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EFFECT OF IRRIGATION SYSTEMS AND WATER QUANTITIES ON GROWTH, YIELD AND REFLECTED RADIATION OF CUCUMBER PLANT.

Al-Dakheel, Y. Y. * ; A. F. Hamaiel ** and E. A. A. Tartoura **

* **Soil and Water Dept. Collage of Agric. Science and Food, King Faisal Univ., Kingdom of Saudi Arabia.**

** **Vegetables and Ornamentals Dept., Faculty of Agric., Mansoura Univ., Egypt.**

ABSTRACT

Greenhouse experiment were conducted during two successive seasons of 2000 and 2001 aiming to study the effect of different irrigation systems (drip and 20 cm subsurface irrigation) and different water quantities (33 %, 66 % and 100) of field capacity on growth, yield and quality of cucumber plant. Also soil humidity and reflected radiation of plants.The results showed that, using drip irrigation system was in favour for producing the highest plant height, number of leaves/plant, dry/fresh weight ratio per plant, leaf area/plant, number of fruit/plant, shape index, total yield/plant, dry/fresh weight ratio per fruit, soil humidity and average fruit weight. The 100 % of field capacity treatment gave the highest values for plant height, number of leaves/plant, dry/fresh weight ratio per plant, leaf area/plant, dry/fresh weight ratio/fruit and soil humidity. On the other hand the 66 % of field capacity treatment gave the best results for number of fruit/plant, shape index, total yield and average fruit weight. The interaction between irrigation systems and water quantitative produced the highest values for number of leaves/plant, dry/fresh weight ratio per plant, leaf area/plant, dry/fresh weight ratio/fruit and soil humidity by using drip irrigation with 100 % of field capacity, however, the highest values for plant height, number of fruit/plant, shape index, total yield/plant, average fruit weight and reflected radiation of plant per all waves length were recorded after using drip irrigation with 66 % of field capacity treatment.

Finally it is possibly suggested that drip irrigation with 100 % or 66 % of field capacity could be useful for enhancing growth, yield and reflected radiation of cucumber under greenhouse condition in Al-Hassa Oasis KSA.

Keywords: Cucumber, *Cucumis sativus*, Greenhouse, irrigation system, drip irrigation, subsurface irrigation, water quantities, reflected radiation.

INTRODUCTION

Cucumber (*Cucumis sativus* L.) irrigation with different irrigation systems and different water quantities has become important in the greenhouse production especially under Al-Hassa condition. The soil in the Al-Hassa region of the KSA are characterized by their common nitrogen (N) and phosphorus (P) deficiency (Al-Taher, 1999). Cucumber plants are known for their high requirements of water to produce high yield and good fruit quality. Water quantity and irrigation system may be assessed in several ways, plant height, number of leaves, leaf area, dry/fresh weight ratio per plant, fruit weight and fruit yield of cucumber plant.

Many investigators studied the using of different irrigation methods and different irrigation quantities, Navazio and Staub (1994) used two irrigation regimes on cucumber, the results showed that high differences in yield between the two irrigation regimes. Mannin (1988) found that the highest yield of cucumber was obtained by using 100 % ETM (maximum evapotranspiration) irrigation rate. Marr *et al.* (1991) found that yields of 7500 kg/ha were obtained when watermelon irrigated with drip system. Camp *et al.* (1993) evaluated two surface (surface a and b, either one or two tubes/bed) and surface (surface 2, two tubes below each) micro irrigation treatments and application frequencies, high (three times per day) and low (one time per day) for muskmelon production in the spring seasons. Results showed that the highest yield was obtained with two tubes below each bed treatment. Mangal *et al.* (1987) mentioned that the muskmelon plants irrigated at 0.8 and 1.0 of pan evaporation coefficient (PEC) in the first year, and 0.6 and 0.8 (PEC) in the second year, produced the highest yield and plant growth. Al-Dakheel (2000) found that the greatest fresh weight, leaf area, number of fruit/plant and total yield of melon were produced by treatment with 15 cm subsurface irrigation in the two seasons. While, the highest values for plant height and fruit weight were obtained by using surface irrigation.

