Growth and production of kiwi under different irrigation systems.

K. CHARTZOULAKIS, N. MICHELAKIS and E. VOUGIOUKALOU*

GROWTH AND PRODUCTION OF KIWI UNDER DIFFERENT IRRIGATION SYSTEMS.
K. CHARTZOULAKIS, N. MICHELAKIS and E. VOUGIOUKALOU.
Fruits, Jan.-Feb. 1991, vol. 46, n° 1, p. 75-81.

ABSTRACT - An experiment was carried out to study the influence of the different irrigation systems used in kiwi plantations on the water consumption, trunk radius increase, root and water distribution in the soil profile. The yield varied greatly between the different varieties and the water efficiency was different in the irrigation systems. Trunk radius increase was not affected by the irrigation systems and both irrigation water and root system reached deeper soil layers with minisprinklers than with drippers.

CROISSANCE ET PRODUCTION DU KIWI SOUS DIFFERENTS SYSTEMES D'IRRIGATION.
K. CHARTZOULAKIS, N. MICHELAKIS and E. VOUGIOUKALOU
Fruits, Jan.-Feb. 1991, vol. 46, n° 1, p. 75-81.

RESUME - Une étude a été conduite sur l'influence de différents systèmes d'irrigation utilisés en plantations de kiwi et portant sur la consommation d'eau, l'accroissement de la circonférence du tronc, ainsi que sur la distribution des racines et de l'eau dans le sol. Les rendements varient selon les variétés et l'efficacité des apports d'eau selon les types d'irrigation. La circonférence du tronc n'est pas influencée par ces derniers ; l'eau, l'irrigation et les racines atteignent les couches du sol plus profondes avec des minis sprinklers qu'avec des goutteurs.

INTRODUCTION

Kiwi (*Actinidia sinensis*) is a plant which because of its morphology, particularly the shallow root system and the great volume of leaf area, requires an effective water supply and a cool, humid environment. Inadequate water supply, low humidity and high temperature cause leaf burn because of the intensive transpiration especially in young plants (Lotter, 1983). Further more, water consumption by young kiwi plants increases when the humidity of the environment decreases (Xiloyiannis and Natali, 1983).

A great variety of irrigation systems is being used today for the irrigation of kiwi, the type depending on the soil texture and microclimate of the area (Sale, 1981 ; Beutel, 1983 ; Vitagliano, 1983). The most commonly used irrigation system is the in line dripper, mainly because of its low cost, easy installation and water saving. A second system used is minisprinkler irrigation, using one or two minisprinklers of 30-50 l/h per plant, which wet a greater surface area of the soil, increases air humidity and has less clogging problems. In some cases, sprinkler irrigation is used over or below the plant canopy. In arid areas a combination of drip and sprinkler irrigation is used (Beutel, 1983).

The water requirement of kiwi varies according to soil texture, microclimate and irrigation system used. In central and northern Greece, the annual irrigation water requirement of kiwi from May to October are estimated to be 800-1000 mm with overhead sprinkler irrigation (Brousovanas, 1978). Generally, the water requirement of kiwi, especially during different stages of growth, has not been sufficiently studied and there is a lack of experimental data on the effects on growth of the different irrigation systems.

The work presented here was carried out at the Subtropical Plants and Olive Tree Institute of Chania, Greece, to evaluate four irrigation systems used in relation to water consumption and plant growth.

* - Institute of Subtropical Plants and Olive Tree - CHANIA Greece

METHODS AND MATERIALS

Four different irrigation systems were tested in a kiwi plantation with 5 year old trees planted at 6 m spacing, in rows 4 m apart, in Nerokourou, Chania, Crete.

The soil of the experimental field was sandy-loam with a pH 7.1, electrical conductivity of saturated extract (EC) 0,316 dS/m and field capacity 25% (Fig. 1).

