RESULTS AND DISCUSSION

4.1. Effect of irrigation and fertilization on growth characteristics of carrot plants:

Data illustrated in Figs.(1 and 2)and Table (1) show the effect of irrigation, fertilization and their interaction on morphological characteristics of carrot plants.

Concerning the effect of irrigation, data in Fig. (1) revealed that, increasing water supply i.e. irrigation every two weeks throughout the growing season increased all the studied vegetative growth parameters, i.e. plant length, top and root length as well as fresh and dry weight per plant during both seasons of growth. In this respect, the highest increments in the forementioned growth parameters were obtained as a result of the highest level of water supply (2280 m^3/Fad.) i.e. irrigation at 70-80% of field capacity during the growth season.

Such increasing effect of irrigation on plant growth parameters may be attributed to the role of water in accelerating the physiological processes and increasing the up-take of macro-nutrients (Fig. 5) which consisted and incorporated in the formation of protoplasmic material necessary for cells formation and consequently increasing the plant growth. These results are in accordance with those reported by each of Elkner and Michalik (1973), El-Mansi et al. (1975), El-Beheidi et al. (1976) and Hartmann et al. (1986).

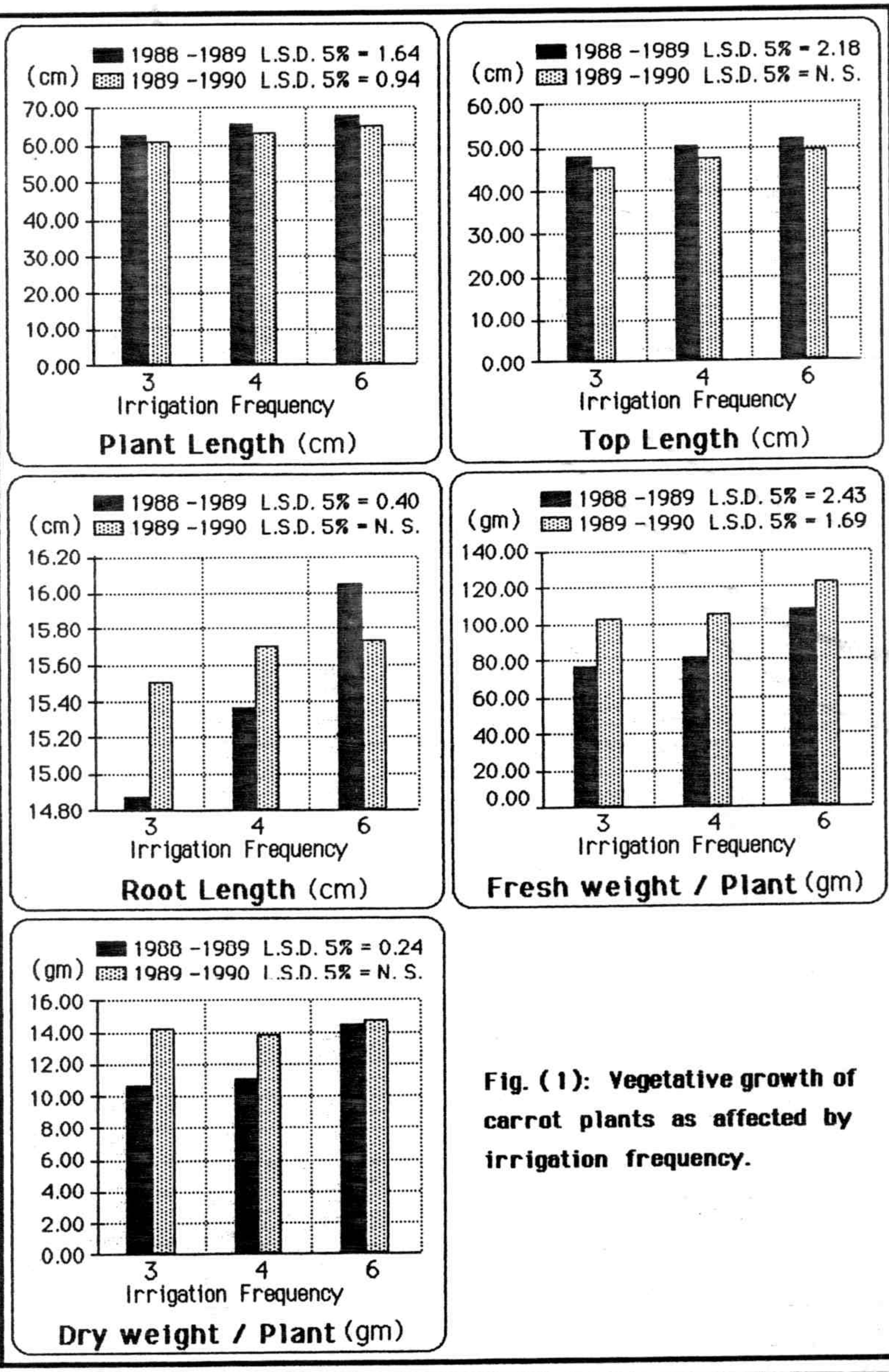

Fig. (1): Vegetative growth of carrot plants as affected by irrigation frequency.

Regarding the effect of fertilization, data at Fig.(2) show clearly that length of each of whole plant, top and root as well as fresh and dry weight per plant were significantly increased with increasing the NPK fertilization level. In this respect, the fourth fertilization level i.e. 40 kg-N + 32 kg P_2O_5 + 100 kg K_2O per Faddan reflected the highest increments in all studied growth aspects. However, increasing NPK fertilizer rate than the fourth used level tended to decrease all previously mentioned growth measurements. Such increments in plant growth parameters may be due to the phyisological role of such macro-nutrients in formation and assimilation of the growth substances and increasing the net assimilation rate and concequently the plant growth. Obtained results are in agreement with those obtained by Habben (1973) and Emura and Hosoya (1979) on carrot, Bourke (1985) and El-Sayed (1987) on sweet potato and El-Sayed and Omran (1984) on red beet who reported that fertilized plants with N, P and K fertilizers at different levels increased different growth aspects of such plants.

According to the effect of the interaction, it is obvious from the data at Table (1) that irrigation six times i.e. every two weeks throughout the growing season and applying NPK fertilizer at 40 kg-N + 32 kg P_2O_5 + 100 kg K_2O per Faddan resulted in the maximum values of plant growth aspects. It could be concluded that under similar conditions of such

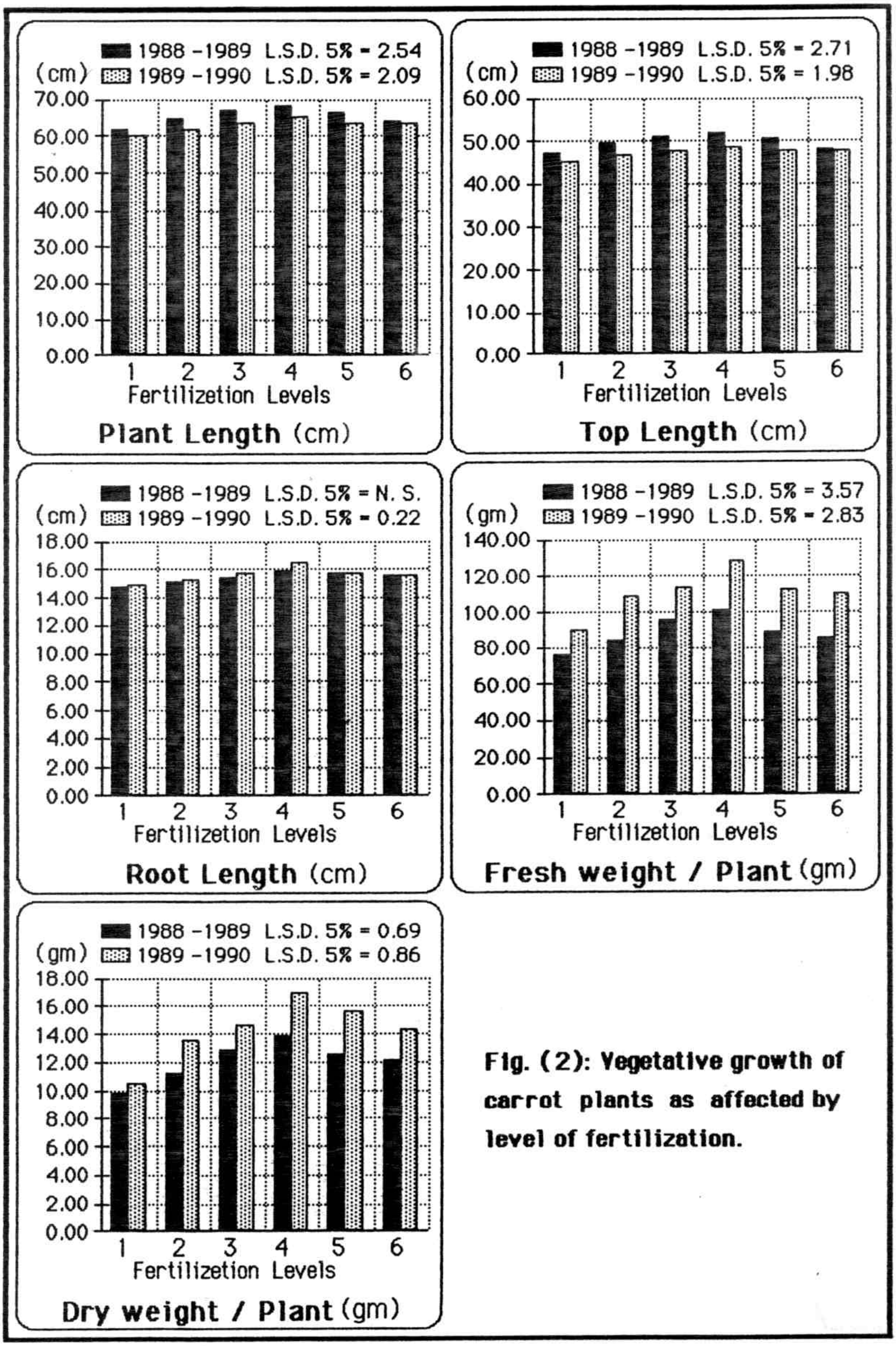

Fig. (2): Vegetative growth of carrot plants as affected by level of fertilization.

