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GROWTH, YIELD, N UPTAKE AND WATER USE EFFICIENCY OF CARROT (*DAUCUS CAROTA L.*) PLANTS AS INFLUENCED BY IRRIGATION LEVEL AND NITROGEN FERTILIZATION RATE

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ABSTRACT :

Field experiments were carried out during winter seasons of 2000/20001 and 2001/2002 at the Experimental Farm of the Faculty of Agric., Al-Azhar Univ., Assiut on clay eyloamy soil to study the effect of irrigation levels and N fertilization rates on growth and yield as well as N uptake and water use efficiency of carrot. The results indicated that frequent irrigation with 100% replenishment of evaporation losses resulted in highest root yield, total dry matter, leaf area index, and N uptake. Water use efficiency recorded high value with 75% replenishment of evaporation losses. Also, the results showed that increasing nitrogen rate up to 120 kg N/fed significantly, increased the dry matter, root yields, water use efficiency and N uptake in all tested treatments. Apparently nitrogen recovery percent increased with evaporation replenishment up to 100% level and with increasing rate of nitrogen up to 80 kg N/fed, then decreased with increasing rate of applied nitrogen.

There were two phases the interaction effect. First response of root yield to nitrogen increment was significant, at 75% level of evaporation replenishment. This indicate that evaporation replenishment improved nitrogen utilization. Secondly, that the response to irrigation level application was, particularly noticed when levels of nitrogen were applied. The highest root yields were obtained with at 100% evaporation replenishment and 120 kg N/fed. On the other hand, maximum water use value were recorded with 120 kg N/fed and at 75% level of evaporation replenishment.

INTRODUCTION:

The optimum production of field crops can be reached through application of the necessary amounts of nutritive elements as well as adequate amount of irrigation. Water among the nutritive elements that should be made available to growing plants, is nitrogen It seem to gain priority. Carrot is an important short duration root vegetable grown for both fresh market and processed foods. Improving growth and yield have been reported in carrot with increasing frequency of irrigation (Bradley *et al*., 1967; El-Beheidi. *et al*., 1976; Dragland, 1978; Orzolek and Carroll, 1978; Nortje and Henrico, 1986). The unprecedented demand for limited water supply along with ever increasing cost of nitrogenous fertilizers necessitates judicious use of both water and nitrogen for carrot without adverse effect on the yield. Information on water requirement of carrot has received a little attention and the irrigation

practices followed are arbitrary. The management of irrigation water is important, since it governs evapotranspiration, water use efficiency, moisture extraction pattern, and nutrient uptake.

Hartmann *et al.* (1986) used four levels of irrigation. They found that the highest irrigation level increased root weight by 15% and leaf production by 50% as compared with lowest irrigation level. Farthermore, high irrigation levels of carrots can leach N out from the soil, while low irrigation levels provide insufficient water for N mineralization and for dissolving NO_3. Studies (Slyusar, 1986), on production of carrot under irrigation regimes indicated that the optimum soil moisture capacity was 60-70%. While, Grigorov and Sarana (1990) indicated that the optimum soil moisture content was 80-85% of field capacity at the early stages of growth and 70% at stages after thickening of the root collar. In experiments conducted with carrot cv. Nants, the effects of different levels of irrigation and N and P fertilizer application on yield and quality were studied (Batra,1990). The results showed that plant height, leaf fresh weight, root length and diameter, crop yield of root and leaf dry matter contents were greater at irrigation depth/cumulative pan evaporation ratios of 0.8 and 1.2 than at ratio 0.4. Also, it had been reported that nitrogen applied at 30,60 or 90 kg/ha significantly increased root and leaf dry matter and yield compared with the control without N. Prabhakar *et al.* (1991) found that frequent irrigation with 100% replenishment of evaporation losses resulted in highest root yield, total dry matter and leaf area index as well as N uptake and water use efficiency. Also, they showed that maximum root yields and water use efficiency were recorded with 120 kg N/ha. Paradiso *et al.* (2002) found that with two levels of nitrogen fertilization 100 and 300 kg N/ha the seasonal water consumption use values varied between 234 and 320 mm, and daily water consumption use values ranged between 0.6 and 4 mm/day, respectively. Also, they concluded that lower marketable yield was obtained at the minimum N rate (1.7 k.g/$m^{2)}$. Moderate water sress reduced yield from 3.1 to 2.1 kg/m^2. Treatments had a significant effect on plant growth as dry matter production.

