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IRRIGATION SCHEDULES IN AN AVOCADO PLANTATION USING TRICKLE AND SPRINKLING IRRIGATION SYSTEMS

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Introduction

The avocado, which is a subtropical mesophyte, is grown in the coastal plain of Israel in areas where there is no danger of frost. This crop is particularly sensitive to soil moisture and aeration, and to salt concentration, especially chlorides. These characteristics, as well as the crop's economic value, led to search for new and more efficient methods of water application, such as permanent installations with a sprinkler for each tree, and more recently, trickle irrigation.

The trickle irrigation method was first developed in the arid zones of Israel (with a hot, dry climate and high salt concentrations in the water) where its use has produced large yields. By comparison, the yields obtained by sprinkling were lower by 50% or more. These achievements with trickle irrigation are attributed to the system's ability to directly provide the plant's root system with water and nutrients at an optimum rate, independently of the soil's composition and properties. The constant addition of water at a rate similar to the evapotranspiration level maintains a low water tension in the soil, with no fluctuations in the matrix and osmotic potentials between successive irrigations.

It is reasonable to expect that those characteristics of trickle irrigation responsible for the achievement of such remarkable results under extreme growing conditions will have a similar effect on crops sensitive to water regime and salinity when grown under much better conditions.

The purpose of the avocado experiment was to study whether the use of trickle irrigation under normal growing condition (favorable climate, medium-textured soil and good quality water containing about 70 mg Cl/L) will enhance growth and increase yields above those normally obtained with sprinkler irrigation.

The first stage of the research began when the grove was planted in the spring of 1968, and included the testing of different trickle nozzles, and measurements of water distribution, salt accumulation and growth rate of the young trees irrigated at different frequencies by trickle and sprinkler irrigation.

ARRANGEMENT OF THE TRICKLE SYSTEM IN THE FIELD

During the first years after planting the avocado, one lateral of nozzles was sufficient to wet the root zone. The planting distance is 6 x 6 m, and thus the laterals were placed 6 m apart. On these laterals were located nozzles with a 1 gallon/hour discharge, 2 nozzles were used per tree, at a distance of 0.5 m to each side of the tree. As the plantation matured 2 additional nozzles have been added along the lateral, providing a spacing of 1 m between nozzles.

Method of operation

The water pressure in the general sprinkling and trickle irrigation network is 2.5 atm. (atmospheres). The components attached at the head of the trickle system, including the filter, reduce the pressure by about 0.5 atm., and the pressure regulators maintain a constant operating pressure of 1 atm. at the head of the trickle lateral.

At the beginning of each plot is a secondary line which distributes the water into the trickle laterals. At the beginning of this secondary line is connected a discharge regulator whose capacity is in accordance with the size and number of nozzles being used. In preparation for irrigation, the technician adjusts the automatic valve at the "head" to deliver the desired quantity of water. The irrigation is terminated automatically after this amount is discharged.

To apply fertilizer materials, the tank is connected to the "head", and the nutrient solution is introduced into the water flowing to the trickle network.

Sprinkling method

During the first and second year of the experiment the sprinkling was carried out by placing one static spray nozzle beside each tree. Each nozzle discharged about 80 l/hr. (liters). Each sprinkling plot is equipped with a separate automatic valve and a water meter. Fertilizer is broadcast by hand, with each tree receiving a measured quantity. At the third year a rotating hummer type sprinkler with discharge of 120 l/hr replaced the static nozzle.

Experimental design

A randomized block design was used, with the treatments replicated 4 times. Each plot consists of 4-6 rows, with 6-8 trees per row. Since each tree is irrigated individually, and the trees are still young and do not completely cover the ground, there are no border rows being used at the present stage of the experiment.

The irrigation treatments are as follows:

Trickle irrigation: A — every day, B — twice a week, C — once a week.

Sprinkler irrigation: D — once a week, E — once every two weeks.