Table (1): Vegetative growth of carrot plants as affected by irrigation and fertilization treatments.

Season		1988-1989					1989-1990				
Irrigation frequency	Fert. levels	Plant length (cm)	Top length (cm)	Root length (cm)	Fresh weight/plant (gm)	Dry weight/plant (gm)	Plant length (cm)	Top length (cm)	Root length (cm)	Fresh weight/plant (gm)	Dry weight/plant (gm)
3	1	57.98	43.58	14.40	69.31	9.24	59.33	44.66	14.67	92.02	11.72
	2	63.18	48.47	14.71	75.27	10.18	60.22	45.36	14.86	104.32	14.00
	3	63.47	48.70	14.77	79.87	11.03	61.28	45.53	15.75	101.48	14.02
	4	64.16	49.32	14.84	81.54	11.48	62.83	46.55	16.28	113.40	16.23
	5	63.66	48.59	15.07	75.91	10.95	60.31	44.65	15.66	104.08	15.14
	6	63.12	47.69	15.43	77.30	11.18	61.22	45.57	15.65	103.90	14.08
4	1	63.32	48.97	14.35	71.61	9.08	59.60	44.64	14.96	82.25	9.90
	2	64.09	49.16	14.93	74.24	9.76	62.24	46.96	15.28	98.10	12.14
	3	66.91	51.34	15.57	83.72	11.44	63.74	47.92	15.82	109.60	14.20
	4	68.76	52.99	15.77	86.29	11.87	66.26	49.79	16.47	130.71	17.47
	5	67.19	51.25	15.94	91.10	12.91	64.33	48.50	15.83	105.73	14.98
	6	64.53	48.85	15.68	81.52	11.35	63.66	47.84	15.82	104.33	14.17
6	1	64.71	49.39	15.32	89.02	11.13	61.88	46.94	14.94	93.55	10.02
	2	67.74	51.99	15.75	103.79	13.95	63.60	47.83	15.77	125.19	14.48
	3	70.32	54.01	16.31	123.19	16.23	65.23	49.38	15.85	129.52	15.54
	4	71.59	54.64	16.95	133.94	18.20	66.84	50.24	16.60	140.76	17.01
	5	68.08	51.88	16.20	99.13	13.77	65.37	49.52	15.85	127.34	16.68
	6	64.03	48.33	15.70	97.80	13.75	68.59	53.22	15.37	121.25	14.68
L.S.D.		n.s	n.s	n.s	6.19	1.20	n.s	n.s	n.s	4.90	n.s

experiment, the highest irrigation treatment (using 2280 m^3/Fad. of water) combined with the fourth level of NPK fertilizer (40 kg-N + 32 kg P_2O_5 + 100 kg K_2O/Fad.) resulted in the highest carrot plants growth.

4.2. Photosynthetic pigments of carrot plant foliage:

Data presented at Figs. (3 and 4) and Table (2) show the effect of different irrigation and fertilization treatments as well as their interaction on photosynthetic pigments of carrot plants.

With regard to the effect of irrigation, it is evident from data at Fig. (3) that a, b and total chlorophyll as well as carotenoides content of plant foliage were significantly decreased with shortening the irrigation frequencies throughout the growing season. In this connection, the highest content of pigments were revealed as a result of application of the least amount of irrigation water (1140 m^3/Fad.) i.e. irrigation at 50-59% of field capacity during the growing season. Increasing photosynthetic pigments content in plant foliage of such treatment may be due to subjecting carrot plants to the highest level of water deficats which led to an intensive concentration of such pigments in plant foliage. This result may be explained on the base of that treatment of the highest water supply resulted in the highest values of plant growth measurements as shown by data of Fig. (1). Similar results were reported by El-Mansi et al. (1975) and El-Beheidi et al. (1976) on carrots who reported that irrigation either at

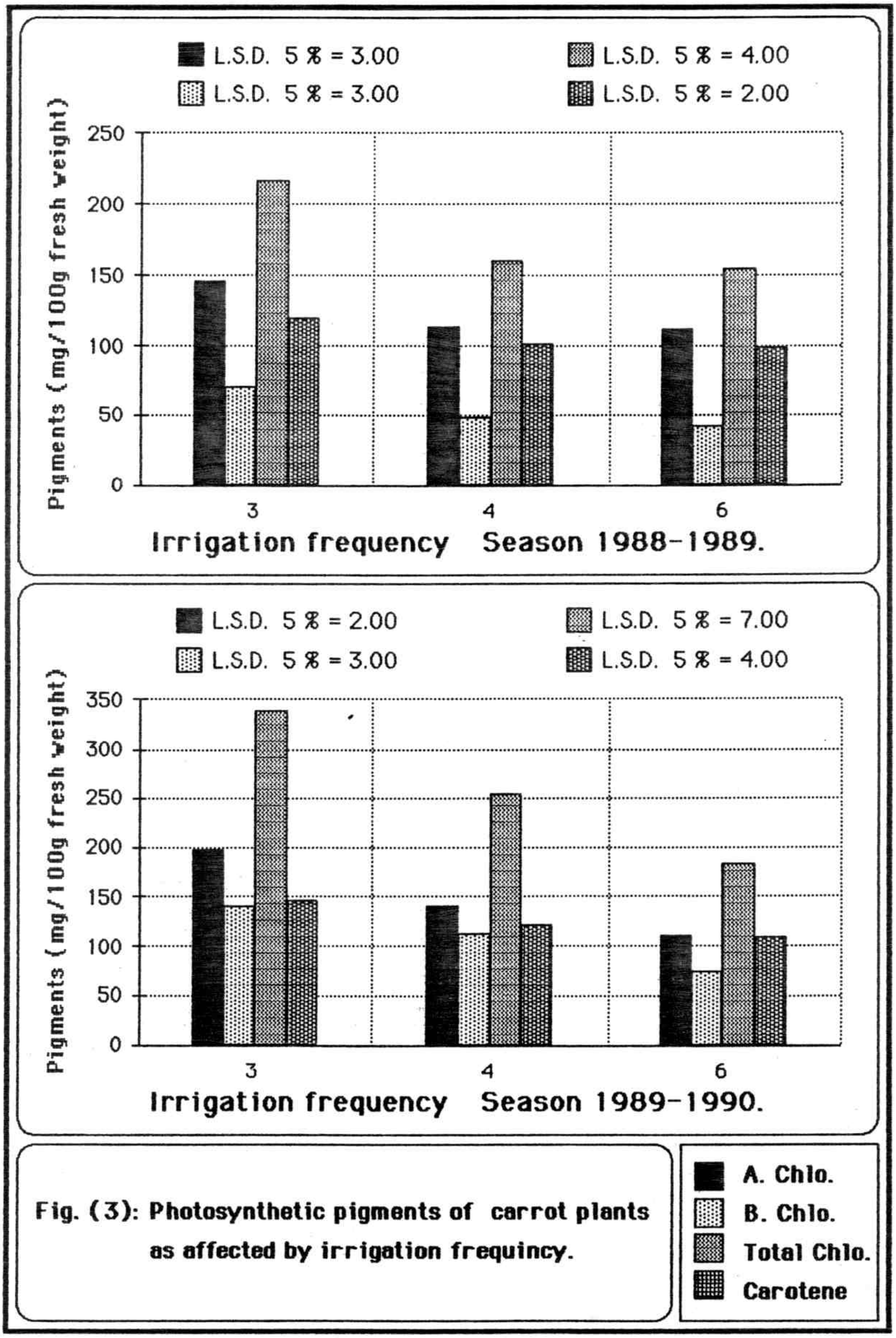

Fig. (3): Photosynthetic pigments of carrot plants as affected by irrigation frequincy.

depletion of 20% of soil water or at shorter irrigation frequencies decreased the photosynthetic pigments content of carrot plant foliage.

Data for the effect of fertilization on photosynthetic pigments of carrot plant foliage expressed as a, b and total chlorophyll as well as carotenoides compounds are shown at Fig. (4). From such data it is clearly evident that all photosynthetic pigments molecules were positively responded to increasing NPK fertilization level. In this regard, the highest used fertilization level (60 kg-N + 48 kg P_2O_5 + 150 kg K_2O per Faddan) reflected the highest photosynthetic pigments content. Such results may be attributed to the main role of used macro-nutrients in the formation and constancy of such pigments in plant tissues. These results are in agreement with those found by Afifi et al. (1989) on cow pea and Khalil (1989) on cucumber who reported that there was progressive and consistent increase in the contents of photosynthetic pigments in plant leaves with increasing the level of N, P and K fertilizers up to the highest used one.

Concerning the interaction effects of irrigation and fertilization treatments, data at Table (2) indicated that the longest irrigation intervals, i.e. irrigation every four weeks interval throughout the growing season combined with the highest used level of NPK fertilizer resulted in the the maximum values of photosynthetic pigments content. These results are true during both the two seasons of this work.