Many Reachers had studied the effect of nitrogen application on carrots (Arora and Gupta, 1972; Otani 1974; and Sharma and Singh, 1981; Bruckner, 1986 and Skrbic, 1987 a and b). Studies (Mesquita *et al.*, 1985) on carrots (cv. Nantes) were treated with N at was 0, 60,120 or 180 kg/ha and P_2O_5 at 0, 300, 600 or 900 kg/ha. The crop was sprinkler-irrigation. The response curve showed that N at 138 kg/ha and P_2O_5 at 731 kg/ha, would give the highest yield.

Recently, Hassan *et al.* (1992); Raynal (1994); Eppendorfer and Eggum (1995); Ruhlmann (1996) and Abo Sedera and Eid (1992) concluded that fertilizing carrot plants with 60 kg N+ $72K_2O$/fed, proved to be the most effective treatment for obtaining good vegetative growth with higher yield and best quality. Hochmuth *et al.* (1999) studied the effects of N fertilization (140, 150, 160 and 180 kg N/ha) on carrot yield and quality. They found that yield of cv. Nantes carrot, increased with N fertilization. Those N rates that maximized carrot root yield, maximized quality as determined by sugar and carotenoid concentrations.

Finally, Beni *et al.* (2001) assessed the response of carrots cultivars to various amounts of N, P and K fertilizers. Applications of 200 kg N/ha, 33 kg P/ha and 123 kg K/ha (applied before sowing, at the 4^{th} leaf stage, during midvegetation and root development period) increased yield and crop quality. Gutezeit

(2002) found that the highest total root yield were reached in sandy and loamy soils at level of soil moisture (75% volume of available field capacity) and 150 kg N/ha. High yield and quality are important for growers of carrots (*Daucus carota L.*). Therefore the objective of this study was to determine the optimum soil moisture and N fertilization rate to maximize carrot yield and external quality as well as water use efficiency.

MATERIAL AND METHODS:

The present work was conducted during winter seasons of 2000/2001 and 2001/2002 at the Faculty of Agric., Al Azhar Univ., Assiut, to study the effect of irrigation levels and N fertilizer rate on growth, yield, N uptake and water use efficiency of carrot. In the first season, the soil used was a clayey loamy having of pH 7.90 and contains 82,15 and 135 ppm of available N, P and K, respectively as well as 2.13% of organic matter. In the second season, the experiment was conducted in the same place and the values of chemical and physical determination were almost the same as the first season. The available water in the top 60 cm soil profile was 120 mm. The water table was deeper than 2m for the entire cropping season during both years. Soil moisture constants are shown in Table (1). Average monthly meteorological data are recorded in Table (2).

Table (1) the soil moisture constants (% by weight) and bulk density gm/cm^3 of the experimental field in the surface 60 cm depth.

Constants depth (cm)	Field capacity	Wilting point	Available water %	Bulk density gm/cm^3
0 – 15	24.49	11.03	13.46	1.26
15 – 30	27.88	12.80	15.08	1.30
30 – 45	28.24	13.10	15.14	1.34
45 – 60	32.85	15.70	17.15	1.35

Table (2): Average monthly metrological data at Assiut in 2000/2001 and 2001/2002 season.

