DRIP IRRIGATION OF CITRUS—PANEL

SOME EXPERIENCES WITH DRIP IRRIGATION IN MEXICO[1]

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Dependence on water is a characteristic of all nations. Water is a fundamental element as much in agricultural products as it is in industrial products. It has been estimated that production of one can of vegetables requires 40 liters of water. The transformation of petroleum, a very important factor for industrialized economies, could never subsist without water, as it requires the use of 10 liters of water to obtain 1 liter of gasoline. We have heard 2 fine papers during today's session about overhead irrigation and flood irrigation. We will now deal with drip irrigation systems.

Drip irrigation consists fundamentally of delivering water to the root zone of plants by means of a system of tubing and allowing it to leave in a manner controlled by means of dispersers of various types, which are generally called emitters. Water is distributed to plants, in our case, citrus, with strict control of quantity of water and period of time irrigated. Drip irrigation is characterized by maintaining soil moisture of an adequate section of the root system between saturation and field capacity during the growing season or during a predetermined time.

Many papers have mentioned a various number of advantages of this system of irrigation. The most important are:

1) It can be used in soils with extreme changes in topography, where other systems cannot be used, or would cause problems of erosion.
2) It permits the use of low-volume sources of water.
3) It permits the use of water with relatively high content of soluble salts (it has been reported that drip irrigation can use water with as much as 3,000 ppm soluble salts).
4) It permits water savings as compared to other systems of irrigation due to the efficiency of water distribution and application.
5) There are fewer weeds, which means lower costs of production.
6) Costs of operation are generally lower than other systems of irrigation.
7) Irrigation systems can be designed for easy operation, with the possibility of total automation due to the diversity of equipment and material.
8) Utilization of lower volumes of water, savings realized in some cultural practices, and low cost of operation compensate for the initial costs of the equipment and its installation, thus permitting ammortization in a short period of time.
9) There is practically no interference with orchard management (cultivation, spraying, harvesting, *etc.*) unlike other systems of irrigation. There may be other advantages of drip irrigation, but I mention only some of the most important ones.

There are 180,000 hectares of citrus in Mexico, producing an annual yield of 1,800,000 metric tons. The important citrus-producing areas are located in the states of Vera Cruz (the largest citrus area in Mexico), Nuevo Leon, which is nearest to the Texas industry, Tamaulipas, and San Luis Potosi. There are smaller citrus-producing areas in the states of Sonora and Sinaloa. Mexican limes are also produced in the states of Colima, Michoacan and Guerrerro.

The citrus areas are thus distributed over the more arid northern part of Mexico and tropical southern Mexico. There is both irrigated and non-irrigated citrus in the northern region, while most of the citrus is non-irrigated in the tropical region. For example, approximately 70% of the citrus is irrigated in Nuevo Leon, which has 20,000

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hectares producing 400,000 tons of citrus. Flood irrigation is the most common system used.

Fig. 1 shows the monthly mean temperature, rainfall, and pan evaporation recorded at the experiment station at General Teran, Nuevo Leon. One can easily see that precipitation exceeds evaporation only during the months of September and October, thereby creating a deficit of available moisture during the rest of the year. Supplemental irrigation is necessary for citrus in this region.