During the first year of the experiment, the water amounts were based on a uniform water loss for the entire field of 1 mm*/day (36 liters/tree) *(*Loss in millimeters from an evaporative pan*.) For the second and third year, a rate of 2 mm/day was used and for the fourth year a rate of 3 mm/day was used. The total annual application was 200 mm, 400 mm and 600 mm respectively.

Varieties and rootstocks

The avocado varieties included in the experiment are Fuerte, Hass and Ettinger. All three are arranged in regular series in all the treatments, and are grafted on Mexican and West Indian rootstocks in alternate rows.

Measurements

In the spring, before irrigation is begun, and in the fall (the end of the irrigation season), soil samples were collected to determine the moisture profile and salt content at various distances from the tree trunk. At the same time, measurements were made of tree height and thickness of scion and rootstock. These thickness measurements were made on all the trees of each treatment using a calibermeter, 4 cm below and 8 cm above the graft. Daily measurements of soil moisture changes at depths of 8" and 24" has been done using tensiometers.

RESULTS

During the first three years of the research no differences could be detected between the different soil moisture regimes. The amount of water customarily applied by farmers during this period, 1-2 mm/day, was greater than the actual evapotranspiration, and the soil moisture tension measured by tensiometers did not exceed 35 cb (centibars) in any of the treatments. Only in the fourth year (1971/72) was there a difference in soil moisture between the treatments, and a clear response of the tensiometers to the irrigation regime.

There was a general relation between the total salinity of the soil and in chloride content. Therefore, the electrical conductivity in the soil profile is presented for 1969 and 1971 in Figures 1 and 2, respectively, as measured perpendicular to the crop row. It was not possible in 1971 to measure the conductivity at a distance of 20 cm from the trunk, and the determinations were begun at a distance of 70 cm.

Regarding tree development, no significant differences have been found until now between the various treatments.

DISCUSSION AND SUMMARY

During the initial stages of plant development, soil moisture regime and nutrition play a major role. Nevertheless, the experiment has shown that during this period the plant requirement for water is relatively moderate, and in the treatments studied the plants were not severely stressed, and there was no detectable advantage of any of the treatments. Only in the fourth year was there a noticeable effect of irrigation regime on the moisture tension in the root zone. Two phenomena shown in the figures pertaining to trickle irrigation deserve special attention: (Figure 3)

1. When irrigation was daily, the measured tension on the first day of the week was particularly high. (Irrigations were not given on the Sabbath, but a double amount was applied on Friday).
2. When irrigations were given twice weekly, the soil moisture tension on the fourth day, just prior to irrigation, was much higher than that on the third day, just prior to irrigation.

FIG. 1 : SALTS DISTRIBUTION AND ACCUMULATION (1969)