Season	2000/2001				2001/2002			
Months	E. Pan mm	Max. temp. °C	Min. temp. °C	Relative Humidity	E. Pan mm	Max. temp. °C	Min. temp. °C	Relative Humidity
December	2.6	24.8	10.3	81.3	3.8	25.3	12.9	70.1
January	4.3	25.6	14.9	73.3	4.1	25.3	10.6	60.3
February	5.9	29.5	15.2	61.9	6.6	30.3	14.5	53.0
March	7.2	31.9	18.9	57.7	7.1	31.4	16.0	58.5

The treatments comprised for irrigations levels and four evaporation replenishments i.e 25, 50, 75 and 100% based on class A pan cumulative values Doorenbos and Pruitt, (1977) and Zazueta and Smajstrla (1984) and four N levels (0, 40, 80, and 120 kg/fed.). These 16 treatment combinations were replicated four times in a factorial randomized block design. Each experimental unit consisted of five rows of 3.5 m long and 60 cm apart. Each plot size covered an area of 3.5 × 3.0 m (10.5 m^2). Carrot seeds (cv. Nantes) at a rate of 3 kg/fed were sown on both sides of each row on December, 4 in both years. After complete emergence the plants were thinned to have a uniform spacing of 3-5 cm. All plots received a constant level of P and K at rats of 30 kg P_2O_5 and 50 kg K_2O/fed. Super phosphate was added at two doses, the 1st (15 kg P_2O_5 /fed) was broadcasted during seed bed preparation and the 2nd (15 kg P_2O_5 /fed) was added after 30 days from planting. Mean while, K was added as K_2 SO_4 at two doses, the

1st (25 kg K_2 O/fed) after 4 week and the 2nd (25 kg K_2 O/fed) after 8 week from the plantation. Nitrogen (urea 46% N) treatment amounts were divided into two equal dose and added after 4 and 8 weeks of sowing. Four irrigations were given before imposing the differential irrigation treatments. At each irrigation 40 mm depth of water was applied. Irrigations were scheduled when the class A pan cumulative values reached 40, 60, 80 and 160 mm for 100, 75, 50, and 25 percent replenishment of evaporation losses.

Soil samples were collected (using a soil auger) from 60 cm depth before and 48 h. after each irrigation as well as at sowing and harvest and the crop evapotranspiration was computed using equation (Brutsaert, 1982).

$$Cu = D \times BD\,(Q_2 - Q_1)/100$$

Where:
Cu = actual evapotranspiration.
D = soil depth.
BD= bulk density of soil (gm/cm^3).
Q_2= percentage of soil moisture two days after irrigation.
Q_1= percentage of soil moisture just before next irrigation.

Water use efficiency values were calculated with by dividing of the root yield kg by m^3 water consumed according to the following equation (Begg and Turner, 1976).

$$WUE = \frac{\text{Root yield (kg/fed)}}{\text{Seasonal ET (mm/fed)}} = \text{kg/fed-mm water}$$

A sample of ten plants was collected from all the replications for each treatment at harvest for dry matter and nitrogen determination. Plant materials (leaves and root) were digested using a mixture of concentrated H_2SO_4 and $HCLO_4$ acids (Jackson, 1973). Total nitrogen determined by using micro-kieldahl method, as described by A.O.A.C. (1985). Nitrogen uptake was computed using data of nitrogen concentration in leaves and root multiplied with their respective dry matter. Apparent recovery of applied nitrogen was calculated using the following expression: (Thompson *et al*, 2000).

$$\text{Apparent recovery (\%)} = \frac{\text{N uptake in fertilized plots} - \text{N uptake in control plots}}{\text{N applied}} \times 100$$

To study the input–output relationship, response equations were fitted as described by Munson and Doll (1959). Harvest index was calculated by dividing the root dry matter by total dry matter (leaves and root). The leaf area index (LAI) was calculated according to Winter and Ohlrorgge (1988) as follows:

$$LAI = \frac{\text{Leaf area / plant}}{\text{Land area / plant}}$$

Statistical analysis of the data was done by following the procedures suggested by Gomez and Gomez (1984).