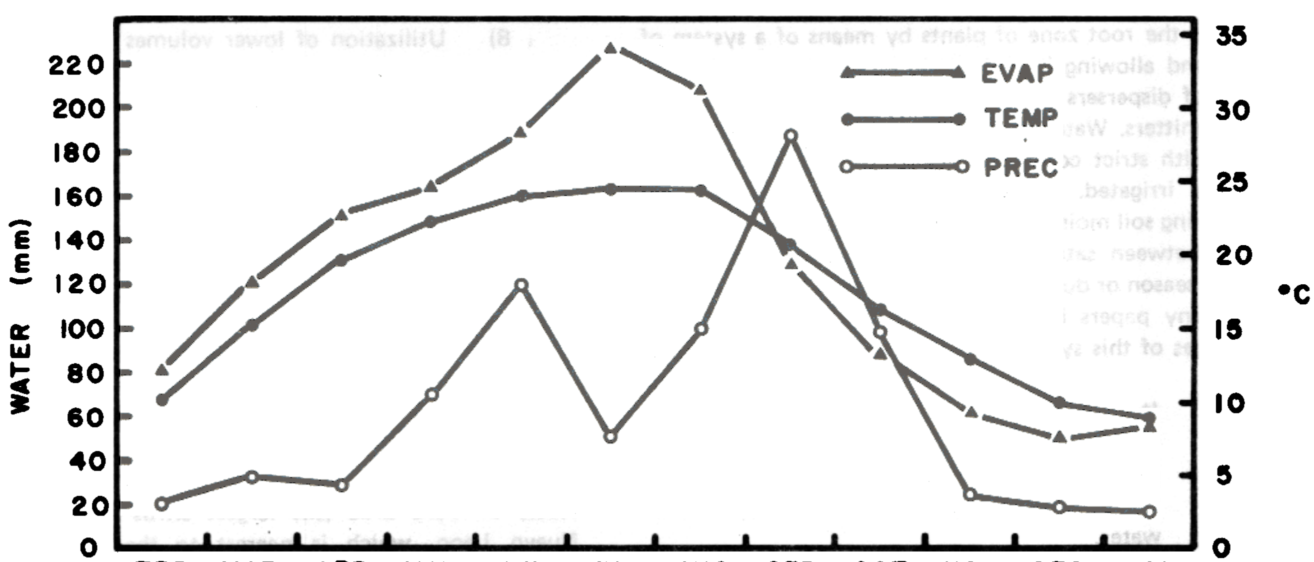
Critical irrigations are those required to keep the trees alive, and are considered necessary in February, April, July and November (Fig. 1). Necessary irrigations in March, May and June are those needed for optimum growth and production, but are not always possible unless sufficient water is available. Other irrigations in August, December and January are possible only when water is available. Bear in mind that flood irrigation is the principal means of irrigation and the source of water is from rivers. Irrigation is possible, however, only when the rivers are high as the rivers are not dammed to facilitate water storage and availability.

The requirements for water by citrus in this area are estimated in accord with the differences between rainfall and evaporation (Fig. 1). Obviously, the highest requirements for water are from April through September. These data are used to determine the volume of water which must be applied by flood irrigation in cubic meters per hectare per month (Fig. 1). The amount of water required by citrus under flood irrigation is further broken down into liters of water per tree per day (Fig. 1), with 150 trees per hectare.

The differences in soil water distribution under drip irrigation and under flood irrigation are shown in Fig. 2. The soil moisture drops from field capacity to the 20% wilting point after 10 days under flood irrigation. The tree root system operates, therefore, for longer periods of time under conditions of soil moisture very near to the permanent wilting point if irrigation is not applied at 10-day intervals as shown here. In fact, many growers in northern Mexico will not irrigate until they see signs of wilting.

The water is applied daily under drip irrigation, however, in such quantities that soil moisture fluctuates around field capacity (from 0 to 0.3 atm). Thus, the tree root system is operating in a soil moisture at or near field capacity at all times, so that moisture stress and tree wilting do not occur.

Table 1 shows some effects of drip irrigation on



	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN
Irrigation schedule[z]	C	N	C	N	N	C	O			C	O	O
Estimated water requirement (cm)	6.3	8.4	10.2	11.3	11.7	12.2	11.8	10.1	8.8	7.0	6.9	6.2
Water volume m^3/ha/mo	630	840	1020	1130	1170	1220	1180	1010	880	700	690	620
Liters/tree/day	135	180	218	241	250	261	252	216	186	150	147	132

[z]C—Critical irrigation, N needed irrigation, O—optional irrigation.

Fig. 1. Average monthly precipitation, temperature, pan evaporation and irrigation requirements at the Campo Agricola Experimental, General Teran, Nuevo Leon, Mexico.