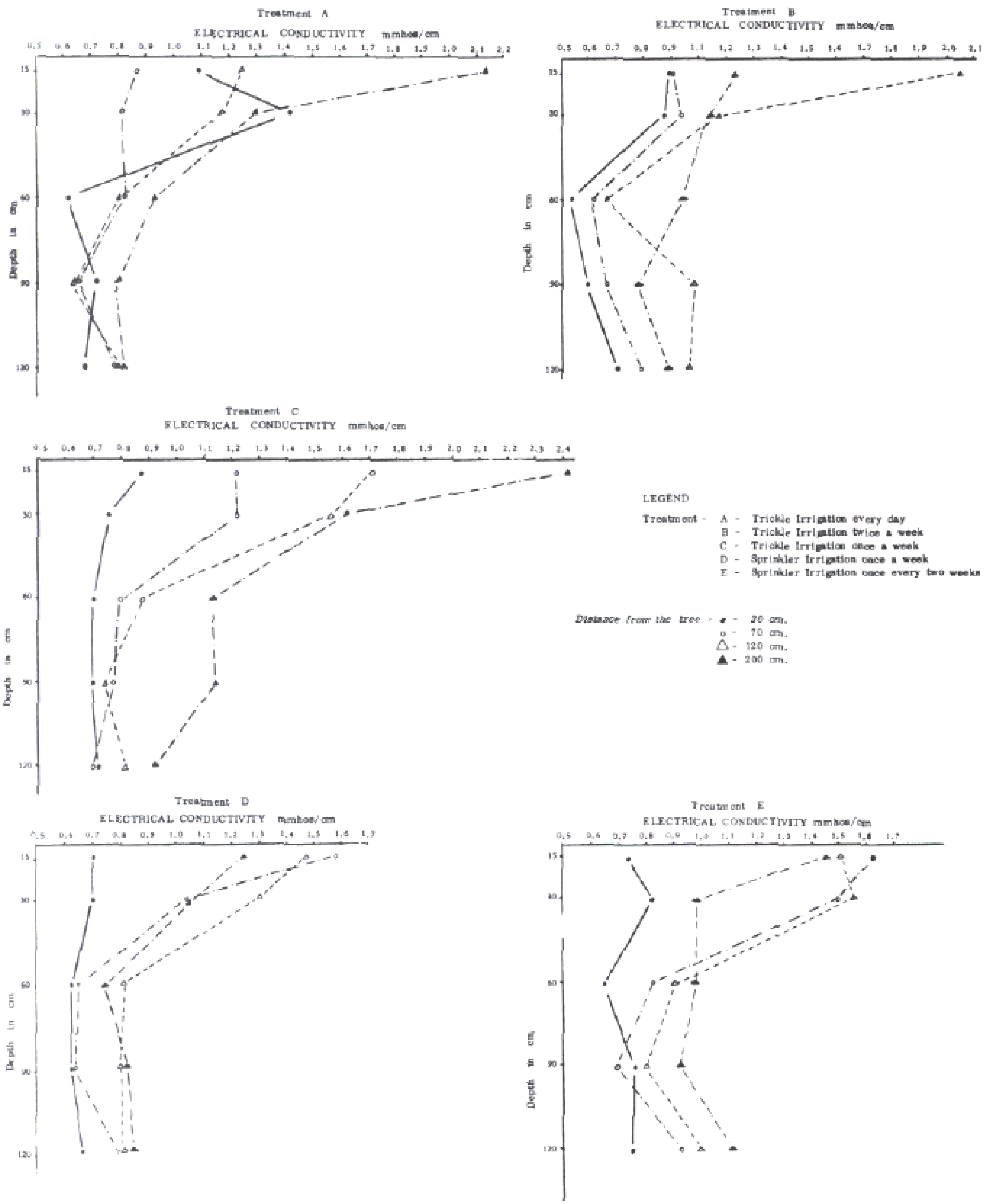
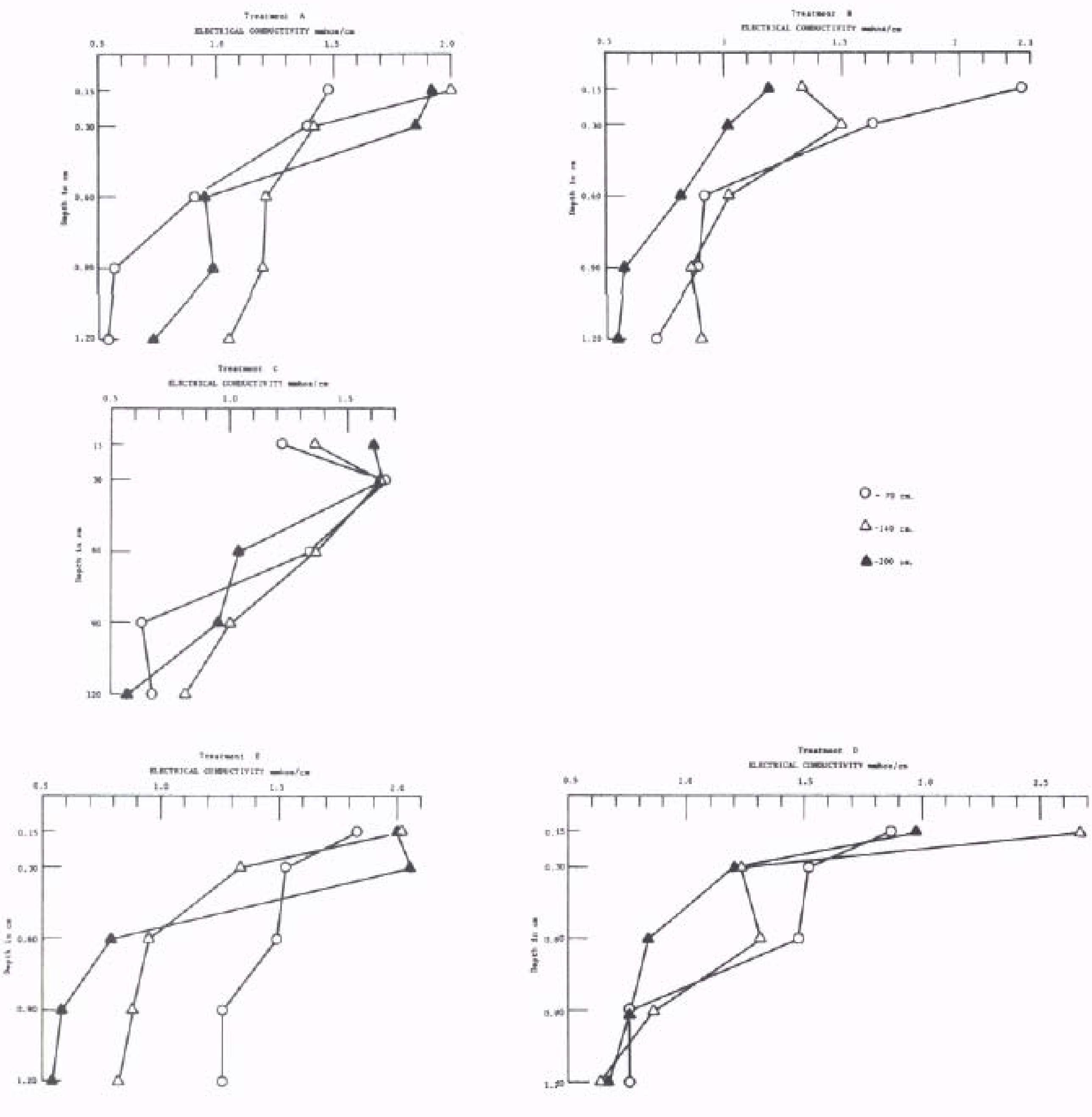