Each irrigation system was applied to four rows of cv Monty, Bruno, Abbot and Hayward and measurements were taken from six plants of each variety and irrigation system. The following irrigation systems were applied :

a. Drip irrigation (DR) with one line of drippers of 4 l/h, 1 m apart on a polyethylene pipe, i.e. six drippers per plant.

b. Mini-sprinkler irrigation (MS1) with one mini-sprinkler of 70 l/h per plant at a height of 600 mm above the soil surface.

c. Sprayer irrigation (MS2) with two half-cycle sprayers of 30 l/h per plant, at height 600 mm above the soil surface. This method was replaced by double drip line in 1984.

d. Sprinkler irrigation (SP) with overhead sprinklers of 260 l/h arranged in grids of 4 x 6 m.

During 1982-83 irrigation was controlled by tensiometers located at a depth of 300 and 600 mm. The distance of the tensiometers from the dripper was 200 mm, from the minisprinkler and sprayer 400 mm and from the sprinkler 1.5 m. In 1984 tensiometers were located 400 mm away from the dripper, 1 m from the minisprinkler and 2 m from the sprinkler, at 300 and 900 mm depth. Irrigation started when the soil water tension, in the shallow tensiometer reached - 20 kPa and stopped when irrigation water reached the deep one.

To study the root and water distribution in the soil. trenches were dug parallel to the irrigation lines one day after irrigation. The estimation of the root system was done according to the Bakemans and De Wit method and water content was determined gravimetrically by drying samples at 105°C in the laboratory from cores of the profile of the grid.

For the evaluation of the irrigation system, the following parameters were recorded.

1. Soil water tension, daily.
2. Irrigation water applied.
3. Trunk radius, monthly.
4. Yield and number of fruit per plant.
5. Sugar content of the fruit.

RESULTS AND DISCUSSION

The average water applied was 244 mm for the drippers, 336 mm for the sprayers, 280 mm for the minisprinklers and 732 mm for the sprinklers. During 1984-86 it was 340, 357, 477 and 782 mm respectively (Table 1). The differences in water applied should be attributed to the fact that soil moisture reached deeper layers during the 1984-86 period.

The differences between the irrigation systems were due to the different wetted soil surface, losses by evaporation and possibly to the different transpiration rates. In the drip treatment the soil water potential was lower during the irrigation period than in all other treatments at both depths. At the depth of 600 mm the soil water potential was higher in the MS treatment (Fig. 2). Obviously, in spite of the low water consumption, drip irrigation ensures better soil moisture conditions in the rootzone. Irrigation intervals was longer in the overhead irrigation but not that much.

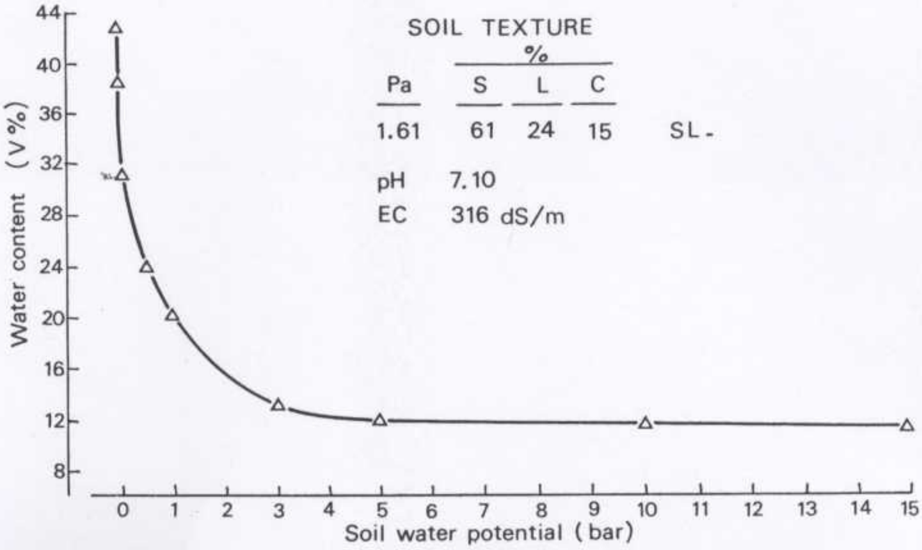

Fig. 1 * Soil texture, bulk density (Pa), pH, electrical conductivity (EC) and soil moisture characteristic curve.

