Sprinkle, Furrow and Trickle Irrigation of Muskmelon in an Arid Zone[1]

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Abstract. **In a comparison of sprinkle, furrow and trickle irrigation applied during the growing season from August to December to muskmelon (*Cucumis melo* L. cv. Haogen-2), vegetative growth was found more rapid and yields were earlier and higher with the trickle method. No yield differences were detected between sprinkle and furrow irrigation. Salt accumulation on the leaves was greater with sprinkling than with the other 2 methods which do not wet the foliage. The chloride concn in the leaves was also high throughout the entire growing season with sprinkle irrigation. Soil chloride content during the growing season varied according to the method of irrigation.**

The muskmelon is a summer plant. Its cultivation during a transition period between favorable climatic conditions and marginal conditions demands that there be a rapid initial vegetative development, with no delay in the onset of the reproductive stage. This is not achieved by earlier seeding of the crop, since fruit development begins while temperatures are still relatively high, and the early maturity reduces the crop's economic value.

When optimal applications of nitrogen are given, the main factors affecting melon yields are soil moisture and salinity (2). Under conditions of irrigation with saline water, these 2 factors are regulated to a great extent by the irrigation method.

Methods. The experiment was conducted at Yotvata in the Arava Valley in the south of Israel. It is a desert region, and the agriculture there is based on growing out-of-season vegetables on an intensive scale. The growing season begins in August and ends in May (Table 1). The soil is a sand to a loamy sand, with a $CaCO_3$ content of approx 15%. In irrigated soil, the pH of a saturated soil paste is 7.7 to 8.2. The cation exchange capacity is very low, between 2-4 meq/100 g soil. The soil is naturally saline, and the customary practice is to leach it by sprinkling before putting it under cultivation. All irrigations are with well-water having an electrical conductivity of 3.1 mmhos/cm. The concn of the major ions, expressed in meq/liter are as follows: Ca^{+2} = 18.2, Mg^{+2} = 7.5, Na^- = 14.6, K^- = 0.5, Cl^-= 15.9, SO_4^{-2} = 20.9, and HCO_3^- = 4.0. According to the U. S. Salinity Laboratory, this type of water is classified as C_4S_1.

The muskmelons were planted in double-row beds on August 2, 1967. Plant density was 22,000 plants per ha, and the net area of a single plot was 27 m^2. Each of the 3 methods of irrigation was replicated 4 times in a randomized block design.

The intervals between irrigations and the amounts of water applied were identical for all 3 irrigation methods. Applications were every 2-3 days, and the amount was based on the evaporation from a U. S. Weather Bureau Class A pan located near the plots. A total of 645 mm was applied to the crop in each treatment, including 15 mm rainfull which fell within a short period of time. In the sprinkle treatment, water was applied at the rate of 5 mm/hr at night in order to avoid interference by wind and losses from evaporation (5, 6). For the furrow irrigations, short rows 12 m in length were employed in order to achieve uniform water distribution, with the furrows prepared in the form recommended for saline conditions (1). The trickle irrigation method has been described previously (7).

Manure and superphosphate were given prior to planting, as is customary in the region. Nitrogen was added only as a side-dressing, beginning 14 days after planting, over a period of 70 days applied in liquid form through the trickle irrigation system and as a solid in the other 2 irrigation methods. Applications were made with every irrigation, and calculated to supply 4.5 kg N/ha/day.

Soil samples for salinity measurements were collected before the experiment began and at the end of the season, in one of the blocks, in 6 replicates. The samples were removed from the crop row, and extracts prepared from 1 soil : 1 water pastes. Chloride concn was determined with a Cotlove-type Buchler chloridometer. Leaf tests were performed by using standard methods (8). The degree of contamination of the leaf surface by salts was determined as follows: A fresh sample of leaves of uniform wt was dipped for 10 sec in 100 cc of water, with constant agitation. The leaves were then removed and dry wt determined. The electrical conductivity of the wash-water was measured in micromhos/cm at 25°C with a Wheatstone bridge circuit, and a "Contamination Index" calculated which expresses the electrical conductivity of the water in micromhos/cm per g of dry matter.