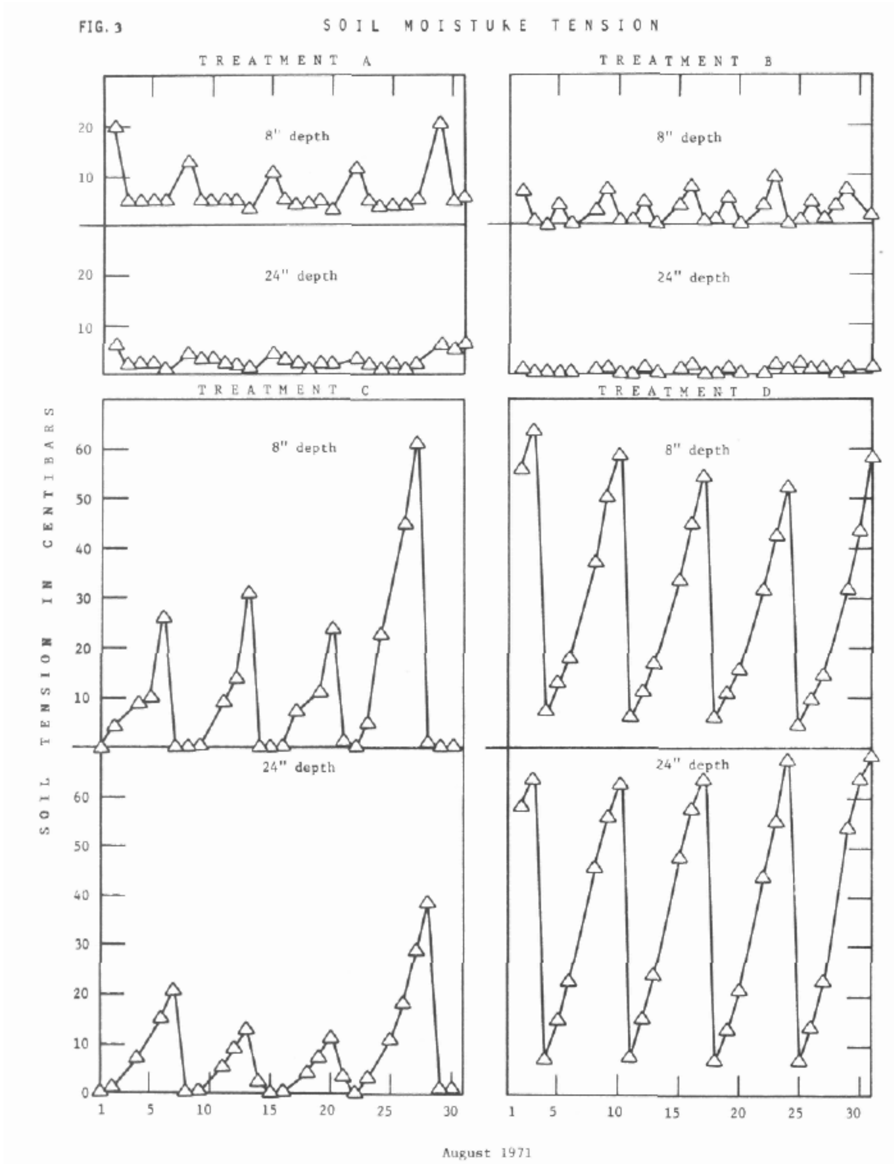