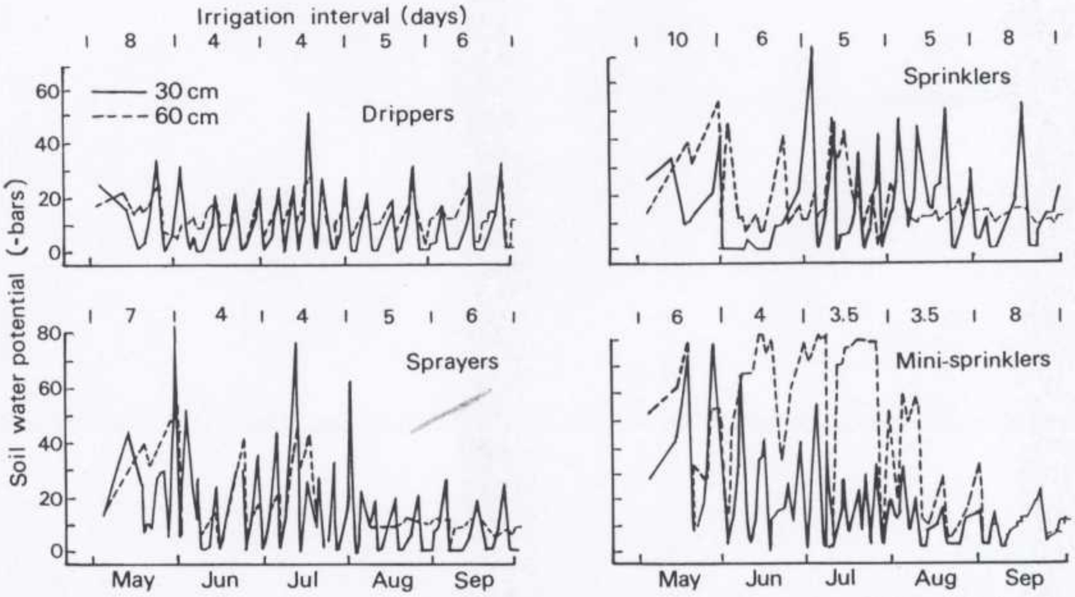

Fig. 2 * Fluctuation of soil water potential and irrigation interval at different irrigation systems in kiwi.

The water use coefficient kc = ETc/Epan where ETc is the measured evapotranspiration of the crop and Epan the class «A» pan evaporation was higher during 1984-86 in sprinklers (Fig. 3). In spite that evaporation is decreasing since August, this ratio is increasing in all systems because the water reserves in the soil are exhausted and the contribution of soil is low.

The increase of trunk radius was not significantly different between the irrigation systems. The highest increase (8.7 mm) took place in June and the lowest (0.3 mm) in February (Fig. 4).

Significantly different among the irrigation systems was the wetted soil surface per plant ranged from 1.9 m^2 to 24 m^2 (Table 2). Even the 1.9 m^2 of the wetted surface gave 45% wetted soil volume which can be considered sufficient for kiwi here, since it is more than 1/3 of the soil volume, which is the lowest accepted percentage for the tree crops (Keller and Karmelli, 1974).