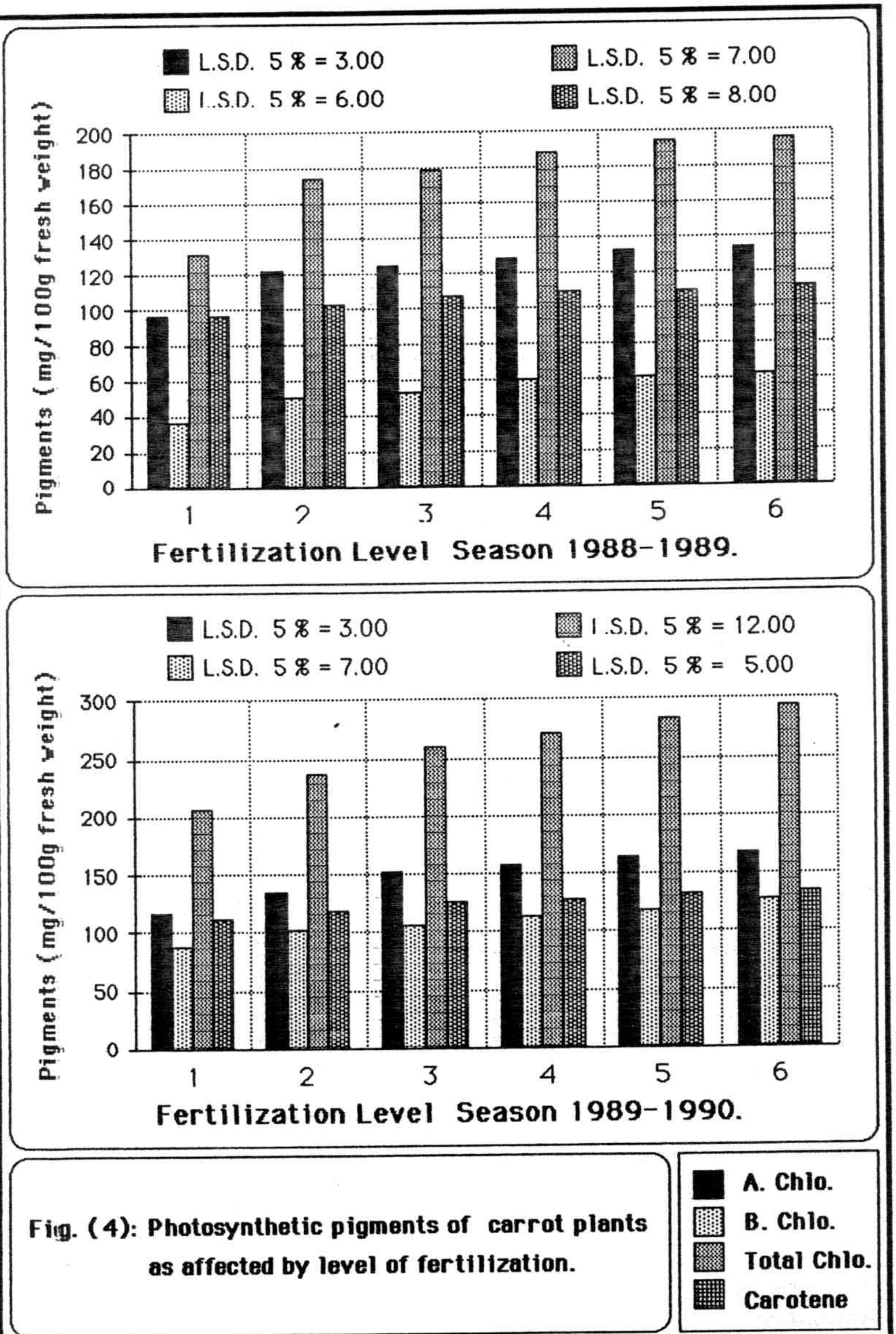

Fig. (4): Photosynthetic pigments of carrot plants as affected by level of fertilization.

Table (2): Photosynthetic pigments of carrot plants as affected by irrigation and fertilization treatments.

		1988-1989				1989-1990			
Irrigation frequency	Fert. levels	Chlorophyll (mg/100 g fresh weight)			Carote-noides (mg/100g fresh weight)	Chlorophyll (mg/100 g fresh weight)			Carote-noides (mg/100 g fresh weight)
		A	B	Total		A	B	Total	
3	1	105	48	153	105	164	121	285	139
	2	149	75	224	120	193	140	333	141
	3	153	76	228	121	202	141	343	146
	4	154	76	230	122	205	147	351	147
	5	157	77	234	123	206	147	353	148
	6	156	76	232	124	210	152	362	152
4	1	90	27	117	94	111	85	195	101
	2	106	36	142	95	119	106	225	119
	3	109	41	149	103	138	108	246	126
	4	117	58	175	106	146	115	261	127
	5	126	60	186	107	161	127	288	128
	6	127	64	191	108	163	142	305	127
6	1	92	35	126	93	77	61	138	95
	2	113	42	155	94	91	64	155	97
	3	114	43	157	98	117	70	186	107
	4	116	46	160	99	124	76	200	108
	5	116	46	163	100	126	84	210	122
	6	119	47	166	105	128	86	213	125
L.S.D.		5	10	12	n.s	5	n.s	20	8

4.3. Effect of irrigation and fertilization on chemical composition of plant foliage:

1. Macro-elements:

Data presented in Figs. (5 and 6) and Table (3) show the effect of irrigation, fertilization and their interaction on total nitrogen, phosphorus and potassium content of carrot plant foliage.

Regarding the effect of irrigation, such data in Fig.(5) show clearly that total nitrogen, phosphorus and potassium content of plant foliage was significantly increased with increasing the irrigation water supply. In this respect, irrigation at 70-80% of field capacity i.e. irrigation every 15 days interval throughout the growing season, reflected the highest content of previously mentioned macro-elements. These results may be attributed to the role of water in dec decreasing the viscosity and increasing movement of such macro-elements in the soil and increasing the dry matter content of plant (Fig. 1) which led to the increase in the uptake by plant. Obtained results are in harmony with those reported by El-Beheidi et al. (1976), Geissler and Henkel (1985) and Hartmann et al. (1986) all working on carrots and Said et al. (1984) on sweet potato.

Concerning the effect of fertilization, it is evident from data at Fig. (6) that increasing the fertilization rate

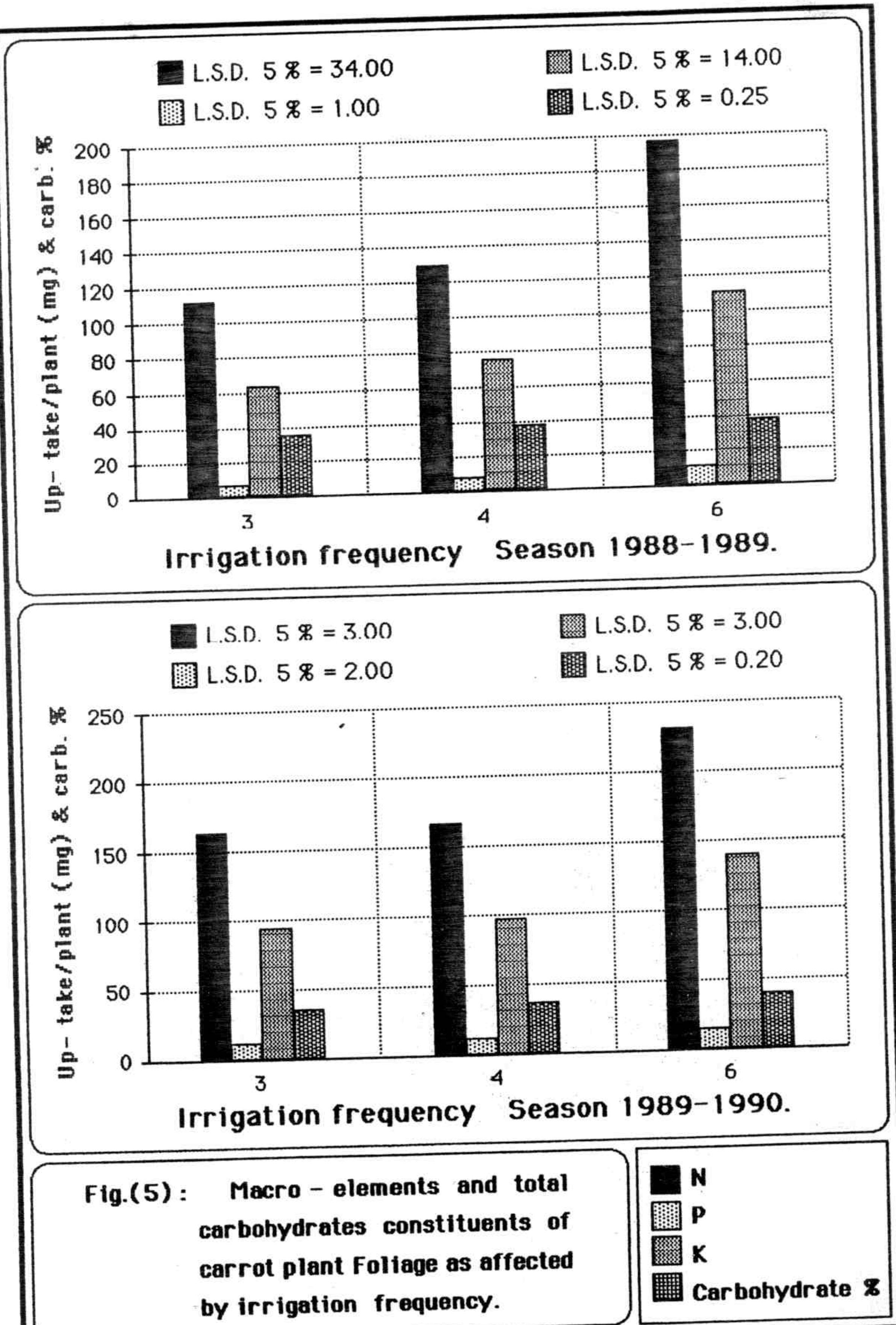

Fig.(5): **Macro - elements and total carbohydrates constituents of carrot plant Foliage as affected by irrigation frequency.**