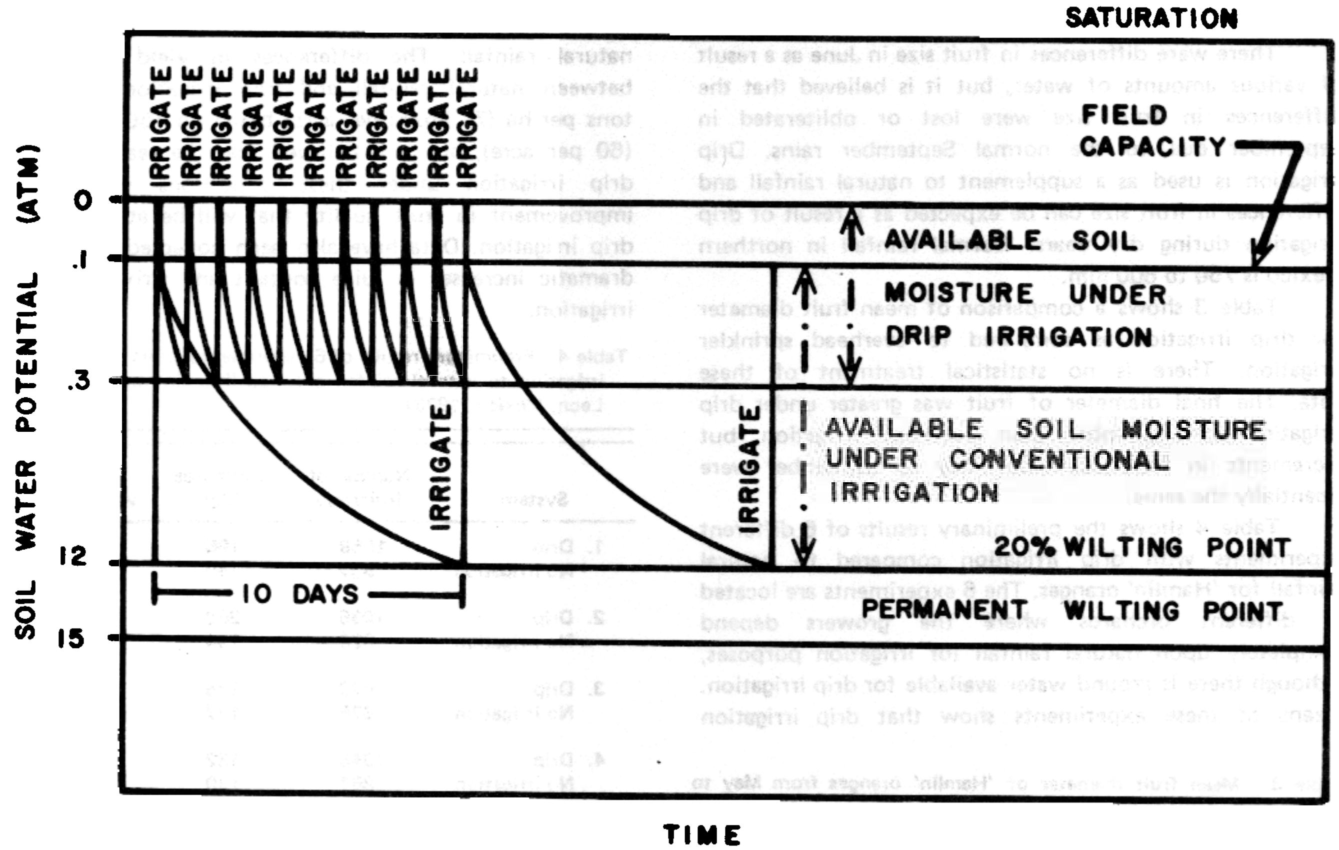


Fig. 2. Soil-water dynamics under drip irrigation and conventional irrigation.

fruit size of 20-year-old 'Hamlin' oranges, with both the number of emitters per tree and the quantity of water applied being varied. The quantity of water applied is expressed as percentage of estimated water requirement. Maximum fruit size during June was obtained with 4 emitters per tree and the amount of water being 100% of the estimated requirement. There is no significant difference between 2, 4 or 6 emitters per tree, however, when the means for the number of emitters per tree are compared statistically. There was no difference between 166% and 133%, nor was there a statistical difference between 133% and 100% of the estimated water requirement. However, 66% of the requirement, which is somewhat dry, did show significantly smaller fruit size than the other 3 treatments.