RESULTS AND DISCUSSION:

Growth and yield:

Most frequent irrigation at 100% replenishment of evaporation loss resulted in significantly higher total dry matter, leaf area index (LAI), and fresh root yield as compared with 25% replenishment of evaporation losses

(Table 3). Root yield increased linearly with higher evaporation replenishment during both years. This increase was largely due to higher root size and more photosynthetic surface (LAI) which resulted in higher dry matter accumulation with higher evaporation replenishments. These findings are in line with the finding of Bradley *et al*. (1967), Hartmann *et al*. (1986) and Slyusar (1986). Longer irrigation intervals are known to produce thinner roots and reduced yields in carrot (Nortje and Henrico 1986). Batra (1990); Grigorov and Sarana (1990) and Prabhakar *et al*. (1991). The highest mean marketable root yield (2 years) of carrot (58.9 and 32.9 t/ha) was recorded at 80% of pan evaporation replenishment (Imtiyaz *et al*., 2000). Water stress should be avoided throughout the carrot growing cycle. The critical period for irrigation is between fruit-set and harvest. An irrigation threshold of 40% soil water deficit should be targeted to avoid water stress. Water stress causes carrots to become woody and hard and too much water causes poor color and rot.

Significant higher yields were recorded with N fertilization and a raveled maximum with 120 kg N/fed (Table 3). The yield significantly increased with every increment of N level up to 120 kg/fed during both seasons except during 2000/2001 The differences between 40 and 80 kg N/fed were not significant. Higher yields with nitrogen fertilization was largely due to higher root size and photosynthetic surface. These findings were harmony with those reported by Sharma and Singh (1981); Mesquita *et al*. (1985); Raynal (1994); Eppendorfer and Eggum (1995) and Sanderson and Ivany (1997). Furthermore, it was found that nitrogen fertilization rates which maximized carrot root yield also maximized carrot quality as determined by sugar and carotenoid concentrations (Hochmuth *et al*., 1999; Gutezeit, 2001; and Beni *et al*., 2001).

Table (3): Growth, yield and yield components of carrots as affected by irrigation and nitrogen fertilization during winter seasons of 2000/2001 and 2001/2002.

Treatments	Total dry matter (g/plant)		Leaf area index (LAI)		Root yield (t/fed)		Root weight (g)		Harvest index	
	2000/2001	2001/2002	2000/2001	2001/2002	2000/2001	2001/2002	2000/2001	2001/2002	2000/2001	2001/2002
E.R (%)*										
25	3.84	4.28	1.16	1.49	5.86	8.31	10.2	13.6	0.54	0.58
50	7.10	8.70	2.06	2.91	15.63	15.14	24.7	23.7	0.58	0.60
75	7.80	8.96	2.20	3.08	23.05	21.39	36.3	33.9	0.54	0.58
100	9.21	9.51	2.96	3.16	28.75	23.34	45.3	37.4	0.51	055
L.S.D$_{0.05}$	1.49	0.92	0.48	0.31	2.78	1.84	3.85	2.62	NS	NS
N levels (kg/fed)										
0	4.43	4.07	1.36	1.54	8.94	8.28	14.8	13.6	0.52	0.59
40	7.34	8.06	2.27	2.38	19.91	15.05	30.5	23.7	055	062
80	7.78	9.13	2.30	3.18	20.78	20.82	32.7	33.2	056	0.63
120	8.42	10.21	2.43	3.57	23.66	24.16	37.3	38.3	055	0.62
L.S.D$_{0.05}$	1.49	0.92	0.48	0.31	2.78	1.84	3.85	2.62	NS	NS