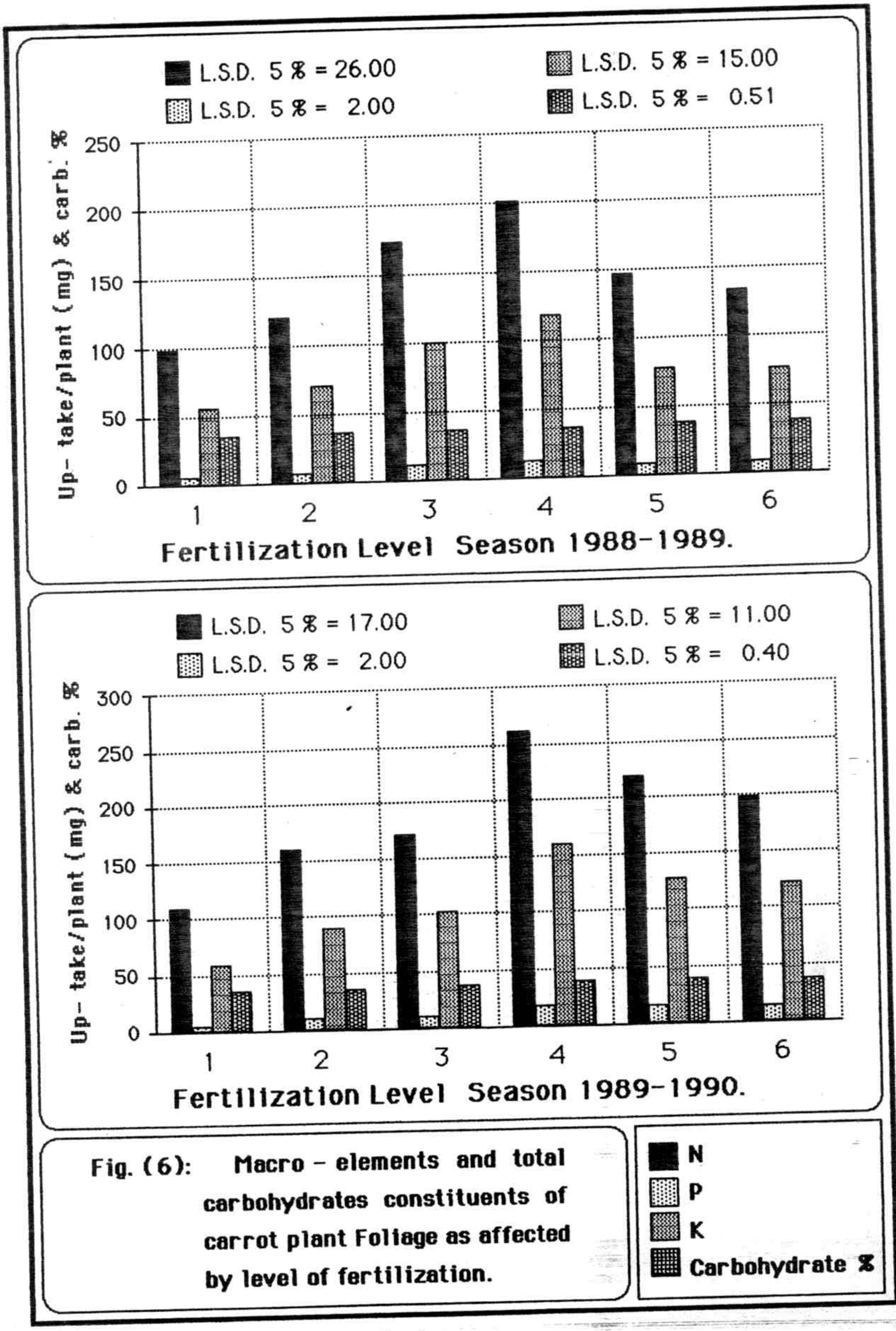

Fig. (6): **Macro - elements and total carbohydrates constituents of carrot plant Foliage as affected by level of fertilization.**

supplied to carrot plants led to significant increases in all determined macro-elements. In this regard, the highest total nitrogen, phosphorus and potassium content were obtained by the fourth used level of fertilization i.e. 40 kg-N + 32 kg-P_2O_5 + 100 kg K_2O per Faddan. Such result may be due to the increase of the concentration of such macro-nutrients in the soil in the region of roots growth which led to increasing the amount absorped by plant. The higher level of fertilization more than the fourth one tended to decrease the up-take of such macro-nutrients in plant foliage. Such depressing effects may be due to the highest concentration of such macro-nutrients in the soil which increased the osmotic pressure for the soil solution and consequently decreased the amounts absorped by plant. Similar results on increasing the content of N, P and K with increasing the fertilization rate were obtained by Mazur and Lukaszuk (1977) on carrot, Abd-Alla et al. (1983) on celery, Suwwan et al. (1987) on tomato, Zhagloul et al. (1988) on pea and Khalil (1989) on cucumber.

As for the interaction effect, it is obvious from data at Table (3) that increasing the amount of water supplied to plants, either through decreasing the irrigation intervals or increasing the irrigation frequencies, throughout the growing season, and increasing the fertilization level up to the fourth one, resulted in the highest N, P and K content of plant foliage.

Table (3): Macro-elements and total carbohydrates constituents of carrot plant foliage as affected by irrigation and fertilization treatments.

Season		1988-1989				1989-1990			
Irrigation frequency	Fert. levels	Up-take/plant (mg) N	P	K	Total carbo-hydrate (%)	Up-take/plant (mg) N	P	K	Total carbo-hydrate (%)
3	1	88	6	53	33.21	124	7	69	32.70
	2	99	6	66	35.70	158	10	93	33.65
	3	118	8	73	35.90	150	10	91	36.06
	4	159	10	90	36.09	199	15	117	36.68
	5	103	5	51	35.61	187	13	95	36.78
	6	103	5	50	35.58	162	11	101	35.44
4	1	86	5	49	35.69	107	6	58	33.74
	2	101	6	63	36.84	121	8	72	35.41
	3	147	9	87	37.22	158	10	89	37.23
	4	160	10	94	37.80	247	17	150	37.37
	5	160	9	82	37.99	164	13	102	37.51
	6	123	7	73	38.47	199	13	113	37.51
6	1	123	6	66	35.21	97	5	51	38.70
	2	162	8	83	35.73	205	12	106	39.08
	3	258	15	139	37.26	209	12	125	39.55
	4	286	18	171	37.74	336	22	217	40.13
	5	178	11	102	38.89	308	20	188	39.65
	6	176	12	106	40.13	234	17	153	39.94
L.S.D.		n.s	n.s	n.s	n.s	29	4	19	n.s

It could be concluded that, under such conditions, irrigation of carrot plants six times throughout growing season and fertilization with 40 kg-N + 32 kg P_2O_5 + 100 kg K_2O per Faddan resulted in the highest values of N, P and K content of carrot plants foliage.

2. Total hydrolizable carbohydrates:

The same data at Figs. (5 and 6) and Table (3) show the effect of irrigation frequency, fertilization level and their interaction on total carbohydrates content of plant foliage.

Refering to the effect of irrigation, it is evident from data at Fig. (5) that the total carbohydrates were significantly increased with increasing the irrigation frequencies (using 6 times of irrigation or irrigation at 70-80% of field capacity) during both seasons of growth. In this respect, the highest used level of irrigation (2280 m^3/ Fad.) reflected the highest values of total carbohydrates in plant foliage compared with those of medium and low used level (1520 and 1140 m^3 of water/Fad.) respectively. Obtained results may be due to that the highest used level of irrigation increased photosynthetic assimilation rate. This result of promotive effect of irrigation (either level or interval) on total carbohydrates content of plant foliage may be attributed to its enhancing effect on dry matter content of carrot plant foliage. This explanation is in confirmity with those reported by El-Mansi et al. (1975) and El-Beheidi et al.

(1976). Contra results were reported by Paschold (1979) on carrots.

Regarding the effect of fertilization level, data at Fig. (6) show that total carbohydrates of plant foliage were significantly increased with increasing the NPK fertilizers rate during both the growing seasons of this work. In this regard, addition of the fourth, fifth or the sixth used levels of NPK fertilizers reflected the highest carbohydrates content in carrot plant foliage. Such results may be due much to the role of macro-elements in increasing photosynthetic pigments content (Fig. 4) and consequently the photosynthetic assimilation of carbohydrates. Abd-Alla et al. 1981, 1983 and 1985, on spinach, celery and pepper plants, respectively and Gabal et al.(1990) on coriander, reported that N, P and K fertilizers, either in a single form or in compound fertilizers, positively affected the total carbohydrates content of leaves of such plants.

Concerning the interaction effect, it is obvious from the data in Table (3) that application of six irrigations throughout the growing season combined with the highest used NPK rate in the first season and the fourth used level in the second season resulted in the highest values of total carbohydrates content of plant foliage.

4.4. Yield and its components of carrots:

Data illustrated at Figs. (7 and 8) and Table (4) show the effect of irrigation, fertilization and their interaction on total yield and its components.