Al-Naeem (2000) mentioned that the using of 15 cm subsurface irrigation system was in favour for producing the highest number of fruit/plant and total yield/m^2, while, the treatment of surface irrigation system gave the best values for plant height and weight, leaf area, number leaves/plant. Fruit weight reached to the highest value by using 25 cm subsurface irrigation. Al-Dakheel and Al-Naeem (2000) found that the interaction between water quantities and irrigation system treatment of 100 % at field capacity with surface irrigation gave the highest value for all vegetative growth and melon yield parameters. The same researchers mentioned that the drip irrigation with 75 % of water field capacity was the recommended treatment for minimizing irrigation water quantity under Al-Hassa condition. Moynihan and Hamam (1992) found that the drip irrigation system was the best system when compared with furrow irrigation on cucumber. Nagawiecka and Boron (1991) found that leaf water potential could be used as an index for determining cucumber crop water requirements. The effect of water stress on sugar beet canopies was evidenced through an increase in the spectral response of the crop; however, a diurnal variation in the magnitude of vegetation indices resulted from changes in illumination geometry, as well as from canopy architectural (Al-Dakheel, 1995; Danson and Al-Dakheel, 2000).

Carlson *et al.* (1991) concluded that it may be possible to monitor remotely the beginning of crop water stress over dense vegetation before catastrophic damage occurs. Riggs and Running (1991) pointed out that the difference in water status must be larger than the natural variation to cause detectable differences in reflectance. They concluded that detection of water stress at landscape scale from satellite sensors in the NIR is probably not possible only conifers nearing lethal level of water stress (-3.0 to – 5.0 Mpa) would seem to produce reflectance differences great enough to be detectable under normal remote sensing conditions.

MATERIALS AND METHODS

Greenhouse experiments were carried out during the two seasons of 2000 and 20001 at the Agricultural, Veterinary Training and Research Station of the King Faisal Univ., Al-Hassa, KSA. The main properties of the soil in greenhouse are listed in the Table 1, including the salinity (EC), pH, $CaCO_3$ concentration and particle size distribution. The soil analysis was done following the methods out lined in Rowell (1994). EC was determined in a 1:2.5 soil water extract and pH values were measured in 1:2.5 soil water suspension.

Table 1: Main properties of the soil in the greenhouse.

Salinity (EC,ds/m)	pH	F.C	$CaCO_3$ (%)	Particle size distribution(%)		Textural class
				Sand	Silt and Clay	
1.60	7.80	12	7.00	96	4	Sandy

In the current study, two irrigation systems (drip and 20 cm subsurface irrigation) and three water quantities (33 %, 66 % and 100 % of field capacity) were tested. Thus, every experiment consisted of six irrigation treatments and four replications. The design of the experiment was split plot with the main plots being designated for the irrigation systems and the sub-plots for the water quantities. The total area of every plot was 24 m^2, which was divided into 4 rows. Each row 6 m long and 1 m width. The plants were grown in a spacing of 0.50 m apart. 20 days old cucumber seedlings (Erigon cultivar) were used, which were transplanted on 1st and 10th of November 2000 and 2001, respectively. Other recommended culture practices of the Ministry of Agriculture and Water were followed.

Some measurements on cucumber plant were done to determine the effect of the two irrigation systems and water quantities on their vegetative growth parameters, total yield and yield quantity. The measurements were completed on a representative sample of 10 plants randomly being selected from each plot. They included, plant height, number of leaves/plant, dry/fresh weight ratio per plant, leaf area/plant, number of fruit/plant, shape index, total yield/plant, dry/fresh weight ratio per fruit, average fruit weight. Soil humidity (zero-30 and 30-60 cm) depth, and reflected radiation were determine. The solar radiation incident on a plant leaf or canopy is reflected, absorbed or transmitted, which may be expressed as

Irradiance, $I\lambda = r\lambda + a\lambda + t\lambda$

Where r λ is the reflectance, aλ is the absorption and tλ is the transmittance at wavelength λ. A small fraction of the absorbed energy is re-emitted as fluorescence, estimated as 3 % of the quantal absorption of photosynthetically active radiation (Clayton, 1965). In remote sensing, leaving aside fluorescence, it is almost invariably r which is measured, but instruments used on the ground also give the opportunity to measure t. this enables precise calculation of a, which is clearly the variable most fundamental to

photosynthesis and plant growth, the relationship between a vegetation canopy and its spectral pattern can be symbolized according to Goel (1989) as follow:

$S = R (t; \lambda; \theta_s; \psi_s; \theta_o; \psi_o)$

Where S is the spectral signature of a plant canopy;
R is the functional dependence of S and the other parameters;
t is the emergence time of the plant;
λ is the wavelength; θ_s and ψ_s are the solar zemith and azimuth angles, respectively;
θ_o and ψ_o are the view zemith and a zimuth angles, respectively.