***E.R: Evaporation replenishment(%)**

The interaction effects of rate evaporation replenishment and N fertilization were significant during both years (Table 4). Root yields obtained with irrigation scheduled at replenishing 75 or 100% evaporation loss with 120 kg N/fed were significantly superior than

yields obtained at losser irrigation frequencies and lower nitrogen rates except 80 kg N/fed at 100% evaporation replenishment during 2000/2001. During 2001/2002, the highest root yield was obtained with most frequent irrigation and highest N level (120 kg/fed). These findings are consistent with Dragland (1978); Batra (1990), Prabhakar *et al.* (1991); Saparov (1992) and Paradiso *et al.* (2002). (Gutezeit, 2002) found that highest total yields were obtained in sandy and loamy soils at level of soil moisture (75% volume available field capacity) and 150 kg N/ha.

Table (4) Interaction effect of evaporation replenishment and nitrogen fertilization on root yield (t/fed) of carrot.

N levels (kg/fed)	2000/2001 season					2001/2002 season				
	Evaporation replenishment (%)					Evaporation replenishment (%)				
	25	50	75	100	Mean	25	50	75	100	Mean
0	4.89	5.64	11.33	13.91	8.94	5.27	8.16	9.38	10.31	8.28
40	5.69	16.93	22.88	31.33	19.21	6.97	14.53	17.84	20.90	15.06
80	6.21	19.73	25.77	34.21	21.48	9.37	17.73	28.13	28.01	20.81
120	6.67	20.22	32.21	35.55	23.66	11.63	20.14	30.20	34.56	24.13
Mean	5.87	15.63	23.05	28.75	18.32	8.31	15.14	21.39	23.45	17.07

Nitrogen concentration and uptake:

Nitrogen Concentration in both, leaves and roots increased with replenishing evaporation losses up to 75% in 2000/2001 and up to 50% in 2001/2002, beyond which there was a marginal decrease (Table 5). Increase in N concentration with water stress up to a certain level has been well documented (Begg and Turner 1976). High irrigation levels reduced the NO_3 level in carrots by leaching N out from the soil, while low irrigation levels provided insufficient water for N mineralization and for dissolving NO_3 (Hartmann *et al.*1986). Total as well as leaf and root N uptake increased mainly due to higher leaf and root dry matter. These results corresponded with those findings of El-Beheidi *et al.* (1976); Prabhakar *et al.* (1991) and Saparov (1992). Both N concentration and uptake were significantly increases with N fertilization up to 120 kg/ha in both years. Higher N uptake increased as a combined effect of increasing N concentration and dry matter production. These findings where in agreement with those of Prabhakar *et al.* (1991); Abo Sedera and Eid (1992); Hassan *et al.* (1992); Ruhlmann (1996); Paradiso *et al.* (2002) and Sanderson and Ivany, 1997. Also, Sanderson & Ivany, 1997 found that N concentration of carrot plant ranged from 3.2 to 4.1% and was significantly increased in both years. Regarding the effect of the interaction between evaporation replenishment and N fertilization, the same data show clearly that N concentration and uptake was not significant.

Apparent recovery of applied N:

Total N recovery (Table 6) of carrot crop was comparable to that observed in most field crop. There was a marked increase in the recovery of applied N with increasing supply of irrigation water up to a replenishment level of 75% of evaporation loss, beyond which there was a marginal increase. Recovery of applied N improved marginally with increasing N dose up to 80 kg/fed and then declined marginally with increase in amount of applied N. These results were similar to those obtained by Omer *et al.* (1970) and Parabhakar *et al.* (1991) they found that apparent nitrogen recovery percent

increased with moisture application and decreased with the increasing rate of nitrogen. Nitrogen recovery increased with application of chemical fertilizer N up to mixture of 1 : 1 (50 kg organic N: 50 kg inorganic N/fed), but there was no further increase with mixture of 1:3 (25 kg organic N : 75 inorganic N/fed) especially for farmyard manure and broad been straw amended soil (Metwally and Khamis 1998 and El-Nagar 2003).

