Summer Drip Irrigation Requirements for Cucumber[1]

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ABSTRACT

Cucumbers (Variety Poinsett 76) were drip irrigated during March, 1980 at Fortuna Substation to evaluate the water requirement and effect of silver coated plastic mulch on crop performance. The moist treatment gave significant increases in crop yield at the 5% level compared with wet and dry treatments. The use of plastic mulch further increased production by 4.6 tons per hectare.

INTRODUCTION

Drip irrigation (6) is described as the frequent, slow application of water to soils through mechanical devices called emitters or drippers located at selected points along the water delivery lines. The emitters dissipate the pressure from the distribution system by means of orifices, vortexes, and tortuous or long flow paths. The emitted water moves within the soil system largely by unsaturated flow (6). The drip irrigation is also called trickle—, high frequency—, daily flow—, diurnal—, tension—, capillary—, continuous moisture—, or point source irrigation. There is no difference in the concept these names represent. Development of drip irrigation (6) dates back to 1869. Initial systems were developed for greenhouse potted plants. Later these systems were extended to row crops. Several of the currently recognized advantages of drip irrigation (6) include efficient water use (minimum direct losses from evaporation, inhibited weed growth, no runoff), uniform and better quality crop, reduction in the development of pests and diseases, fertilization through irrigation and high application efficiency. Drip irrigation, like other irrigation methods, will not fit every agricultural crop, specific site, or objective. For crops with high plant densities requiring large amounts of drip line per land unit, drip irrigation may not be economical. Drip irrigation is an acceptable system of irrigating many crops; yet, it should not be expected to replace other irrigation methods.

The crop water requirements under drip irrigation may be different from those under conventional methods (6). Most methods of estimating water requirements presently utilized provide estimates of evapotranspiration. The evaporation of water from the soil surface is implicitly related to the method of irrigation application and irrigation scheduling.

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Direct measurement of crop transpiration under drip irrigation has not been conducted for many crops. To schedule an irrigation correctly, the amount of soil moisture available to a crop and the water use by that crop must be quantified (7). Both timeliness and amount of water affect irrigation efficiency. However, timing has the greatest effect on crop yield and quality. Studies relating to stress during certain stages of growth and plant development support this (6, 7). Only two pieces of information are necessary to schedule irrigation: the allowable depletion level at which the effective root zone needs to be refilled and the periodic monitoring of the soil profile to determine if a recharge is needed (7). Tensiometers, because of their simplicity, availability and the lower range, are well adapted to drip irrigation work (6).

Splittstoesser (11) indicated that the cucumber plant stops growing if adequate water is not available. Heslip (4) reported that cucumber yield was increased because of higher soil temperature from plastic mulching. This condition hastened seedling emergence and increased plant vigor (12, 13). Other workers (1 to 5, 8 to 13) have also reported increased cucumber yield in plastic-mulched plots.

A study to determine the possibility of using drip irrigation for cucumber production was conducted at the Fortuna Substation, located in the semiarid southern coast of Puerto Rico. The soil belongs to the San Antón series with a pH of 7.9. The conductivity of the soil solution is 0.40 mmhos per cm. Maximum, minimum and average temperatures during the cucumber growing period were 32.8, 16.7 and 24.8° C respectively. The seasonal rainfall and Class A pan evaporation were 145.3 mm and 342 mm, respectively.

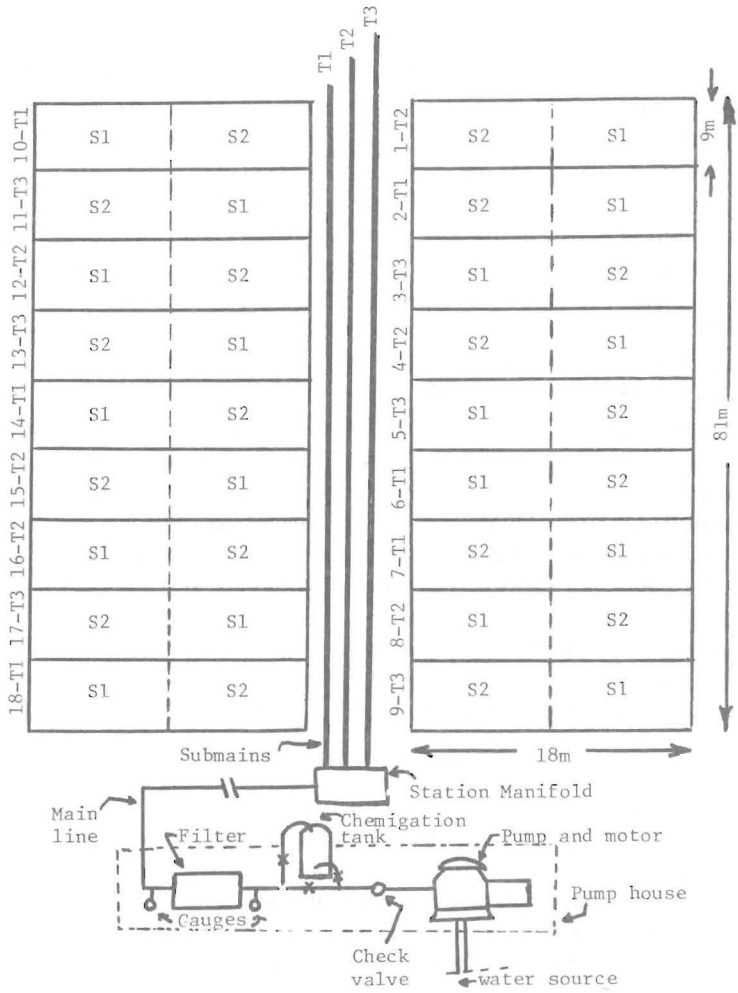
The objectives of this study were to evaluate cucumber performance with silver coated black plastic, and estimate the drip irrigation requirements of the cucumber crop (variety Poinsett 76).