Data obtained were subjected to the proper statistical analysis according to Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Vegetative growth

Irrigation systems:

Data presented in Table (2) showed that there were high significant differences among the plants irrigated with two irrigation systems in the average two seasons of study. The highest plant height, number of leaves/plant, dry/fresh weight ratio per plant, leaf area/plant were produced by treatment of drip irrigation system.

Water quantities:

Table (2) showed that the highest values for all vegetative growth were obtained after using 66 % of field capacity.

Data in Table (2) showed the interaction between irrigation system and water quantities. The drip irrigation system with 100 % of field capacity gave the highest results for number of leaves/plant, dry/fresh weight ratio per plant, leaf area/plant, while the highest value for plant height was obtained after using drip irrigation with 66 % of field capacity.

These results are in line with those obtained by Mangal *et al.* (1987) who mentioned that the muskmelon plant irrigated at 0.8 and 1.0 of pan evaporation coefficient (PEC) in the first year, and at 0.6 and 0.8 (PEC) in the second year, produced the highest plant growth, Al-Dakheel (2000) found that using 15 cm subsurface irrigation system was in favor for producing the best fresh weight/plant, dry/fresh weight ratio per plant leaf area of muskmelon plant, Al-Naeem (2000) found that the highest vegetative growth was obtained after using drip irrigation at 100 % of field capacity, while Al-Dakheel and Al-Naeem (2000) found that the drip irrigation at 100 % of field capacity gave the highest value for plant height, number of leaves/plant, dry/fresh weight ratio per plant and leaf area of melon plant.

Table (2): Average of plant height, number of leaves, dry/fresh weight ratio/plant and leaf area (Average two seasons 2000 and 2001).

Treatments		Plant height (m)	No. of leaves /plant	Dry/fresh weight ratio/plant	Leaf area (cm^2)
Irrigation system	Drip irrigation	3.42	33.44	20.25	1913.0
	Subsurface irrigation (20 cm)	3.26	30.33	19.16	1772.0
LSD at 5 %		**0.08**	**1.03**	**0.33**	**4.80**
Water quantities	33 %	3.12	31.53	19.66	1839.0
	66 %	3.71	33.00	20.41	1903.0
	100 %	3.32	33.44	20.84	1928.3
LSD at 5 %		**0.09**	**0.08**	**0.20**	**11.2**
Interaction					
Drip irrigation	33 %	3.16	32.00	19.13	1845.0
	66 %	3.75	33.66	20.30	1935.0
	100 %	3.35	34.66	21.33	1960.0
Subsurface irrigation (20 cm)	33 %	3.13	29.00	18.56	1740.0
	66 %	3.50	32.00	19.50	1811.0
	100 %	3.15	33.00	21.30	1933.0
LSD at 5 %		**0.08**	**0.80**	**2.77**	**8.0**

Yield and yield quality

Irrigation systems

Data in Table (3) showed that the highest results for number of fruit/plant, shape index, yield/plant, dry/fresh weight ratio per fruit were obtained after using drip irrigation system.

Water quantities

The highest values for all yield and yield quality were obtained after using 66 % of field capacity except, dry/fresh weight ratio per fruit was the highest value with 33 % field capacity (Table 3).

Interaction between irrigation and water quantities, the data in Table (3) showed that there were high significant differences between two irrigation systems and different water quantities. Data showed that the drip irrigation with 66 % of field capacity gave the highest values for number of fruit/plant, shape index, yield of cucumber plant, while dry/fresh weight ratio per fruit was the highest after using drip irrigation with 100 % of field capacity. Similar results were obtained by Navazio and Staub (1994) who used two irrigation regimes on cucumber, and found high differences in yield between the two irrigation regimes.

Table (3): Average of number of fruit, shape index, total yield/plant and dry/fresh weight ratio/fruit (Average two seasons 2000 and 2001).