FIG. 2 : SALTS DISTRIBUTION AND ACCUMULATION (1971)





These two phenomena clearly show that the application of water at short intervals, using small amounts equal to the daily evapotranspiration rate, does not maintain a reserve supply of moisture in the soil which will be adequate in the eventuality of a breakdown in the irrigation system or in the case of especially hot and dry days. This condition, also found in trickle irrigation experiments with other crops, is even more greatly emphasized by the reduced active root zone close to the trickier, and the high concentration of rootlets in a very small volume of soil.

The relation between the irrigation method and soil water tension on the one hand, and the accumulation of salts in the soil on the other hand, depends also on the amount of rainfall. Salinity determinations made annually in the spring showed that all the salts which accumulated during the previous season were completely leached out by the rains, and the salt concentration returned to its initial level — 0.5 - 0.7 mmhos/cm.

However, at the end of the hot season there were differences between the trickle and sprinkle irrigation regimes. There was also a difference between sprinkling with a 1969 nozzle and sprinkling with a 1971 hammer-type sprinkler. Since soluble salts generally move with the water, a knowledge of the water distribution will make it possible to understand the movement of salts and the nature of their accumulation.

In a field where the entire surface is uniformly wetted by sprinkling, the main direction of water movement is downward. In trickle irrigation, water movement is mainly influenced by capillary forces, and the water spreads throughout the soil in the form of concentric circles around the trickier. During the first two years of the experiment there was a certain similarity between the trickle method and sprinkling with nozzles concerning the nature of water distribution. Since the nozzles spread the water in diameter of only 60-80 cm, there was a fair amount of spread from a central point to the sides. However, as the rate of application was considerably higher than in the case of trickling, the water moved downward due to gravity to a greater extent, and to the sides to a lesser degree.

Although with the hammer-type sprinkler the wetted soil surface was much larger than in the case of trickling or with nozzles, the water distribution is not uniform, and at greater distances from the sprinkler the amount of water decreases. It can be assumed, therefore, that also in the case of the hammer-type sprinkler, where the entire soil surface is not uniformly wetted, those places receiving a small amount of water will not be wet enough for leaching and salt accumulation will be similar to that resulting from trickling.