MATERIALS AND METHODS

A drip irrigation system was installed at the Fruits Substation, during March 1980. The system included a small electrically operated centrifugal pump, a 200-mesh screen filter, a pressure regulating valve, manifold accessories and main, submains and laterals. The water source was a well-fed reservoir. A volumetric metering valve monitored the water from the main to each submain. A submain was provided for each treatment. Laterals of dual chamber drip tubing with 0.76 mm orifices spaced 60 cm apart were placed 1.8 m apart to supply the water to the plants at 55–69 KPA (8–10 lb/in^2). Layflat tubing was used for the main and submains. All irrigation materials were placed on the soil surface with orifices (emitters) facing upward.

Beds were shaped with a bed shaper on 1.8 m spacing. The 0.0015

gauge silver coated black plastic mulch was manually placed over the desired beds. Holes were manually punched in the plastic at the position of the seedlings. Plot size was 9 × 9 m (5 beds each 9 m long). Outer beds in each plot were left as border. The cucumbers were subjected to three water regimes (wet, moist and dry), with six replications in a randomized



Main treatments	Subtreatments	
T1 = Wet	S1 = No plastic	Plot size = 18 x 9m
T2 = Moist	S2 = Plastic	Bed size = 1.8m
T3 = Dry		

FIG. 1.—Field layout for cucumber performance under trickle irrigation.

split-plot block design as shown in figure 1. The split-plots were used to evaluate the effect of silver coated plastic mulch on cucumber yield.

Cucumber seeds (variety Poinsett 76) were sown March 31, 1980 at the rate of four seeds per hill on both sides of the dual chamber drip line in a zig-zag pattern at a distance of 15 cm from the drip line. The hill spacing was 60 cm down the row.

Water application rates were based on readings of tensiometers 15, 30 and 45 cm below the soil surface to control the irrigation scheduling for the wet, moist and dry treatments. The tensiometers were installed according to "Tensiometer installation guide by Irrometer Company, Inc.[3], Riverside CA". Irrigation was applied when the soil moisture tension, as measured by the tensiometers, was 45 cbars. Irrigation was terminated when the moisture tension dropped to 15 cbars.

The cucumbers were manually picked on 43, 46, 49, 52, 57 and 60th julian day[4]. The last picking was on May 30, 1980. The fruit performance data included average fruit weight, volume and density. Archimedes principle was used to determine the average fruit volume.

RESULTS AND DISCUSSION

Total water volume applied during the growing period per emitter was 116.6, 90.3 and 71.3 liters for the wet, moist and dry treatments, respectively; and per plant, water applications were 14.6, 11.3 and 8.9 liters for wet, moist and dry treatments, respectively. Average daily water application per emitter was 1.9, 1.5 and 1.2 liters and 0.24, 0.19 and 0.15 liters per plant for the wet, moist and dry treatments, respectively. Seasonal water applications per hectare was 1.08, 0.84 and 0.66 million liters for the wet, moist and dry treatments, respectively, equivalent to 10.8, 8.4 and 6.6 cm-hectare for the wet, moist and dry treatments, respectively. Sixty-seven percent of the water was applied during fruit formation.

Table 1 shows the average volume, weight and bulk density in six pickings of the cucumbers grown with mulch and without mulch under the wet, moist and dry treatments. In the non-mulch plots, average volume per fruit and weight per fruit were maximum in the fifth picking and average density per fruit was maximum in the third picking. With mulching, average volume per fruit and weight per fruit were maximum for first picking in the wet and moist treatments and in the fifth picking of the dry treatment. Average fruit density was maximum in the fifth picking. The minima were observed in the sixth picking in all treatments and subtreatments.

[3] Trade names are used only for identification purposes and do not imply preference for this material by the Agricultural Experiment Station.

[4] Julian day is a count of number of days after planting. Date of planting is zero julian day.

Table 2 shows percentage distribution of the yield for each picking in each treatment. The yield was highest in the fifth picking and lowest in the sixth. Overall distribution of total yield was 11.7, 11.9, 12.6, 23.4, 31.7 and 9.0% in the first through sixth picking, respectively.