Data at Fig. (7) reveal that there were a progressive and consistent increments in total yield of carrot plants, and root weight with shortening the irrigation interval i.e. irrigation every 15 days interval throughout both the two growing seasons (1988/1989 and 1989/1990). In this respect, irrigation at 70-80% of field capacity (using 2280 m^3/Fad.) reflected the heaviest total yield (Ton/Fad.) and average root weight during both seasons of this study. Obtained increments in total yield of carrot plants are very tightly related with those of the individual plant weight (Fig. 1). Obtained results may be attributed to the adequate amounts of water in case of the wet irrigation treatments which increased the up-take of macro-elements as shown at Fig. (5). The increments in total yield as a result of such treatment may be also due to increasing the amounts of free water in carrot plant tissues and consequently increasing the physiological net assimilation rate of plant.

These results are in confirmity with those obtained by El-Mansi et al. (1975), El-Beheidi et al. (1976), all working on carrot, and Said et al. (1984) on sweet potato. On the other hand, Jankowiak, (1983) on carrot reported that

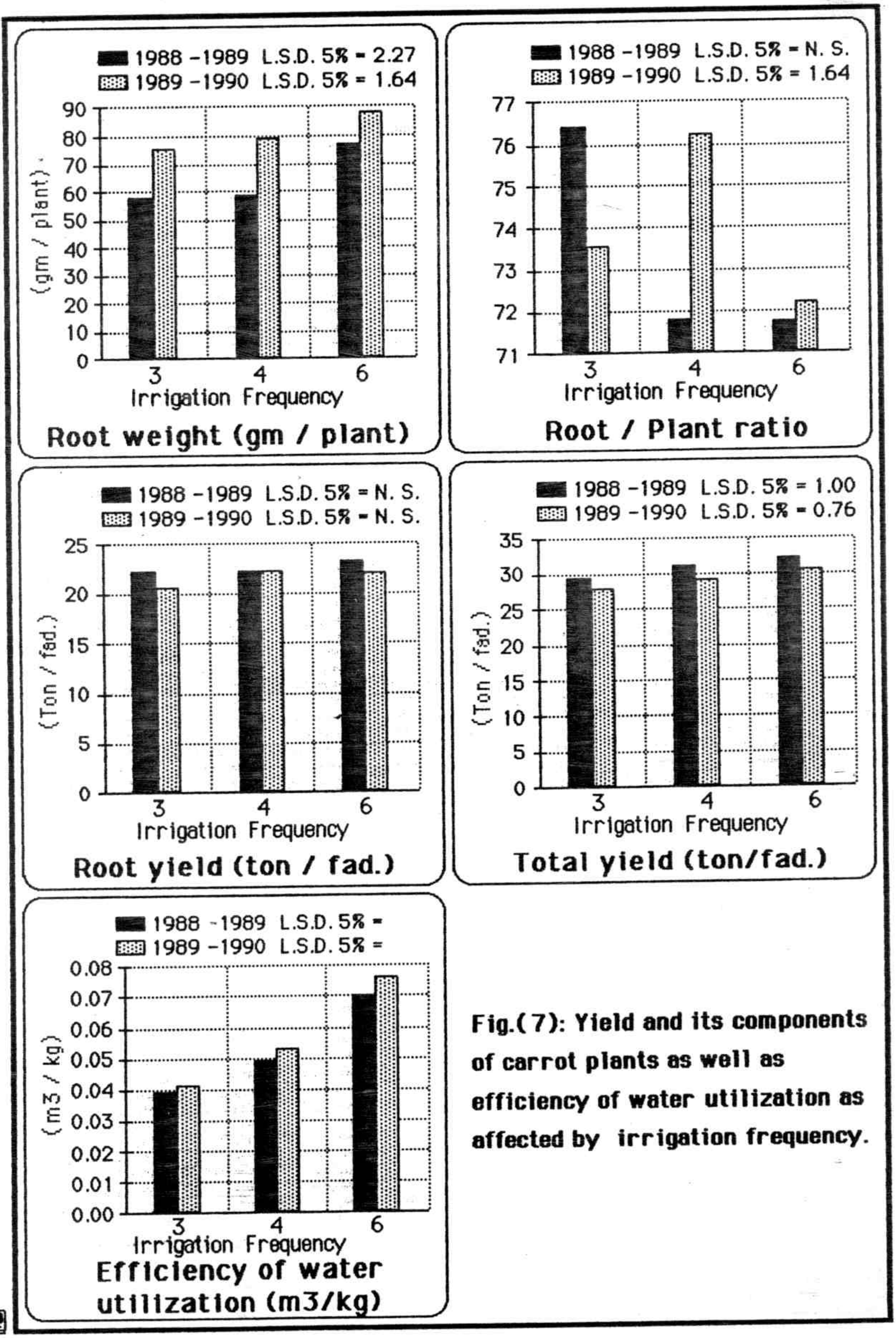

Fig.(7): Yield and its components of carrot plants as well as efficiency of water utilization as affected by irrigation frequency.

maintaining soil moisture at 70% rather than 60% of field capacity did not show significant yield increments. On the contrary, the same data at Fig. (7) show that the ratio of the root to plant weight and root yield were steadly decreased with shortening the irrigation interval. These results were true during both seasons of this work. Such result may be due to that the increase of plant foliage at higher rate of irrigation supply (Fig. 1) was more than that of the increase detected in root growth, expressed as root weight (Fig. 7). In this regard, Nortje and Henrico (1986), who came to similar conclusion, found that the top/root ratio was enhanced by frequent irrigation.

Refering to the efficiency of water utilization (expressed as m^3 of water/kg of produced yield) as affected by applied water frequency, the data at Fig. (7) show that utilized water was increased with increasing number of irrigations throughout the growing season. It is evident that the highest quantity of water (70-76 m^3) necessary for producing one ton of carrot plants were used in case of application of 6 irrigations to carrot plants. This means that the efficiency of water utilization was decreased with increasing quantity of water supplied.

Refering to the effect of fertilization, it is obvious, from the data at Fig. (8), that increasing the level of NPK fertilizers led to significant increments in total yield of carrot plants, root weight per plant and carrot roots yield

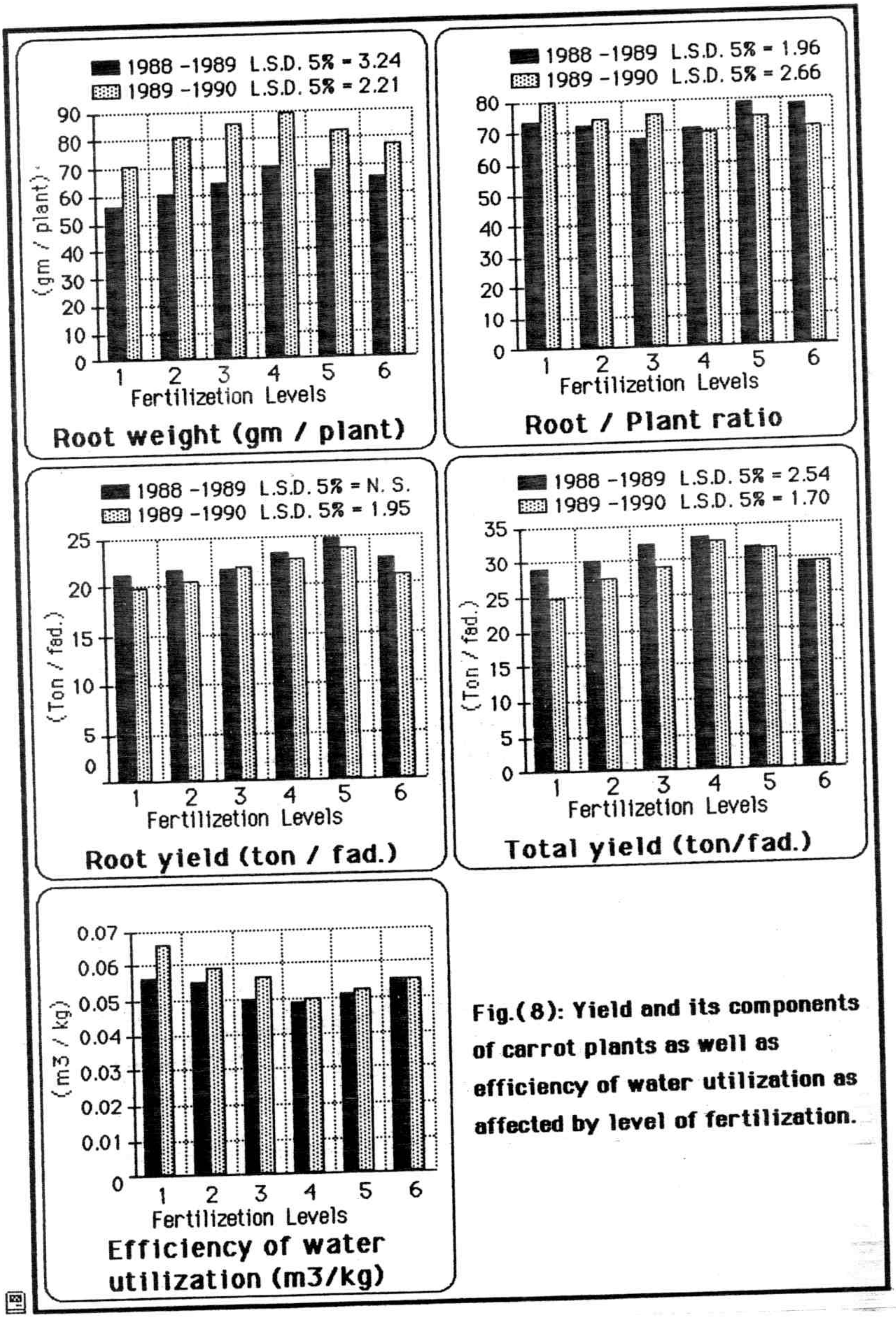

Fig.(8): Yield and its components of carrot plants as well as efficiency of water utilization as affected by level of fertilization.

but up to the fourth or fifth used level of fertilization (40 kg-N + 32 kg-P_2O_5 + 100 kg-K_2O/Faddan) which showed the highest increments in such characters during both seasons of this study. However, increasing fertilization rate up to the highest used level tended to decrease the total yield and root weight of plant. The increase in total yield may be due to that it was the function of the increase in fresh weight of individual plant (Fig. 2). Obtained results may be also due to the increase in the photosynthetic pigments (Fig. 4), the plant up-take of macro-elements (Fig. 6) and consequently the physiological process of plants which reflected the highest net assimilation rate resulted in high dry matter content per plant (Fig. 2). These results are in harmony with those obtained by Luzzati et al. (1975), Mazur and Lukaszuk (1977), Emura and Hosoya (1979), Maurya and Goswami (1985) and Mesquitafilha et al. (1985) all working on carrot.