Table (5): N concentration and uptake in carrot as affected by evaporation replenishment (ER) and N fertilization rates.

Treatments	N concentration (%)				N uptake (kg/fed.)					
	Leaf		Root		Leaf		Root		Total	
	2000/2001	2001/2002	2000/2001	2001/2002	2000/2001	2001/2002	2000/2001	2001/2002	2000/2001	2001/2002
(ER) (%)										
25	1.08	1.34	0.90	1.09	9.30	16.22	9.57	10.56	18.87	26.68
50	1.29	1.48	0.98	1.17	19.73	25.77	19.84	23.82	36.57	49.59
75	1.48	1.34	0.94	1.02	24.12	38.21	21.28	26.56	48.40	64.77
100	1.22	1.25	1.06	1.13	26.90	41.95	25.39	29.72	52.29	71.67
$L.S.D_{0.05}$	0.13	0.11	0.10	0.10	3.94	6.03	3.80	4.72	7.53	7.40
N levels (kg/fed)										
0										
40	0.98	1.16	0.58	0.72	10.08	16.12	6.83	8.52	16.91	24.64
80	1.09	1.19	0.87	0.98	16.71	23.26	17.21	17.53	33.92	40.79
120	1.49	1.47	1.09	1.22	25.52	37.68	23.21	26.98	48.93	64.66
$L.S.D_{0.05}$	1.54	1.57	1.20	1.49	27.73	45.09	28.83	37.51	56.56	82.60
	0.13	0.11	0.10	0.10	3.94	6.03	3.80	4.72	7.53	7.40

Table (6): Apparent recovery (%) of applied N as affected by irrigation and N fertilization (pooled data)

N levels (kg/fed)	Evaporation replenishment (%)				
	25	50	75	100	Mean
40	11.1	35.2	63.1	56.4	46.5
80	17.1	36.2	59.2	67.7	45.0
120	16.3	36.8	52.7	59.4	41.3
Mean	14.8	36.1	58.3	61.2	42.6

Response Analysis.

Response functions fitted to the yield data of individual years and their means indicated the quadratic nature response to N in carrot (Fig.1) with a very high coefficient determination (R^2 =0.99). Based on pooled data 224.7 kg N/fed was found to be optimum. Imtiyaz *et al.* (2000). Concluded that the seasonal water applied and marketable yield of carrot showed quadratic relationships (R^2 =0.85 – 0.98), which could be used for allocation irrigation water within and between the crops. The net economic return increased with the increase in pan evaporation replenishment.