The same measurements were taken in September and the results are shown in Table 2. There was no statistical difference in fruit size, shown by comparing the means for amount of water applied. There was no statistical differ-

Table 1. Mean fruit diameter of 'Hamlin' oranges in June in relation to the number of emitters per tree and the quantity of water applied (as percent of water requirement).

Number of emitters per tree	Fruit diameter (cm)^z Water applied (% of water requirement) 66	100	133	166	Mean
2	3.95	4.12	4.35	4.32	4.18 a
4	4.17	4.49	4.19	4.37	4.30 a
6	4.17	4.08	4.24	4.45	4.25 a
Mean	4.09 a	4.23 b	4.26 bc	4.38 c	4.24

^{z}Means having a letter in common do not differ significantly at the .05 level of probability.

Table 2. Mean fruit diameter of 'Hamlin' oranges in September in relation to the number of emitters per tree and the quantity of water applied (as percent of water requirement).

Number of emitters per tree	Fruit diameter (cm)^z Water applied (% of water requirement) 66	100	133	166	Mean
2	6.60	6.67	6.94	6.76	6.74 a
4	6.72	6.84	6.76	6.75	6.77 a
6	6.53	6.47	6.66	6.59	6.56 b
Mean	6.62 a	6.66 a	6.79 a	6.70 a	6.69

^{z}Means having a letter in common do not differ significantly at the .05 level of probability.

ence between 2 or 4 emitters per tree, but 6 emitters per tree did result in a significantly smaller fruit diameter.

There were differences in fruit size in June as a result of various amounts of water, but it is believed that the differences in fruit size were lost or obliterated in September due to the normal September rains. Drip irrigation is used as a supplement to natural rainfall and differences in fruit size can be expected as a result of drip irrigation during dry years. Normal rainfall in northern Mexico is 750 to 800 mm.

Table 3 shows a comparison of mean fruit diameter for drip irrigation as compared to overhead sprinkler irrigation. There is no statistical treatment of these data. The final diameter of fruit was greater under drip irrigation in September than overhead irrigation, but increments in fruit size from May to September were essentially the same.

Table 4 shows the preliminary results of 6 different experiments with drip irrigation compared to natural rainfall for 'Hamlin' oranges. The 6 experiments are located in different orchards where the growers depend completely upon natural rainfall for irrigation purposes, although there is ground water available for drip irrigation. Means of these experiments show that drip irrigation resulted in 118 more fruit per tree, 48 kg more fruit per tree, and an average fruit weight of 29 g more than under natural rainfall. The differences in yield are striking between natural rainfall and drip irrigation, about 7.2 tons per ha (72 boxes per acre) based on 150 trees per ha (60 per acre), but it is believed that the real benefits of drip irrigation under these conditions will be the improvement in fruit quality that will be attained under drip irrigation. Data have also been collected which show dramatic increases in juice content and Brix under drip irrigation.

Table 3. Mean fruit diameter of 'Hamlin' oranges from May to September for drip irrigation and overhead sprinkler irrigation.

	Fruit diameter (cm)					
Treatment	May	Jun	Jul	Aug	Sep	Net increase
Drip	3.16	4.24	5.08	5.87	6.69	3.53
Sprinkler	3.05	4.24	4.95	5.69	6.54	3.48

Table 4. Preliminary results of 6 experimental plots comparing drip irrigation to natural rainfall only, on 'Hamlin' oranges in Nuevo Leon, Mexico (1973).

System	Number of fruit/tree	Fruit/tree (kg)	Fruit weight (g)
1. Drip	1059	196	185
No irrigation	937	140	149
2. Drip	1035	208	201
No irrigation	923	144	156
3. Drip	972	175	180
No irrigation	876	127	145
4. Drip	1046	182	174
No irrigation	861	130	151
5. Drip	965	166	172
No irrigation	916	141	154
6. Drip	1055	191	181
No irrigation	912	146	160
Mean Drip	1022	186	182
No irrigation	904	138	153
Mean Difference	118	48	29