Treatments		No. of fruit/ plant	Shape index	Total yield/ plant (kg)	Dry/fresh weight ratio/ fruit
Irrigation system	Drip irrigation	27.0	4.25	3.13	6.18
	Subsurface irrigation (20 cm)	24.66	4.20	2.87	5.76
LSD at 5 %		**1.47**	**0.05**	**0.08**	**0.08**
Water quantities	33 %	23.22	4.10	2.70	5.74
	66 %	25.77	4.16	3.11	5.65
	100 %	24.88	4.10	3.01	5.56
LSD at 5 %		**0.99**	**0.05**	**0.06**	**0.09**
Interaction					
Drip irrigation	33 %	24.66	4.11	2.90	6.06
	66 %	28.66	4.21	3.38	6.13
	100 %	27.66	4.11	3.11	6.18
Subsurface irrigation (20 cm)	33 %	23.00	4.03	2.75	5.78
	66 %	26.00	4.06	2.98	5.75
	100 %	25.00	4.13	3.03	5.75
LSD at 5 %		**1.23**	**0.05**	**0.07**	**0.09**

Al-Dakheel and Al-Naeem (2000) showed that the interaction between water quantities and irrigation system (100 % of field capacity with surface irrigation) gave the highest values for melon yield parameters, Mannin (1988) found that the highest yield of cucumber was obtained by using 100 % ETM (maximum evapotranspiration) irrigation rate. Warriner and Handerson (1989) found that the highest yield of muskmelon was obtained by using drip irrigation.

Soil humidity and fruit weight

Irrigation systems

Data presented in Table (4) showed that the treatment with drip irrigation systems gave the highest values for soil humidity (zero-30 depth) and average fruit weight.

Water quantities

Table (4) showed that the highest results for soil humidity (zero-30 and 30-60 cm depth) was obtained after using 100 % of field capacity, while the treatment 66 % of field capacity gave the highest value for average cucumber fruit weight.

Data in Table (4) showed also that there were big significant differences between irrigation systems and water quantities on cucumber plant, the highest value for soil humidity (zero-30 cm) was obtained after using drip irrigation of 100 % field capacity, while the highest value for soil humidity (30-60 cm) was obtained after using 20 cm subsurface with 100 of field capacity treatment, however the interaction between drip irrigation and 66 % of field capacity gave the highest value for average fruit weight, similar results were obtained by Warriner and Handerson, 1989; Al-Dakheel, 2000 and Al-Naeem, 2000.

Table (4): Average of soil humidity (zero-30 and 30-60 cm) depth and fruit weight (Average two seasons 2000 and 2001).

Treatments		Soil humidity %		Aver.fruit weight (g)
		0 – 30 cm	30 - 60 cm	
Irrigation system	Drip irrigation	3.89	4.55	95.11
	Subsurface irrigation (20 cm)	3.15	3.31	92.33
LSD at 5 %		**0.07**	**0.13**	**1.81**
Water quantities	33 %	3.91	4.23	90.88
	66 %	4.16	4.47	93.66
	100 %	4.37	4.63	92.22
LSD at 5 %		**0.06**	**0.05**	**1.34**
Interaction				
Drip irrigation	33 %	3.65	3.18	92.66
	66 %	3.90	3.31	97.00
	100 %	4.13	3.45	95.66
Subsurface irrigation (20 cm)	33 %	2.90	4.25	91.00
	66 %	3.15	4.63	94.00
	100 %	3.41	4.78	92.00
LSD at 5 %		**0.07**	**0.09**	**1.07**

Reflected radiation

The highest value for reflected radiation from cucumber plant was obtained after using drip irrigation with 66 % of field capacity with all wavelength (690, 970 and 1450 nm) respectively while, the lowest values for reflected radiation with 690, 970 and 1450 nm) were obtained after using drip irrigation with 100 of field capacity (Fig 1). Similar results were obtained by Holmes (1981) who found that the amount of visible radiation is drastically reduced with canopy depth only 100 % of incident solar radiation in the 400-500 nm wavebands reached the ground surface in a wheat canopy 0.9 m high. Canopy reflectance is substantially less than from single leaf due to the attenuation of radiation inside the canopy. Similar results were found by Rigges and Running, 1991; Carlson *et al.*, 1991, 1990; Al-Dakheel, 1995 and Danson and Al-Dakheel (2000).

Therefore drip irrigation systems with 100 % of field capacity were the most favorable treatments for the vegetative growth and soil humidity, while the drip with 66 % of field capacity treatment gave the highest results for yield and yield quality. These results are in agreement with those obtained under reflected radiation with all wavelengths (690, 970 and 1450 nm).