Concerning the ratio of root/plant, no clear trend was detected due to the different levels of NPK fertilizers.

With regard to the effect of NPK fertilizers level on the efficiency of water utilization, it is obvious from the same data at Fig. (8) that increasing the level of used fertilizers up to the fourth used one (40 kg-N, 32 kg-P_2O_5 and 100 kg-K_2O/Fad.) decreased quantity of water necessary for production of one kg of carrot plants. In this respect, such level of fertilization resulted in using the lowest quantity of water (49-50 m^3) needed for production of one ton of carrot plants. This means that under such conditions of fertilization, water supply showed the highest efficiency of water utilization.

Concerning the effect of interaction between the two main studied factors, it is clear, from the data at Table (4) that the highest used water supply (2280 m^3 of water/Fad.) in combination with the fourth fertilization level, reflected the highest values of root weight and total yield of whole plant per faddan during both seasons of this work.

With regard to root yield per Faddan and root/plant ratio, the same data at Table (4) show that the highest values were resulted with using the highest or lowest water supply (without significant differences) in combination with the fifth level of fertilization.

With regard to the efficiency of water utilization as affected by the combination between irrigation frequencies and fertilization level, data at Table (4) show clearly that using the lowest used number of irrigations (3 frequencies) combined with the fourth or fifth used level of N, P and K fertilizers (without big differences) improved the efficiency of water where 36-37 m^3 were used for producing one ton of carrot plants. However, using the treatment of lowest used water quantity in combination with the fifth NPK fertilizers level may be recommended to obtain the highest carrot roots yield/ Fad. for food processing.

Table (4): Yield and its components of carrot plants as well as efficiency of water utilization as affected by irrigation and fertilization treatments.

Season		1988-1989					1989-1990				
Irrigation frequency	Fert. levels	Total yield (Ton/Fad.)	Root weight (gm/plant)	Root yield (Ton/Fad.)	Root/plant ratio	Efficiency of water utilization m^3/kg	Total yield (Ton/Fad.)	Root weight (gm/plant)	Root yield (Ton/Fad.)	Root/plant ratio	Efficiency of water utilization m^3/kg
3	1	27.29	50.03	19.84	72.15	0.042	23.73	65.58	16.96	71.38	0.048
	2	29.24	52.83	20.57	70.19	0.039	26.40	73.23	18.59	70.36	0.043
	3	30.28	56.84	21.56	71.19	0.038	27.50	79.77	21.62	78.61	0.041
	4	31.40	59.01	22.55	73.93	0.036	30.80	82.69	22.47	72.87	0.037
	5	30.70	64.98	24.73	85.65	0.037	30.60	79.61	23.48	76.60	0.037
	6	27.76	65.51	23.66	85.35	0.041	29.20	74.48	20.86	71.74	0.039
4	1	29.52	53.08	21.85	74.13	0.051	24.80	69.00	20.80	83.96	0.061
	2	30.60	53.32	22.02	71.82	0.050	27.20	77.94	21.63	79.66	0.056
	3	32.76	54.82	21.13	65.52	0.046	29.30	82.91	22.28	75.78	0.052
	4	33.92	61.73	24.28	71.61	0.045	33.00	91.21	23.09	69.81	0.046
	5	31.86	65.60	23.71	72.28	0.048	32.10	80.72	24.83	76.38	0.047
	6	27.63	61.43	20.77	75.34	0.055	28.50	75.08	20.52	71.96	0.053
6	1	29.91	66.37	22.34	74.59	0.076	26.00	78.39	21.89	83.97	0.088
	2	30.40	75.98	22.30	73.40	0.075	29.40	90.92	21.44	72.62	0.078
	3	33.79	81.00	22.38	65.77	0.067	30.40	93.22	21.90	72.01	0.075
	4	34.33	89.69	23.07	67.01	0.066	34.20	93.71	22.74	66.62	0.067
	5	33.15	76.25	25.52	77.28	0.069	32.00	88.13	23.08	69.21	0.071
	6	32.90	70.88	23.82	72.52	0.069	30.80	83.32	21.18	68.72	0.074
L.S.D.		n.s	5.61	n.s	3.39		n.s	n.s	n.s	4.61	

Generally, it could be concluded that under the conditions similar to those of this work, six irrigation frequencies i.e. irrigation every 15 days interval and fertilization with 40 kg-N + 32 kg-P_2O_5 + 100 kg-K_2O/Fad. are the most suitable agricultural treatments for obtaining the highest carrot total plant yield and plant root weight. This treatment may be advisable for carrot production for fresh consumption.

However, for obtaining the highest root yield per Faddan, using the treatment of the lowest water supply with the fifth used fertilization level may be recommended specially for food processing purposes.

4.5. Quality of carrot roots:

Data reported in Figs. (9 and 10) and Table (5) show the effect of irrigation frequencies and NPK fertilization level as well as their interaction on root diameter, core and cortex thickness.

Regarding the effect of irrigation frequency, it is obvious, from data at Fig. (9) that the highest root diameter, core and cortex thickness were connected with the highest level of water supply (2280 m^3/Fad.) i.e. irrigation at 70-80% of field capacity during both the two seasons of this study. In this respect, the tendency of the increasing effect of water supply on root diameter and both the core and cortex

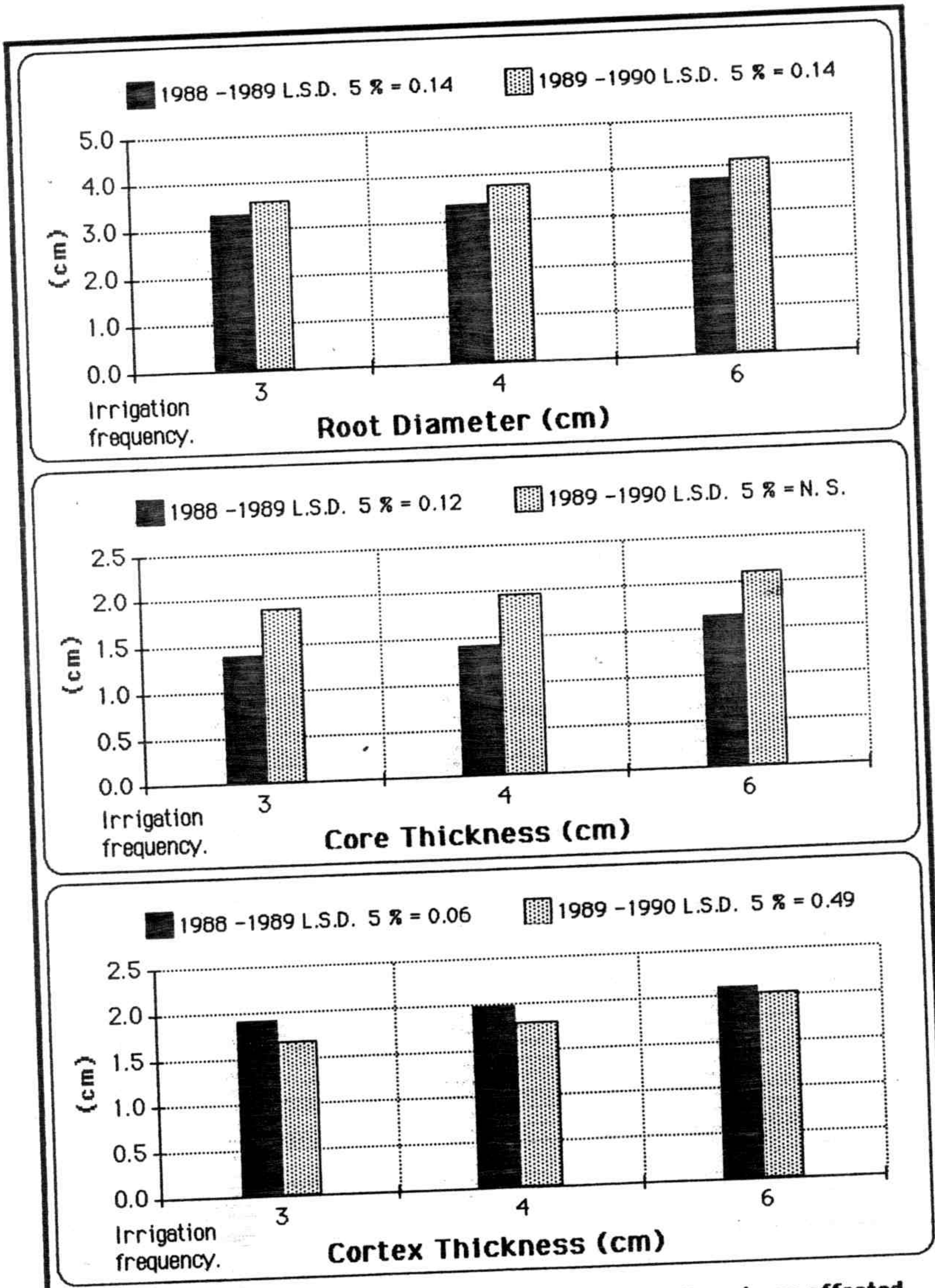

Fig.(9): Physical characteristics of carrot plant roots as affected by irrigation frequency.

thickress was going in an assending order with increasing number of irrigation. Obtained results may be attributed to the clear effective role of increasing water supply on increasing the plant vegetative growth (Fig. 1), the up-take of macro-elements by plant foliage (Fig. 5) and the accumulation of such macro-elements in plant roots (Fig. 11) as well as on increasing the size of plant cells.