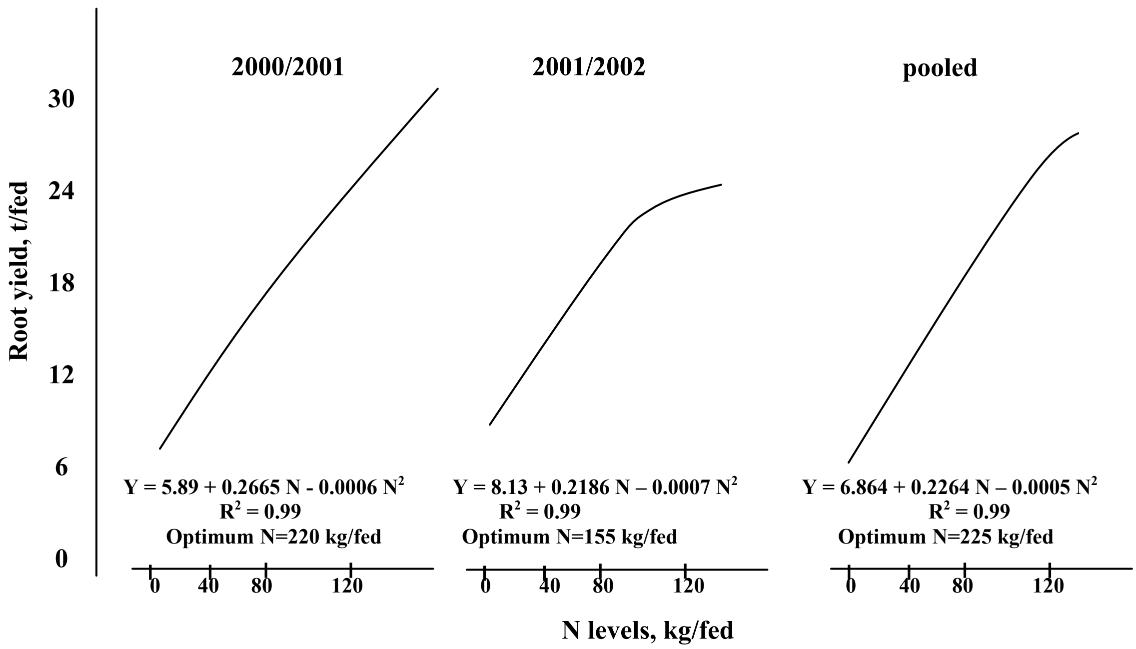

Fig. (1): Fitted response functions of carrot N for root yield.

Water use:

Evapotranspiration (ET) increased with increasing evaporation replenishment (Table 7). Transpiration losses were more noticed with frequent irrigation due to more transpiration area of the crop. Evaporation losses from the soil surface would be naturally higher than under drier regimes. (Narang and Dastane. 1969, Prabhakar *et al.*, 1991 and Paradiso 2002). The second graph (Figure 2) shows the average daily water use. Maximum water use by carrots is approximately 5 mm of water/day. This occurred when the carrots reach marketable size. However carrots can be harvested anytime and peak water use will vary. After the carrots reach peak size, water use begins to decline and then rises slightly before going to seed.

Water use efficiency (WUE) also followed a similar trend as that of ET, except for the irrigation scheduled to replenish 100% evaporation loss during the second season. This indicated that the reduction in ET in mild and severely stressed carrot was at the expense of carrot. These results confirmed the findings of Sing 1978; Grigorov *et al.* (1990) and Parabhakar *et al.* (1991). Irrigation replenishment up to 80% of pan evaporation loss did not influence the irrigation production efficiency for total and root yield of carrot. The results revealed that a further increase in irrigation amount resulted from 100% of pan evaporation replenishment did not increase the marketable root yield of crops but reduced the irrigation production efficiency significantly (Imtiyaz *et al.*, 2000).

Table (7): Water use efficiency (WUE) of carrot as effected by level of evaporation replenishment (ER) and N fertilization rates.

Treatments	Number of irrigation's		Evapotranspirat (mm)		WUE (kg root /fed-mm water)	
	2000/2001	2001/2002	2000/2001	2001/2002	2000/2001	2001/2002
ER (%)						
25	5	6	226.4	238.4	25.9	34.9
50	8	9	282.5	308.2	55.3	49.1
75	11	12	371.8	361.0	62.0	59.2
100	13	14	449.7	432.1	63.9	54.3
N levels (kg/fed)						
0	9	10	329.5	332.8	25.8	24.9
40	9	10	331.0	333.3	56.5	48.1
80	9	10	332.6	334.8	58.2	62.9
120	9	10	335.1	335.8	66.7	68.9