Vegetative growth. Growth rates, determined by weighing entire plants, are presented in Fig. 1. The rates were different for the 3 methods, with the highest in the case of trickle, followed by furrow and sprinkle irrigation, in that order. The rates were particularly high in the period between 25 to about 55 days from planting. Samples of the 3rd, 4th, and 5th leaves on the main stem, which were 10, 20, and 43 days old, respectively, had the same wt in all 3 irrigation methods. The average fresh wt of these leaves was 4.8, 6.6, and 6.3 g. The total dry wt (at 65°C) of the leaves per plant at the end of the experiment were 486 g (sprinkle), 733 g (furrow), and 917 g (trickle). These differences are significant at the 5% level. It seems, therefore, that the increased growth rate of muskmelon plants irrigated by trickling is mainly due to the greater no. of leaves on the individual plant. The dry wt values at the end of the growing season do not completely reflect the difference between treatments in the plants'

Table 1. **Climatological data for the experimental site in the Arava Valley, Israel.**

Month	Mean daily air temperature, °C Min	Max	Mean daily relative humidity (%)	Class A pan evaporation (mm/day)
Jan.	7.1	20.0	61	4.9
Feb.	6.4	21.6	51	6.3
Mar.	9.5	25.0	43	8.4
April	14.4	30.7	38	11.1
May	18.8	34.3	36	14.2
June	19.7	37.4	44	16.3
July	21.4	38.6	43	15.7
Aug.	22.8	39.3	30	15.5
Sept.	19.7	36.7	53	13.1
Oct.	17.4	33.0	57	9.8
Nov.	13.6	28.3	68	7.4
Dec.	7.5	23.6	62	5.2

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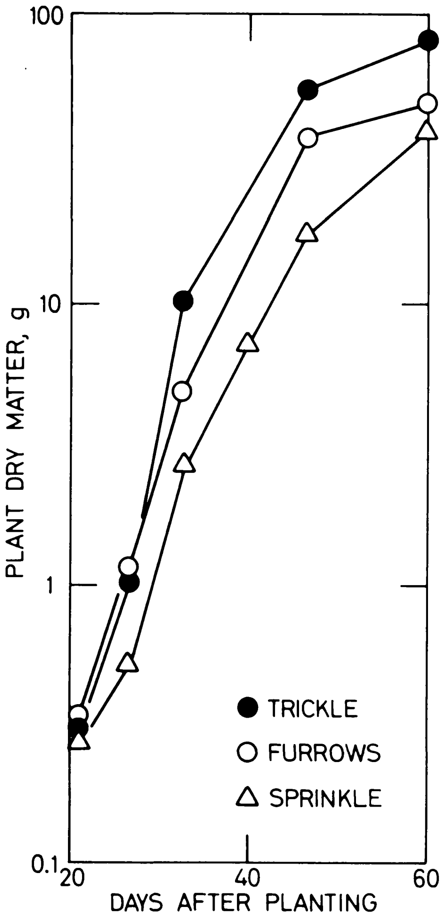

Fig. 1. Growth of muskmelons under trickle, furrow, and sprinkle irrigation.

Table 2. The yield of muskmelons obtained with 3 irrigation methods, and % distribution of fruit according to size.

Variable	Irrigation method Sprinkle	Furrow	Trickle
Total yield (kg/plot)	72.1 b[z]	78.7 b	113.9 a
Exportable[y] yield (kg/plot)	55.8 b	46.1 b	84.7 a
Size distribution		*% of total no. of fruit*	
>5 (large)	3.9	24.6	17.8
6-8 (medium)	35.8	37.7	46.5
9-11 (small)	60.3	37.7	35.7

[y]Fruit size and quality acceptable by international marketing standards.

[z]Values in each row followed by the same letter do not differ significantly at the 5% level, according to the Q-test.

vegetative condition. The foliage in the trickled plots was fresher at the end of the season, and the percentage dry wt of the leaves was lower than in the sprinkle and furrow plots where many of the leaves were dry.

Yield. Pistillate flowering began 35 days from planting in each irrigation method. The date of ripening of the first fruit was not the same, however. The first fruit ripened 59 days from the beginning of pistillate flowering with sprinkle irrigation, after 50 days with furrow irrigation, and after 41 days with trickle irrigation.