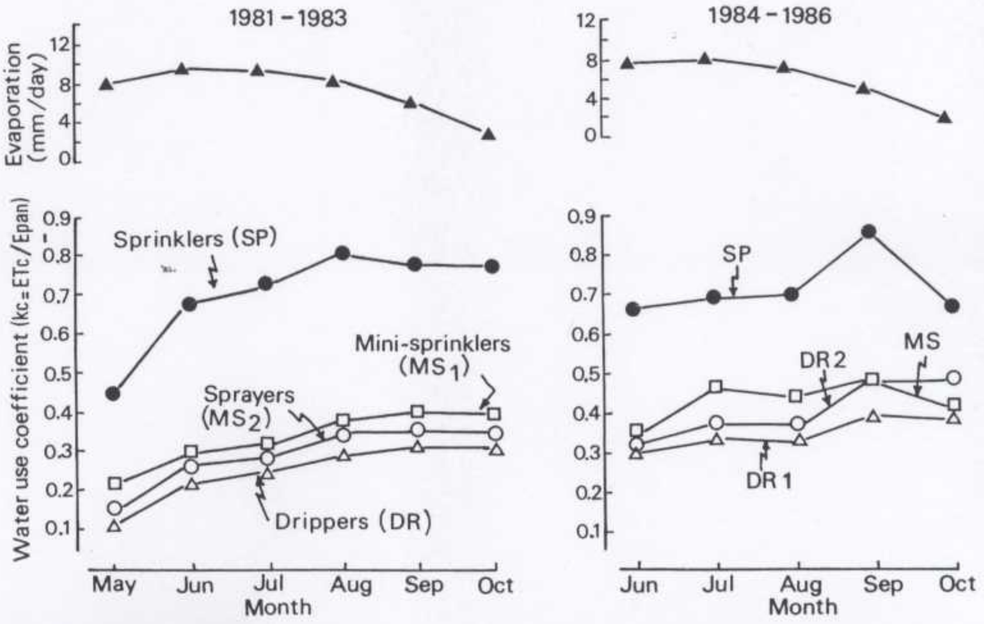

Fig. 3 * Consumptive water use coefficient for kiwi under different irrigation systems.

TABLE 1 - Average evaporation, rainfall and water applied during 1982-1986.

Year	Evaporation (mm)	Rainfall (mm)	Irrigation water (mm)			
			Dr_1	MS_2/Dr_2	MS	SP
1982	1283	794	260	351	289	766
1983	1490	774	228	321	270	704
1984	1388	752	402	423	382	671
1985	1521	549	302	304	419	689
1986	1356	745	379	411	515	875
Av. 82-83	1351	784	244	336	280	732
Av. 85-86	1438	647	340	357	477	782

* Dr_2 Since 1984.

TABLE 2 - Wetted area per plant (m^2) and % of the total area covered by the plant.

Irrigation system	Wetted surface per plant	
	m^2	% of total
Drippers	1.9	7.9 c
Mini-sprinklers	8.2	34.2 b
Sprayers	8.7	36.2 b
Sprinklers	24.0	100.0 a*

* Values with different letters are significantly different at $P = 0.05$

The soil moisture in the drip treatment was uniform and about 25-30 (V %), up to the depth of 1.2 m. The linearity of isomoisture line indicates the existence of impermeable soil layer at the depth of 1.2 m. Possibly the absence of this layer is a reason for higher soil moisture and more roots beyond the depth of 1.2 m in the minisprinklers and not the higher water application (Fig. 5).

Root density was higher and more uniform with the drip treatment than the minisprinkler (Fig. 5). There was a tendency of root concentration near the minisprinkler and the roots reached deeper layers but only under the

TABLE 3 - Effect of irrigation system on the average yield of kiwi

Cultivar	Year	Yield (kg/tree) Irrigation system			
		Dr_1	MS_2Dr_2[1]	Ms	Sp
Bruno	1982	12.85	17.75	19.05	24.25
	1983	5.31	9.00	3.60	10.65
	1985	17.91	22.91	11.93	21.49
	1986	39.88	33.87	20.71	32.75
	Av. 1982-83	9.08	13.37	11.32	17.45
	Av. 1985-86	28.89	28.39	16.32	27.12
	1987	33.00	43/30[2]	18.45	19.43
Monty	1982	16.70	19.90	19.05	28.30
	1983	3.34	6.95	1.60	2.04
	1985	9.50	14.25	17.75	21.50
	1986	17.35	16.38	21.20	33.60
	Av. 1982-83	10.02	13.42	10.30	15.17
	Av. 1985-86	13.42	15.31	15.97	28.05
	1987	16.16	26/14	15.75	24.30
Abbot	1982	10.40	11.85	14.45	4.80
	1983	1.14	0.43	0.48	0.60
	1985	0.66	0.79	0.75	2.20
	1986	9.45	5.65	10.95	3.15
	Av. 1982-83	5.55	6.14	7.65	2.70
	Av. 1985-86	5.50	3.22	5.85	2.67
	1987	5.60	12/1.13	3.75	1.70
Hayward	1982	6.15	6.40	6.50	6.50
	1983	1.60	1.35	0.33	1.70
	1985	1.13	2.00	0.42	1.05
	1986	1.20	1.65	1.30	1.00
	Av. 1982-83	3.85	3.85	3.41	4.40
	Av. 1985-86	1.16	1.82	0.86	1.02
	1987	5.02	16/0.25	2.42	2.35