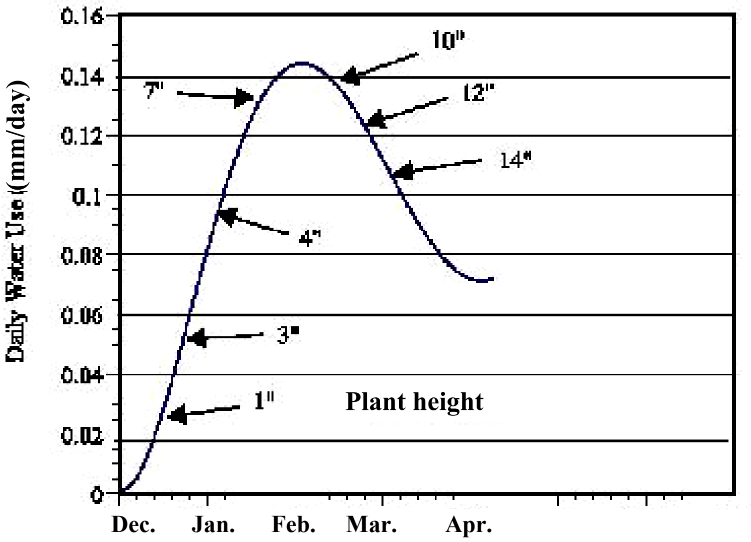

Figure (2): Average daily water use for carrots utilizing a calendar schedule.

The result WUE in most frequently irrigated treatment during the second season was due to proportionally grater loss of water than corresponding increase in root yield. Nitrogen fertilization marginally increased ET due to increases on leaf area but markedly increased the WUE up to an application rate of 120 kg N/fed. This increase of WUE with increase in rate of N fertilization is due to of proportionately, lesser loss of water than corresponding increase in the yield. Moreover, efficient use of water under high fertility conditions in other crops have been reported (Parabhakar *et al.* 1991; Eppendorfer and Eggum 1995; Paradiso *et al.* 2002 and El-Nagar 2003).

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النمو والمحصول والنتروجين الممتص وكفاءة الاستهلاك المائى لنباتات الجزر المتأثر بمستويات الرى مع معدلات التسميد الأزوتى

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أجريت تجربة حقلية خلال موسمي النمو الشتوى ٢٠٠٠/٢٠٠١ ، ٢٠٠١/٢٠٠٢ بمزرعة كلية الزراعة – جامعة الأزهر بأسيوط على أرض طمييه طينية لدراسة تأثير مستويات الرى مع معدلات من السماد الأزوتى على النمو والمحصول وكذلك المحتوى الكلى للنتروجين لنباتات الجزر والكفاءة الاستعمالية لمياه الرى.

أكدت النتائج أن زيادة مرات الرى عند المستوى ١٠٠% لتعويض الفقد بالبخر – نتح يؤدى إلى زيادة المحصول والمادة الجافة الكلية ويتبعها زيادة محتوى النتروجين فى النبات. بينما كفاءة استعمال الماء أعطت أعلى معدل لها عند مستوى ٧٥% لتعويض الفقد – نتح، كذلك تبين النتائج أن زيادة النتروجين إلى المعدل ١٢٠ كجم/فدان سجلت أعلى زيادة معنوية فى محصول المادة الجافة ومحصول الجذور وكفاءة استعمال الماء مع كل المعاملات تحت الدراسة. هناك صورتان لتأثير التداخل الناتج من استعمال السماد الأزوتى مع مستويات الرطوبة:

أولاً– استجابة محصول الجذور فى نباتات الجزر لإضافة مستويات النتروجين كانت معنوية فقط مع الرى عند مستوى ٧٥% لتعويض الفقد فى البخر – نتح، كذلك تؤكد النتائج أن زيادة الرطوبة تحسن من الاستفادة من النيتروجين.

ثانياً– استجابة المحصول لمستويات الرطوبة كانت تلاحظ بوضوح خصوصاً مع إضافة السماد الأزوتى.

وتبين النتائج أن أعلى محصول جذور من نباتات الجزر نتج من إضافة ١٢٠ كجم نتروجين/فدان وعند مستوى ١٠٠% لتعويض فى الفقد– نتح وفى المقابل كانت أعلى قيمة لكفاءة استعمال الماء عند مستوى ٧٥% لتعويض الفقد فى البخر – نتح مع إضافة ١٢٠ كجم نتروجين/فدان.