Table 3 shows the effects of the plastic mulch and of the varying water application rates on cucumber yield. The average total yields were 39.5 and 41.3 tons per hectare (17.1 and 17.9 tons per cuerda)[5] with no mulch and with mulch, respectively. With mulch, the average yield for the moist

TABLE 1.—*Fruit performance of cucumbers under drip irrigation. Date of planting: March 31, 1980. Date of last picking: May 30, 1980*

Fruit picking on days	Fruit characteristics					
	Average fruit volume, cm^3		Average fruit weight, g		Average fruit density, g. cm-3	
	P[1]	NP[1]	P	NP	P	NP
			T1 = Wet			
43	317	298	300	280	0.930	0.952
46	256	256	240	240	0.938	0.948
49	259	243	248	232	0.955	0.956
52	253	253	238	240	0.940	0.947
57	306	311	286	291	0.934	0.936
60	176	173	153	161	0.917	0.880
			T2 = Moist			
43	303	291	280	270	0.925	0.916
46	286	290	267	250	0.915	0.939
49	266	255	252	241	0.945	0.948
52	247	238	270	224	0.935	0.944
57	285	307	159	285	0.952	0.931
60	179	176		161	0.901	0.903
			T3 = Dry			
43	296	283	270	260	0.925	0.931
46	269	263	253	243	0.943	0.913
49	266	248	254	240	0.966	0.956
52	251	236	236	222	0.939	0.942
57	305	287	285	272	0.933	0.950
60	188	180	160	171	0.912	0.892

[1] P = Plastic mulch; NP = No plastic mulch. Average of six observations.

treatment was 45.5 tons per ha (19.7 tons per cuerda) compared to 39.5 and 38.9 tons per ha for wet and dry treatments. In the non-mulched plots, the average yield for the moist treatment was 40.9 tons per ha (17.7 tons per cuerda) compared to 38.2 and 39.1 tons per ha for the wet and dry treatments. Although in general plastic mulching had no significant influence on the yield, and the differences between the yields of the corresponding moisture level treatments in the non-mulched plots were

[5] One cuerda is equivalent to 0.9712 acre; 0.39 ha.

not significant, the crop yield under the moist treatment in the mulched plots was significantly greater at the 5% level than the yields under the wet and dry treatments. This may be due to the fact that under mulching the moist treatment was capable of furnishing an adequate supply of water to the plant system while maintaining adequate soil-air-plant relationships.

TABLE 2.—*Percentage distribution of cucumber yield for each picking*

Treatment	Percent of total yield					
	Julian day					
	43	46	49	52	57	60
	Plastic mulch (P)					
T1 = Wet	10.8	12.5	12.6	23.1	31.9	9.1
T2 = Moist	12.8	13.2	12.7	22.6	30.1	8.6
T3 = Dry	12.7	11.7	11.8	24.4	29.7	9.7
Average	12.1	12.5	12.4	23.4	30.6	9.1
	Without plastic mulch (NP)					
T1 = Wet	11.2	12.4	11.9	22.3	34.0	8.2
T2 = Moist	11.3	10.7	13.4	23.6	32.8	8.2
T3 = Dry	11.3	10.4	12.7	24.2	31.3	10.1
Average	11.3	11.2	12.7	23.4	32.7	8.8
Overall Average	11.7	11.9	12.6	23.4	31.7	9.0

TABLE 3.—*Effect of plastic mulch and varying water application rates on cucumber yield (var. Poinsett 76) grown under drip irrigation. Date of planting: March 31, 1980. Date of last picking: May 30, 1980*

Treatment	Seasonal water application		Cucumber yield	
	Liters/plant	cm-ha	Metric tons/ha	Tons/cuerda
		Plastic mulch (P)		
T1 = Wet	14.6	10.8	39.5a[1]	17.1
T2 = Moist	11.3	8.4	45.5b	19.7
T3 = Dry	8.9	6.6	38.9a	16.9
Average			41.3	17.9
		No plastic mulch (NP)		
T1 = Wet	14.6	10.8	38.2a	16.6
T2 = Moist	11.3	8.4	40.9b	17.7
T3 = Dry	8.9	6.6	39.1b	16.9
Average			39.5	17.1

[1] Means followed by the same letter do not differ at the 5% probability level.

RESUMEN

En marzo de 1980 se instaló en la Subestación de Fortuna un sistema de riego por goteo de baja presión para evaluar los requerimientos de riego para rendimientos máximos de pepinillo (variedad Poinsett 76), y para evaluar los efectos de la cubierta plástica negra con revestimiento

plateado en el desarrollo de la cosecha. Las tasas de aplicación de agua se basaron en las lecturas de tensiómetros instalados a 15, 30 y 45 cm de profundidad en los tratamientos "mojado, húmedo y seco". Bajo cubierta plástica, el tratamiento "mojado" sobrepasó significativamente al 5% de significancia el rendimiento de los tratamientos "húmedo y seco". Los requerimientos medios de riego por goteo fueron 10.8, 8.4 y 6.6 cm-ha para los tratamientos "mojado, húmedo y seco", respectivamente. Los datos de la evaluación de la cosecha incluyeron volumen medio, peso medio y densidad media de las frutas.

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