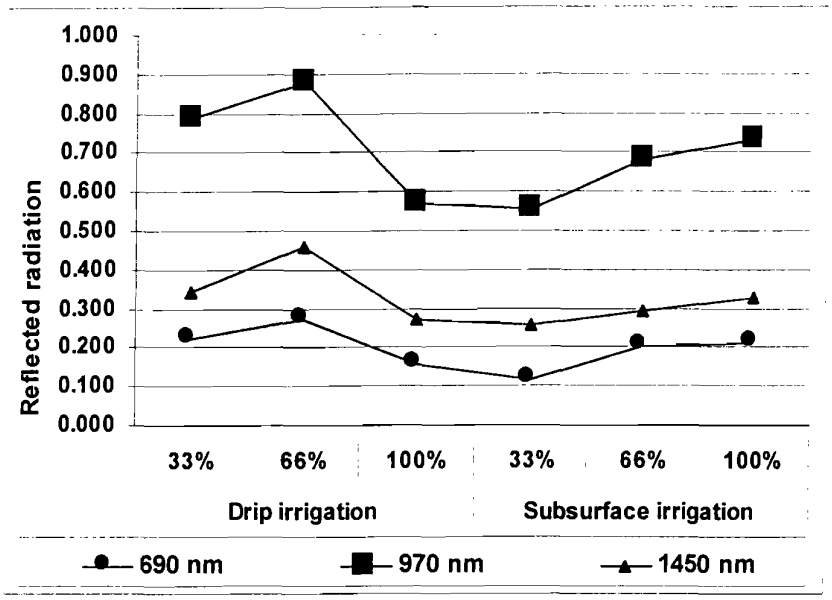

Fig (1): **Reflected radiation as affected by interaction between irrigation system and water quantities.**

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تأثير نظم الرى وكميات المياه على النمو والانتاجية والاشعاع المنعكس فى نبات الخيار

يوسف بن يعقوب الدخيل*، على فتحى حمايل**، السيد أحمد أحمد طرطورة**
* قسم الاراضى والمياه – كلية العلوم الزراعية – جامعة الملك فيصل – المملكة العربية السعودية.
** قسم الخضر والزينة – كلية الزراعة – جامعة المنصورة – مصر.

أجريت هذه التجربة فى البيوت المحمية لمدة عامين متتاليين ٢٠٠٠، ٢٠٠١ بهدف دراسة تاثير نظم الرى المختلفة (الرى بالتنقيط والرى ٢٠ سم تحت سطح التربة) وكميات مياه مختلفة للرى (٣٣% , ٦٦% ,١٠٠% من السعة الحقلية) على كل من النمو والمحصول وجودته فى الخيار ورطوبة التربة والاشعاع المنعكس من النبات.

اشارت النتائج الى ان استخدام طريقة الرى بالتنقيط كانت الطريقة المناسبة لزيادة كلا من طول النبات وعدد الاوراق والوزن الجاف/الطازج للنبات والمساحة الورقية وعدد الثمار وشكل الثمرة ومحصول النبات والوزن الجاف/الطازج للثمرة ومتوسط وزن الثمرة ورطوبة التربة.

بينما اشارت النتائج ان المعاملة باستخدام ١٠٠% من السعة الحقلية اعطت اعلى قيم بالنسبة لكلا من طول النبات وعدد الاوراق والوزن الجاف/الطازج للنبات والمساحة الورقية والوزن الجاف / الطازج للثمرة ورطوبة التربة بينما اعطت المعاملة باستخدام ٦٦ % من السعة الحقلية افضل النتائج بالنسبة لعدد الثمار وشكل الثمرة ومحصول النبات ومتوسط وزن الثمرة.

واشارت نتائج التفاعل بين نظم الرى وكميات مياه الرى الى ان اعلى قيم بالنسبة لكل من عدد الاوراق والوزن الجاف/الطازج للنبات والمساحة الورقية والوزن الجاف/الطازج للثمرة ورطوبة التربة تم الحصول عليها بعد استخدام الرى بالتنقيط مع ١٠٠ % من السعة الحقلية واكثر من ذلك نجد ان اعلى قيم بالنسبة لكلا من ارتفاع النبات وعدد الثمار وشكل الثمرة ومحصول النبات ومتوسط وزن الثمرة والاشعاع المنعكس من النبات تم الحصول عليها بعد استخدام الرى بالتنقيط مع ٦٦ % من السعة الحقلية.

واخيرا يمكن القول بان الرى بالتنقيط مع ١٠٠ % او ٦٦ % من السعة الحقلية يمكن ان يستخدم لزيادة النمو والانتاجية والاشعاع المنعكس من نبات الخيار تحت ظروف البيوت المحمية فى منطقة الاحساء بالمملكة العربية السعودية.