cu, ranged from 120 to 200, 20 to 40, 1100 to 1500 and 9 to 16 ppm, respectively.

During the 5-year experimental period banana yields varied greatly from year to year. This was due to the adverse climatic conditions, mainly frost and strong winds occurring in the area, during the winter months. Depending on the degree of the damage on plant foliage and fruit, production of plots, not short of water, varied from 52 t/ha in 1992/93 to 75 t/ha in 1990/91 (Fig. 2). The low annual yield in 1992/93 was due to severe frost in mid-February which decreased the number of fruit bunches harvested; mean fruit bunch weight was also reduced (Fig. 2). On the contrary, in 1990/91 only minor damages on plant foliage were observed in early February due to strong winds, without any adverse effect on yield. Intermediate yield damages were also caused by frost (February) and strong winds (mid-November) in 1991/92 and 1993/94, respectively. Excluding the year of severe yield damage (1992/93), production was always higher than 60 t/ha when the irrigation requirement was fully met (Fig. 2), exceeding significantly the highest average yield in the banana growing area (Papayiannis and Markou, 1998). This yield compares favourably with production obtained in other banana producing countries (Doorenbos and Kassam, 1979; Goenaga and Irizarry, 1998; Lahav et al., 1981; Lahav and Kalmar, 1987).

Differential irrigation affected plant
growth and yield. Visual observations indicated a slower leaf growth when irrigation was restricted, which was more pronounced in plots receiving only 60% of the irrigation requirement. With the two higher amounts growth was similar, indicating that no benefit was obtained by applying more water than the calculated irrigation requirement.

Reduced irrigation affected flowering and fruit bunch formation. Excluding the first experimental season (1989/90), annual yield increased with increasing amount of water from 60 to 100% of the irrigation requirement due to greater number of fruit bunches produced (Fig. 2). Application of a higher amount of water had no effect on banana production. This agrees with Goenaga and Irizarry (1995), reporting that to attain high yields irrigation must replace the water lost through evapotranspiration, as calculated from pan evaporation measurements. Mean fruit bunch weight, although showing an increasing trend, was not affected by the amount of water (Fig. 2).

Restricted irrigation affected also the earliness of production. In agreement with Goenaga and Irizarry (1995), flowering, which usually starts in early July, and fruit maturity were delayed. As shown in Table 1, accumulated yield in early February was lower in plots irrigated with 60 and 80% of the irrigation requirement than when the plant needs for water were fully met (irrigation ≥1225 mm); moreover, the respective annual yields harvested by that time were 43, 55 and >60%. Differences in yield among treatments were due to the number of fruit bunches harvested, while fruit bunch weight was always similar under all treatments and increased gradually from 14 kg in early October (first harvest) to 25 kg in February, and then decreased to 20 kg in April.

Total production during the 5-year experimental period was similar when the irrigation requirement was met or when higher amount of water was applied. Reducing irrigation by 20 and 40% caused a 13 and 18% decrease in yield, respectively, which was due to the number of fruit bunches produced. Mean fruit bunch weight was similar for all treatments (Table 2). The results confirmed the values of the coefficients used (Fig. 1).

Figure 2. Banana yields as affected by different amounts of irrigation water (LSD at P<0.05).
Table 1. Cumulative banana yield (1990/91) as affected by different amounts of irrigation water applied

<table>
<thead>
<tr>
<th>Water applied</th>
<th>Annual irrigation (mm)</th>
<th>Fruit bunch yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of irrigation requirement</td>
<td></td>
<td>February</td>
</tr>
<tr>
<td>60</td>
<td>735</td>
<td>24.8 b</td>
</tr>
<tr>
<td>80</td>
<td>980</td>
<td>32.0 b</td>
</tr>
<tr>
<td>100</td>
<td>1225</td>
<td>47.7 a</td>
</tr>
<tr>
<td>120</td>
<td>1470</td>
<td>43.8 a</td>
</tr>
</tbody>
</table>

Figures within a column followed by different letters are significantly different at P<0.05.

Table 2. Total (five-year) banana production (1989/90 to 1993/94) as affected by different amounts of water applied

<table>
<thead>
<tr>
<th>Water applied</th>
<th>Fruit bunch yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of irrigation requirement</td>
<td>Annual irrigation (mm)</td>
</tr>
<tr>
<td>60</td>
<td>750</td>
</tr>
<tr>
<td>80</td>
<td>1000</td>
</tr>
<tr>
<td>100</td>
<td>1250</td>
</tr>
<tr>
<td>120</td>
<td>1500</td>
</tr>
</tbody>
</table>

Figures within a column followed by different letters are significantly different at P<0.05.

for calculating the irrigation requirement of banana from pan evaporation data according to Doorenbos and Pruitt (1984). They also indicated that no benefit is obtained by applying more water than the crop requirement. Irrigation, therefore, under the conditions of the experiment with 1200 to 1300 mm of water over the irrigation season proved sufficient for maximum banana production.

ACKNOWLEDGEMENTS

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REFERENCES


