Transpiration Rate and Water Status of a Mature Avocado Orchard as Related to Wetted Soil Volume

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Description of the problem

The avocado crop in Israel has expanded rapidly in the last 30 years, now accounting for approximately 12,000 ha, with average national yields ranging between 9 and 13 tonne ha-1 (Lomas, 1992). Most of the commercial orchards are concentrated in the central coastal plain, where the climatic conditions satisfactorily meet the crop requirements.

The avocado's importance in the Israeli fruit industry has increased, due to the increase in exports: almost twofold, from 1988 to 1992. In 1992 the avocado fruit export, mainly to the European market, reached 52.5 thousand tons, comprising 4.5% of the total fruit exports of the country, third in importance after citrus and apples (Affleck, 1992; FAO, 1992). However, the commercial production of avocado in Israel is restricted by large variations of yield among years that may reach 40-60% depending on the cultivar, climatic and site-specific factors (Lomas, 1992). This significant yield variability produces large fluctuations of export volumes between years, that cause serious marketing problems and economic losses to avocado growers in Israel. Therefore, information relating to proper crop management becomes increasingly important.

Several studies have been carried out in order to determine the factors affecting avocado yield in Israel. Among the main factors that have been described as directly affecting the avocado yield, considerable emphasis has been placed to the climate, the irrigation regime and the factors affecting the process of water uptake from the soil by the roots (Kalmar and Lahav, 1977; Lahav and Kalmar, 1977; Lahav and Trochoulias, 1981; Lahav and Kalmar, 1982; Levinson and Adato, 1991; Lomas, 1988; Lomas, 1992; Lomas and Zamet, 1994; Michelakis et al., 1993; Natan et al., 1991; Scholefield et al., 1980; Schroeder, 1976; Sedgley, 1977; Sedgley and Annells, 1981; Shilo, 1986; Steinhardt and Tomer, 1988; Steinhardt et al., 1989; Sterne et al., 1977; Whiley et al., 1988b).

Climatic factors influencing the evaporative atmospheric demand are responsible for variations in water use during the growing season. The influence of adverse temperatures occurring during the critical stages of flowering and fruit set, has been pointed out as one of the main factors responsible for the low fertility and yield variations observed in avocado orchards in Israel. Conditions of high temperatures accompanied by low relative humidity during the spring season cause a massive abscission of fruits and leaves in avocado, reducing the canopy evaporative area and the potential fruit yield (Argaman, 1983; Gafni, 1984; Levin, 1981; Lomas, 1988; Lomas, 1992; Tomer, 1977). It is well known that at times of high evaporative demand, water stress develops in the canopy of avocado trees, as a consequence of an excessive transpiration rate over the rate of uptake and conduction of water from the soil. If soil water stress develops at the first stages of fruit set, a strong competition for water will develop between the fruits and the leaves. As a result of such competition, the leaves extract water from the young avocado fruits, which shrink very severely and drop (Lahav and Kalmar, 1982). Tree physiological responses to such

environmental conditions determine the adaptation and performance of irrigated avocado trees growing in semi-arid environments (Scholefield et al., 1980).

Among the principal management factors influencing avocado yield, the irrigation regime has been extensively studied under various soil and weather conditions in the main cultivated areas in Israel (Kalmar and Lahav, 1977; Lahav and Kalmar, 1977; Lahav and Trochoulias, 1981; Lahav and Kalmar, 1982; Natan et al., 1991; Steinhardt and Tomer, 1988; Steinhardt et al., 1989). The effect of adequate irrigation is determinant during the periods of heat load occurring in the flowering and fruit set stages in order to avoid canopy water stress. Irrigation strengthen and accelerates the natural ability of the trees to adapt to harsh conditions (Levinson and Adato, 1991).

The maintenance of a tree water status adequate for achieving maximal yield depends on the ability of the avocado root system to take up the required available water from the soil. Avocado roots may supply enough water to satisfy tree requirements, as long as their activity is not limited by external or internal factors (Borys, 1986; Gefen, 1981; Lahav and Trochoulias, 1981; Lomas and Zamet, 1994). However, under high evaporative demand conditions like those occurring in the spring season in Israel, even the water supplied by irrigation is not enough to prevent canopy water stress and fruit drop (Honing and Lavee, 1989). This fact has been attributed to a limited size of the root system in the early spring season (Gefen, 1981).

The spatial distribution of avocado roots is affected by the pattern of soil moisture and soil hydraulic conductivity (Atkinson, 1980). One method for increasing the supply of water available to the tree is through increasing the total soil volume occupied by the roots (Taylor et al., 1983). Previous studies have demonstrated that avocado root distribution closely follows the wetted soil volume (Levinson and Adato, 1991; Michelakis et al., 1993), but it is not clear whether enlarged wetted soil volume increases root-mass production and water uptake capability of the total root system, as compared with a limited wetted soil volume. Therefore, we tested the effect of enlargement of the wetted soil volume on root growth, water uptake and canopy water status of an adult avocado orchard, during periods of high atmospheric evaporative demands in the flowering and fruit set stages. Measurements of leaf water potential, canopy temperature and tree transpiration were utilized to monitor the effect of enlargement of the wetted soil volume on avocado canopy water status.

Hypothesis and Objectives

In our study we considered two factors influencing the avocado water status: (i) the effect of wetted soil volume on the capacity of the tree to take up water from the soil in order to maintain an adequate canopy water status, and (ii) the effect of severe climatic conditions on tree water status during critical growth stages.

The main hypothesis associated with the experiment was that the development of a more extensive root system by enlargement of wetted soil volume via irrigation will improve the water uptake from the soil, and will therefore prevent deterioration of the tree water status during periods of environmental stress. Determination of a threshold value of available water required in

the active root zone to maintain an adequate water status of the avocado tree will facilitate the control of irrigation for a minimum water stress risk.

Flowering is a major event in the growth cycle of avocado. In Israel, conditions of environmental stress during the flowering season are associated with considerable yield loss in commercial orchards. Consequently, the secondary objective of this study was to determine the effect of high evaporative demands occurring during the flowering and fruit set period on avocado tree water status and yield potential.