Similar results were obtained by Kobryn(1973), El-Mansi et al. (1975) and Nortje and Henrico (1986) who reported that the greatest values of root diameter and also of thickness of both core and cortex were recorded by the highest level of water supply.

With respect to the effect of fertilization level on the root quality of carrots, data at Fig. (10) indicated clearly that diameter of root and thickness of core and cortex were significantly increased with increasing the NPK fertilizers level but up to the fourth used one during both seasons of this study. In this regard, the fourth level (40 kg-N + 32 kg P_2O_5 + 100 kg K_2O per Faddan) reflected the highest values of root diameter, core and cortex thickness compared with the other used fertilizer levels. Obtained results are due to the role of nitrogen, phosphorus and potassium in physiological process and enzymatic activities that are acting on cell division, increasing osmotic pressure of root cells and concequently increased the cells size.

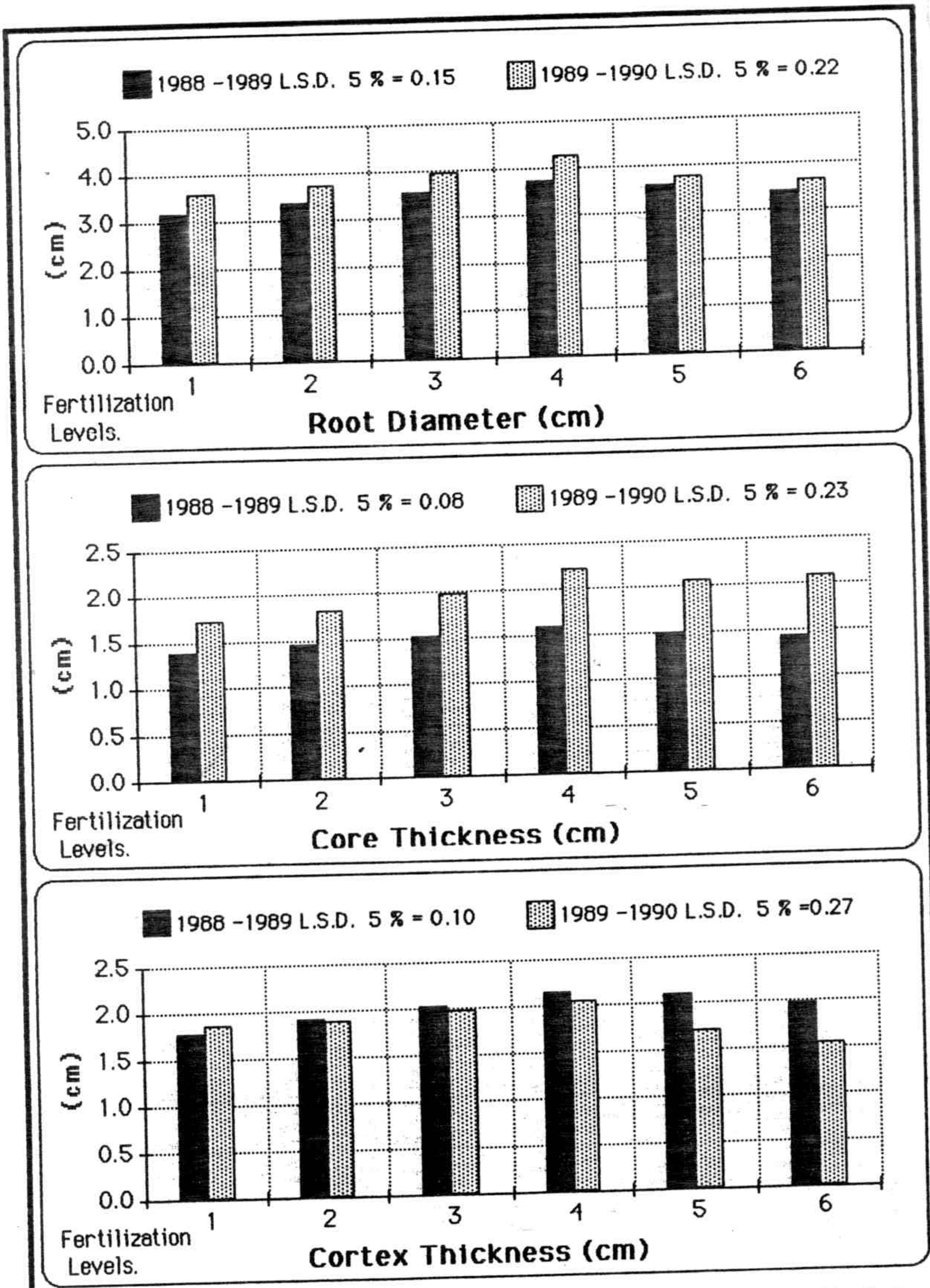

Fig.(10): Physical characteristics of carrot plant roots as affected by level of fertilization.

These results are coincided with those obtained by Emura and Hosoya (1979) on carrot and El-Sayed and Omran (1984) on red beet.

Regarding the effect of interaction between the two main studied factors, no significant differences were noticed.

However, it is evident, in general that irrigation six times throughout the growing season i.e. at shortest interval (15 days) and applying 40 kg-N + 32 kg-P_2O_5 + 100 kg-K_2O/Fad. showed the highest values in this respect and may be recommended for the production of carrot roots with good quality.

4.6. Macro-elements content of carrot roots:

Data on the effect of irrigation, fertilization and their interaction on total nitrogen, phosphorus and potassium content of carrot roots are shown at Figs. (11 and 12) and Table (6).

Data illustrated at Fig. (11) reveal that increasing the irrigation frequency i.e. irrigation after 15 days by interval led to significant increments in all estimated macro-elements during both seasons of growth than other used irrigation treatments. In this concern, the wet irrigation treatment (using 2280 m^3/Fad.) reflected the highest roots content of nitrogen, phosphorus and potassium compared with the semi and dry irrigation treatments i.e. irrigation using 1520 and 1140 m^3 of water/Fad. respectively. The increase of N, P

Table (5): Physical characteristics of carrot plant roots as affected by irrigation and fertilization treatments.

Season		1988 - 1989			1989 - 1990		
Irrigation frequency	Fert. levels	Root diameter (cm)	Thickness (cm)		Root diameter (cm)	Thickness (cm)	
			Core	Cortex		Core	Cortex
3	1	3.00	1.32	1.68	3.38	1.67	1.71
	2	3.27	1.37	1.90	3.50	1.76	1.74
	3	3.37	1.37	2.00	3.63	1.87	1.76
	4	3.48	1.48	2.00	3.94	2.13	1.81
	5	3.36	1.40	1.96	3.52	1.98	1.54
	6	3.27	1.42	1.85	3.42	1.96	1.46
4	1	3.04	1.34	1.70	3.53	1.72	1.81
	2	3.28	1.38	1.90	3.72	1.85	1.87
	3	3.35	1.39	1.96	3.86	1.92	1.95
	4	3.65	1.49	2.16	4.17	2.18	1.99
	5	3.52	1.46	2.06	3.70	1.96	1.74
	6	3.30	1.34	1.96	3.53	2.07	1.46
6	1	3.45	1.51	1.94	3.81	1.77	2.04
	2	3.55	1.61	1.94	3.93	1.86	2.07
	3	3.85	1.78	2.07	4.33	2.10	2.23
	4	3.99	1.79	2.20	4.63	2.35	2.28
	5	3.86	1.63	2.23	4.10	2.28	1.82
	6	3.61	1.54	2.07	3.94	2.24	1.70
L.S.D.		n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