There was a significant increase in yield due to trickle irrigation but no significant difference between the other 2 methods (Table 2). The increased yield by trickling can be attributed in part to the greater no. of fruit per plant which reached marketable size, and in part to the greater no. of large fruit. There was more large fruit with furrow than with sprinkle irrigation.

Chloride contamination of the leaves. Contamination of the leaf surface by salts from the irrigation water was examined on leaves 10, 20, and 43 days old. The 43-day-old samples were collected shortly after a rainfall of 15 mm. Sprinkle irrigation with saline water resulted in external contamination of the leaf (Table 3).

Table 3. The "Contamination Index", in micromhos/cm at 25°C per g of plant dry matter.

Leaf age, days	Irrigation method Sprinkle	Furrow	Trickle
10	7.76a[z]	4.51 b	4.48 b
20	9.37 a	6.23 b	6.81 b
43	4.72 a	5.28 a	4.43 a

[z]Values in each row followed by the same letter do not differ significantly at the 5% level, according to the Q-test.

This was to be anticipated since melon leaves are hairy and have a rough surface. The washing of the 43-day-old leaves by a relatively light rainfall resulted in similar values being obtained for all 3 irrigation methods. The chloride concn (expressed on a dry matter basis) in the melon leaves throughout the growing season is described in Fig. 2. There were wide fluctuations in the concn. especially under sprinkle irrigation conditions. The leaf chloride content in this treatment was greater throughout the entire sampling period than that resulting from the furrow and trickle methods. The differences between these last 2 were not significant.

Ehlig and Bernstein (4) examined the absorption of sodium and chloride by

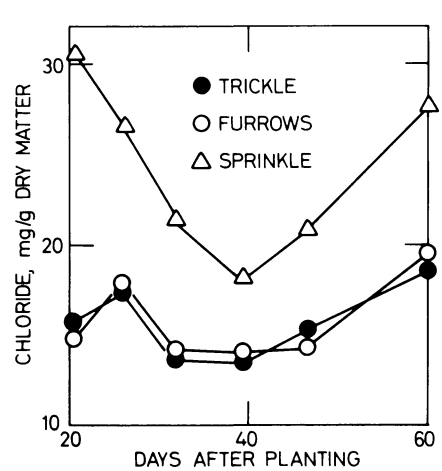

Fig. 2. Chloride concn in muskmelon leaves.

leaves of 4 vegetable crops irrigated by sprinkling with water of different salinities. They concluded that in the case of forage and vegetable crops there is no absorption of chloride by the leaves from the irrigation water. These results were obtained under experimental conditions in which 2-3-hr sprinklings were given weekly. In another experiment with strawberries, a similar conclusion was reached (3). On the other hand, it was stated in this work, in which the weekly irrigations lasted for 5-6 hr, that more lengthy irrigations might cause plant damage under certain conditions. In neither of these 2 experiments were any cucurbit crops included. In the experiment reported here, sprinkle irrigations lasted for a total of approx 130 hr. In another experiment with cucumbers conducted under similar conditions, we observed serious burning of the leaves by the irrigation water, to the extent that the foliage was completely destroyed and the crop died. There was no visible damage to the leaves in the experiment reported here, nor was there any change in leaf wt.

Soil salinity. Because the experiment was conducted on a field which was uniformly leached before the growing season by sprinkle irrigation, the absolute values of soil salinity were low, and the irrigation practice was planned so that the values would not become excessively high during the season. Thus, the main aspect of the study was to compare the processes of salt accumulation or leaching with the different methods of irrigation. The values of accumulation or leaching of the chloride content of soil-water extracts represent the differences in concn between samplings made at the beginning and the end of the experiment (Fig. 3).

With sprinkle irrigation, an equilibrium was reached, so that during the growing season there was practically no change in chloride concn in the soil profile. That is, the magnitude of water application was sufficient to prevent the accumulation of soluble salts, and on the other hand the amounts were small