1. Dr_2 since 1984 2. 43/10 covered/uncovered

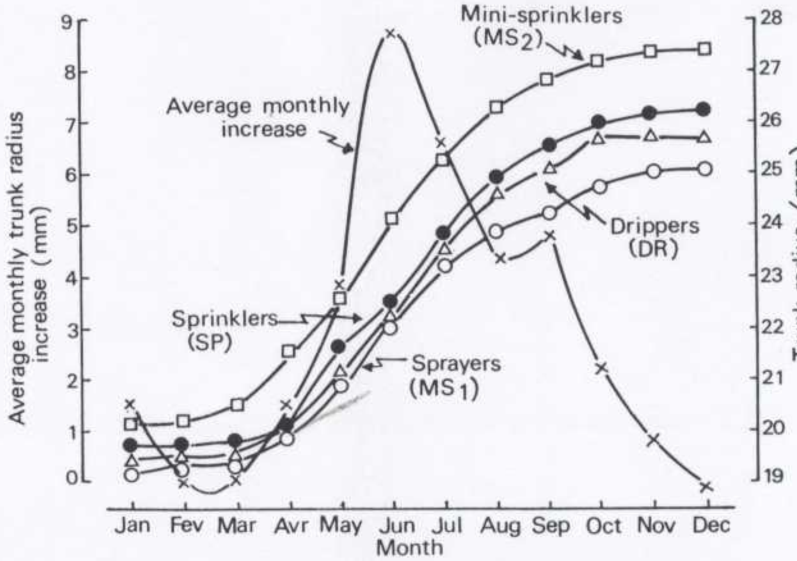

Fig. 4 * Total and average monthly increase of trunk radius of kiwi.

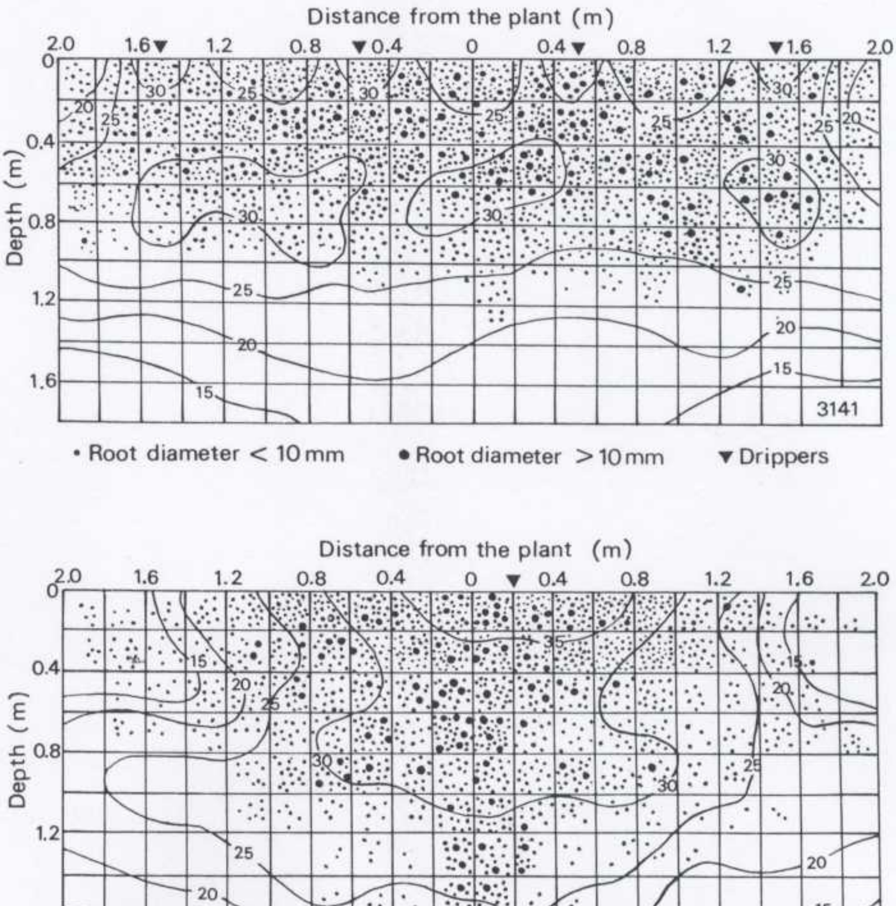

Fig. 5 * Water content and root density at kiwi cv. BRUNO in soil profile parallel to the irrigation line.

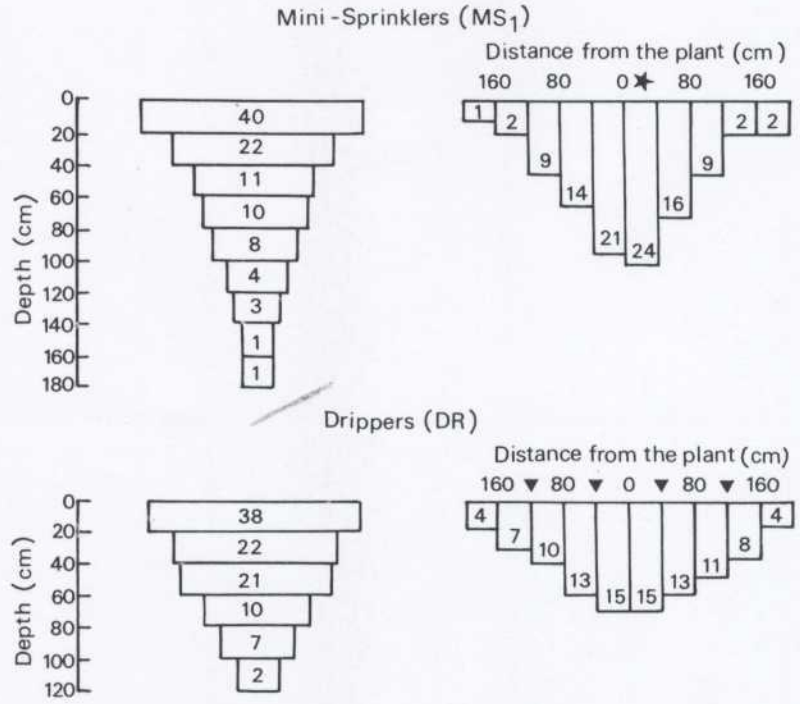

Fig. 6 * Root distribution of kiwi cv. BRUNO, in soil profile parallel to irrigation line.

water source. Generally the root system was developed within the upper 600 mm layer (73-81%) (Fig. 6) where water and aeration conditions were at optimal level. Youssef and Reina (1983), also found that the majority of kiwi root system was developed in the first 500 mm of soil.

Yields are given in Table 3. Bruno and Monty cultivars gave higher yields than Abbot and Hayward which yield was rather negligible during the course of the experiment. The sugar content of the fruit as measured in November 1983 was not influenced by the irrigation system. Clear differences exist among the varieties following the decreasing order : Abbot, Bruno, Hayward and Monty (Table 4). The low yield of the plants was always connected with the wind which blows in the area mainly during April-June and breaks the young shoots bearing the flowers. So in 1984 which was very winding during April-May (average wind speed 35 km/h) we had no production of fruits.

The cultivars Hayward and Abbot are very sensitive to wind conditions and this is why they were of bad performance in our experiment. A part of the experimental field, half of the Dr2 treatment, was covered with net in 1987 and the result in production seem to be very promising (Table 3). Another noticeable point is that all the plants under the net were more vigorous than the others. All this new situation needs further study.