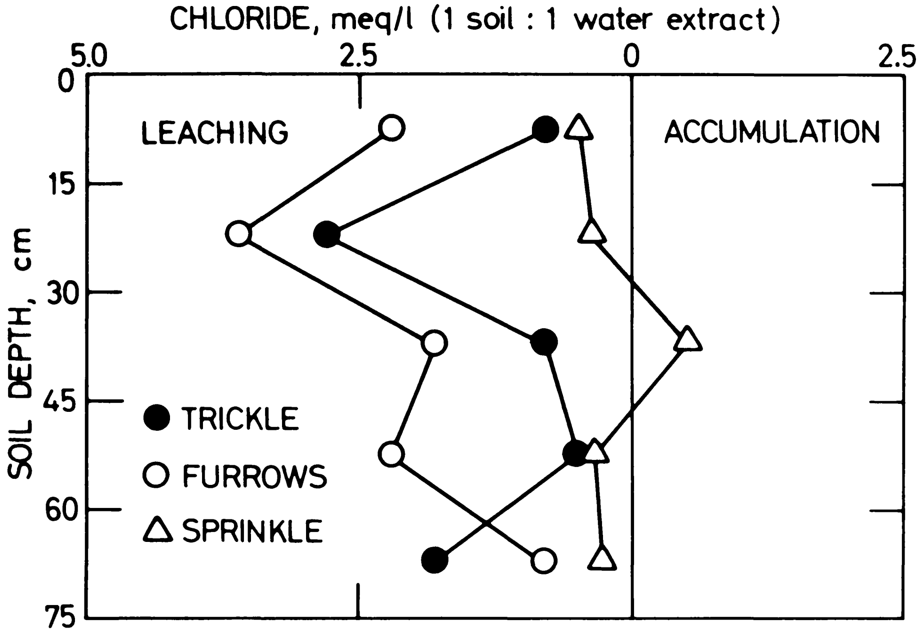

Fig. 3. Differences between chloride concn at the beginning and end of irrigation.

enough to prevent further leaching during the course of the growing season. Under conditions of furrow or trickle irrigation, there was additional leaching of the chlorides, especially in the 15-45 cm soil layer within the row where the samplings were made. With these irrigation methods, the same amount of water as that applied by sprinkling passes through a smaller soil volume due to wetting in the form of strips. This brings about a gradual reduction in chloride concn during the season. In trickle irrigation, there is a trend for the salts to accumulate in a thin crust on the soil surface, in the region of the wetted strip of soil (7). This acounts for the relatively high value recorded in the 0 to 15-cm layer, which includes both the saline crust of a few cm in depth and the rest of the layer which is less saline.

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Sprinkle and Trickle Irrigation of Green Pepper in an Arid Zone[1]

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Abstract. **Pepper plants (*Capsicum annuum* L. cv. California Wonder) were sprinkle and trickle irrigated, each at 2 different frequencies, during the growing season from September to April. Yield, leaf growth, and root development were all greater with trickle than with sprinkle irrigation. Frequency of water application had a slight, but non-significant effect. Yield tended to decrease when the plants were sprinkle irrigated daily. With trickle irrigation, the infrequent interval, every 5 days, tended to reduce the yield. Leaf chloride content was considerably greater under sprinkling, especially at the frequent interval.**

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The research reported here is part of a study to compare sprinkle and trickle irrigation. The interval between irrigations determines, to a large extent, the soil water potential to which the plant roots will be exposed during most of the growing season. The values of total soil water potential, especially in sandy soil and in the presence of a saline soil solution, may change widely over relatively short periods of time. The actual conditions prevailing in the root zone for a certain type of soil and water will depend on the evaporative demand as well as on the soil moisture content and the relative rate of salt leaching and accumulation at the end of the irrigation. These last conditions are largely determined by the method of water application, and differ in trickle irrigation from other methods (5, 6).

Little direct information is available concerning the response of pepper to water regime and salinity under field conditions. Robinson, et al. (11, 12) examined the response of a no. of vegetable crops to gravitational and sprinkle irrigation methods. They described the characteristics of the more commonly used sprinkler method, especially from the point of view of effect on plant population, initial growth rate, and the better salinity profile for early plant development. According to the Salinity Laboratory at Riverside (10), pepper is classified as being moderately sensitive to soil salinity. Average electrical conductivity values of 5 mmhos/cm in the soil profile cause a yield reduction of 50% or more. Another study (9) tested the effect of applying water of various salinities to pepper plants at different ages. Leaf production dropped sharply when saline conditions were imposed at the early germination stage, while later applications of saline water resulted in only a slight yield reduction. There was also a marked drop in evapotranspiration with an increase in