The water utilization efficiency for harvested yield (Ey, kg/m^3) was generally higher in 1985-86 ranging from 0.77 in sprinklers to 1.49, 1.46 and 0.87 in DR1, DR2 and MS respectively, compared to 0.54, 1.17, 1.12 and 1.19, for the SP, DR1, MS2 and MS1 in 1982-83. Only in the MS system the efficiency of water was decreased. If we do not take into account the varieties Abbot and Hayward the water efficiency is double for the varieties Bruno and Monty. According to Sammis *et al.*, (1986) the water efficiency

TABLE 4 - Sugar content (%) of kiwi fruit at 15th of November

	Sugar content (%)				
	Variety				
	Bruno	Monty	Hayward	Abbot	Mean
Dripper 1	9.93	7.21	8.56	11.73	9.35
Dripper 2	9.00	7.36	8.30	11.28	8.98
Minisprinklers	10.93	9.35	8.10	10.60	9.74
Sprinklers	9.43	7.40	8.33	11.33	9.12
Mean	9.28α	7.83γ	8.32γ	11.23β	

Different letters in the same row indicate significant differences at P = 0,05 level may be increased by increasing water application and it is decreased for applications more than evapotranspiration. The high efficiency of drip irrigation makes it more convenient for kiwi. Further more increased irrigation efficiency makes more water available for other uses and generates better net returns to irrigators.

REFERENCES

BEUTEL (J.), WINTER (F.), MANNES (S.) and MILLER (M.). 1976.
Kiwifruit : a new crop in California.
California Agriculture, 30 (10), 5-7.

BROUSOVANAS (N.). 1978.
The kiwi-plant (Greek).

KELLER (J.) and KARMELLI (D.). 1974.
Trikle irrigation design for optimal soil wetting.
Proc. II Intl. Irrigation Congress July 7-14 San Diego, California USA.

LOTTER (J.). 1983.
The suitability of the different areas in the different areas in southern Africa for kiwi fruit.
Atti dell' incontro fruticollo sull'actinidia, p. 119-134.

REINA (A.), GIORGIO (V.) and PUBINO (P.). 1983.
Contributo allo studio del sistema radicale dell'actinidia.
Atti dell' incontro frutticolo sull'Actinidia, p. 211-226.

SALE (P.L.). 1981.
Kiwifruit, management techniques. Nutrition, irrigation and soil management.
New Zealand Ministry of Agriculture and Fisheries. Agrin. Hpp.234.

SAMMIS (T.W.) and WU (I.P.). 1986.
Fresh market tomato yield as affected by deficit irrigation using a microirrigation system.
Agricultural water management, 12.

VITAGLIANO (C.), TESTOLIN (R.) and PETERLUNGEN (E.). 1983.
Diffuzione aspetti colturali e produttivi dell'Actinidia in Italia.
Atti dell' incontro frutticolo sull'Actinidia, p. 41-46.

XILOYANNIS (C.), NATALI (S.), BOTRINI (L.) and FREGNI (G.). 1983.
Risultati preliminari sui consumi idrici dell'Actinidia cv Hayward.
Atti dell' incontro frutticolo sull'Actinidia, p. 249-262.

YOUSSEF (J.), SCARBOLO (E.), GULLINO (C.) and POCHIA (G.). 1983.
Studi sull'apparado radicale dell'actinidia allevata in ambienti diversi.
Atti dell' incontro frutticolo sull'Actinidia, p. 195-209.

CRECIMIENTO Y PRODUCCION DEL KIWI BAJO DIFERENTES SISTEMAS DE IRRIGACION.

K. CHARTZOULAKIS, N. MICHELAKIS y E. VOUGIOUKALOU.

Fruits, Jan.-Feb. 1991, vol. 46, n° 1, p. 75-81.

RESUMEN - Un estudio fué conducido sobre la influencia de diferentes sistemas de irrigación utilizados en plantaciones de kiwi y trata sobre el consumo del agua, el crecimiento de la circunferencia del tronco, asi como la distribución de las raíces y del agua en el suelo. Los rendimientos varian segun las variedades y la eficacia de los aportes del agua segun los tipos de irrigación. La circunferencia del tronco no está influenciada por estos últimos ; el agua, la irrigación y las raíces alcanzan las capas más profundas del suelo con microaspersores que con goteros.