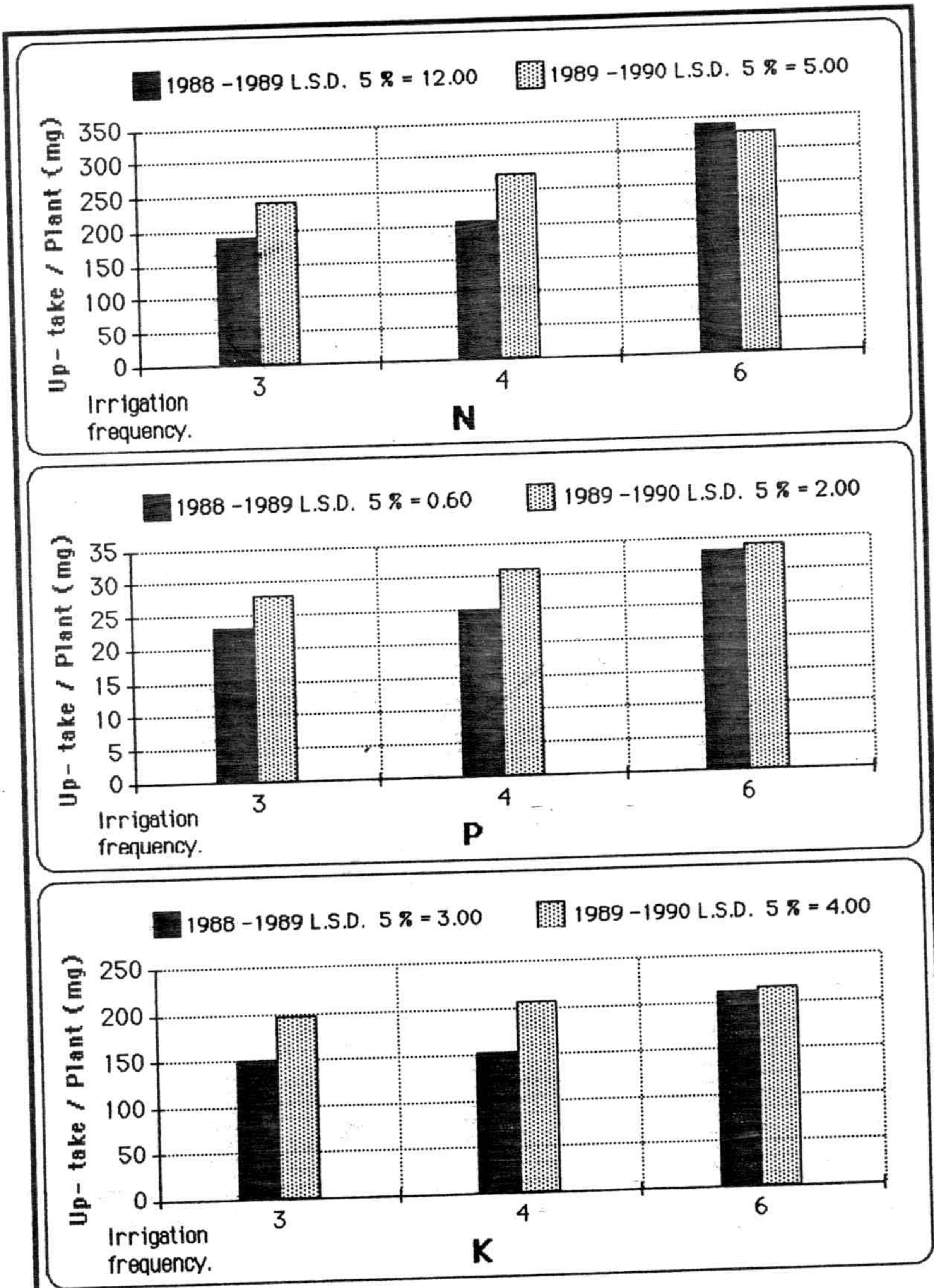

Fig.(11): Macro-elements constituents of carrot plant roots as affected by irrigation frequency.

and K content of roots in case of wet irrigation treatment may be due to the role of water in increasing the up-take of such macro-elements by plant (Fig. 5). In addition, the highest irrigation level permitted an adequate amounts of water for plant absorption on a long period and concequently increased the up-take of such nutrients. Obtained results are coincided with those reported by El-Beheidi et al. (1976), Geissler and Henkel (1985) and Hartmann et al. (1986) all working on carrots.

With respect to the effect of NPK fertilization level, data at Fig. (12) show clearly that total nitrogen, phosphorus and potassium contents of roots were significantly increased with increasing level of fertilization, but to an extented limit (fourth or fifth used level) during both the two growing seasons. In this connection, the highest content of N and K was obtained by the fourth used level while the highest values of P were resulted with the fifth used level of NPK fertilizers.

Moreover, it is evident that the fourth used level of fertilizers (40 kg-N + 32 kg P_2O_5 + 100 kg K_2O/Fad.) showed the highest significant increments in such constituents and which may be advisable in this concern. Such results are expected due to the increasing amounts of fertilizers added to carrot plants. These results are in agreement with those obtained by Mazur and Lukaszuk (1977) on carrot.

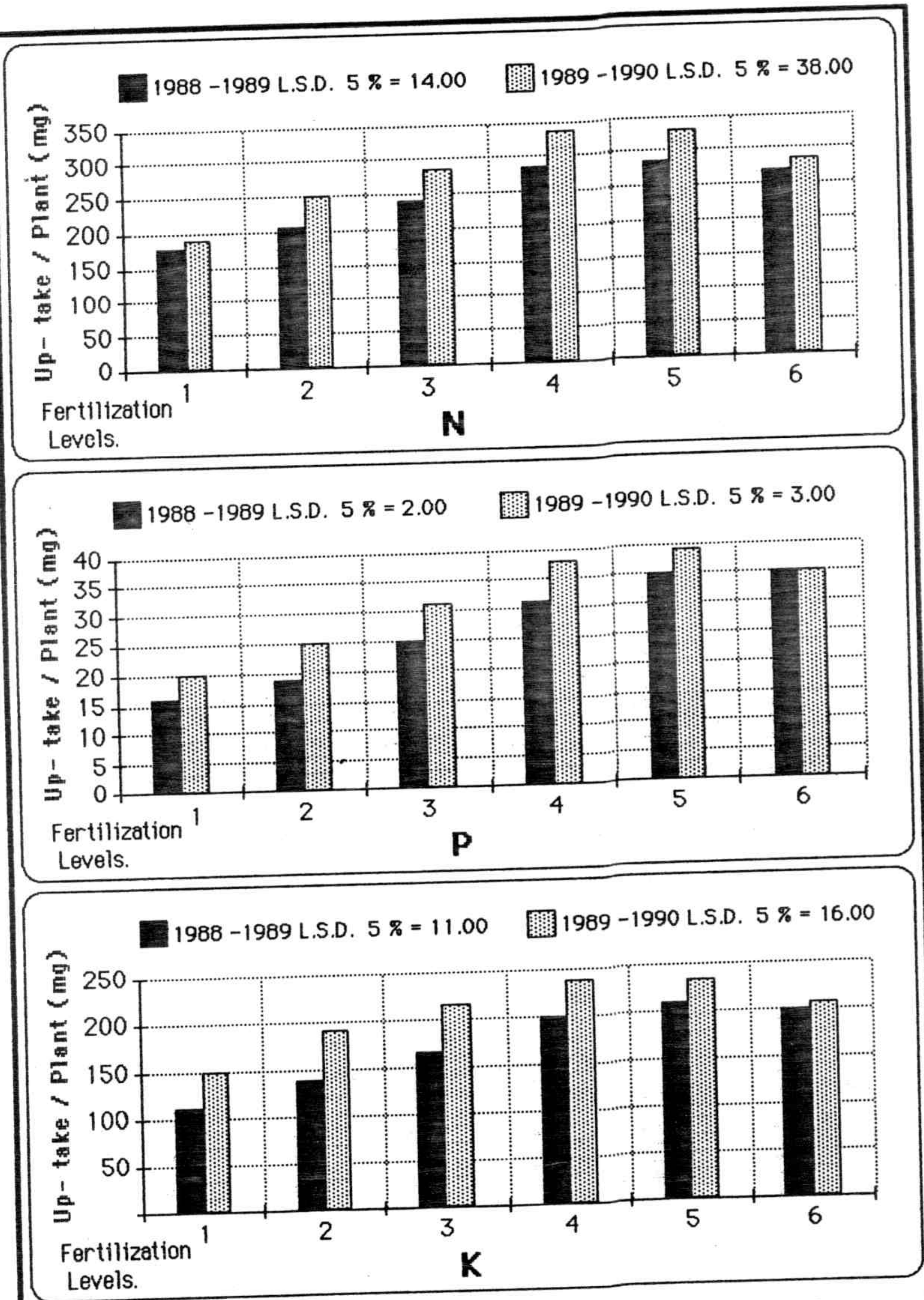

Fig.(12): Macro-elements constituents of carrot plant roots as affected by level of fertilization.

As for the interactional effects, it is clear from data at Table (6) that N, P and K content of roots were steadly increased with decreasing the irrigation interval and increasing NPK fertilizers level up to the fourth one during both the two growing seasons. In this regard, such increments in N, P and K content reached the level of significancy only during the first season of growth.

Generally, under similar conditions of these experiments, irrigation at 70-80% of field capacity and fertilization at the rate of 40 kg N + 32 kg P_2O_5 + 100 kg K_2O/Faddan may be recommended to obtain carrot roots of higher N, P and K content than other used treatments.

4.7. Sugars content:

Data illustrated at Figs. (13 and 14) and Table (7) show the effect of irrigation frequencies, NPK fertilization level and their interaction on sugars content of carrot roots.

With regatd to the effect of irrigation, it is obvious from the data at Fig. (13) that reducing, non-reducing and total sugars (as mg/100 gm dry weight) were negatively affected by irrigation frequencies. In this respect, the lowest content of sugars were connected with the wet irrigation treatment (irrigation rate of 2280 m^3 of water/Fad.) during both the two growing seasons of this work.

On the contrary, the dry irrigation treatment (irrigation at 50-59% of field capacity) reflected the highest values of

Table (6): Macro-elements constituents of carrot plant roots as affected by irrigation and fertilization treatments.

Season		1988-1989			1989-1990		
		Up-take/plant (mg)			Up-take/plant (mg)		
Irrigation frequency	Fert. levels	N	P	K	N	P	K
3	1	130	13	94	160	19	139
	2	151	17	126	200	22	178
	3	181	21	135	237	27	204
	4	207	26	163	293	36	217
	5	229	30	191	306	37	235
	6	233	30	191	254	29	200
4	1	146	15	99	187	19	150
	2	149	16	110	232	23	178
	3	189	22	142	289	31	212
	4	237	28	172	335	40	248
	5	265	36	200	323	41	241
	6	243	32	180	270	34	204
6	1	258	19	140	227	21	161
	2	316	25	180	319	31	213
	3	357	32	218	335	34	228
	4	416	39	262	379	37	245
	5	361	40	232	358	40	227
	6	335	43	226	338	41	217
L.S.D.		25	n.s	18	n.s	n.s	n.s

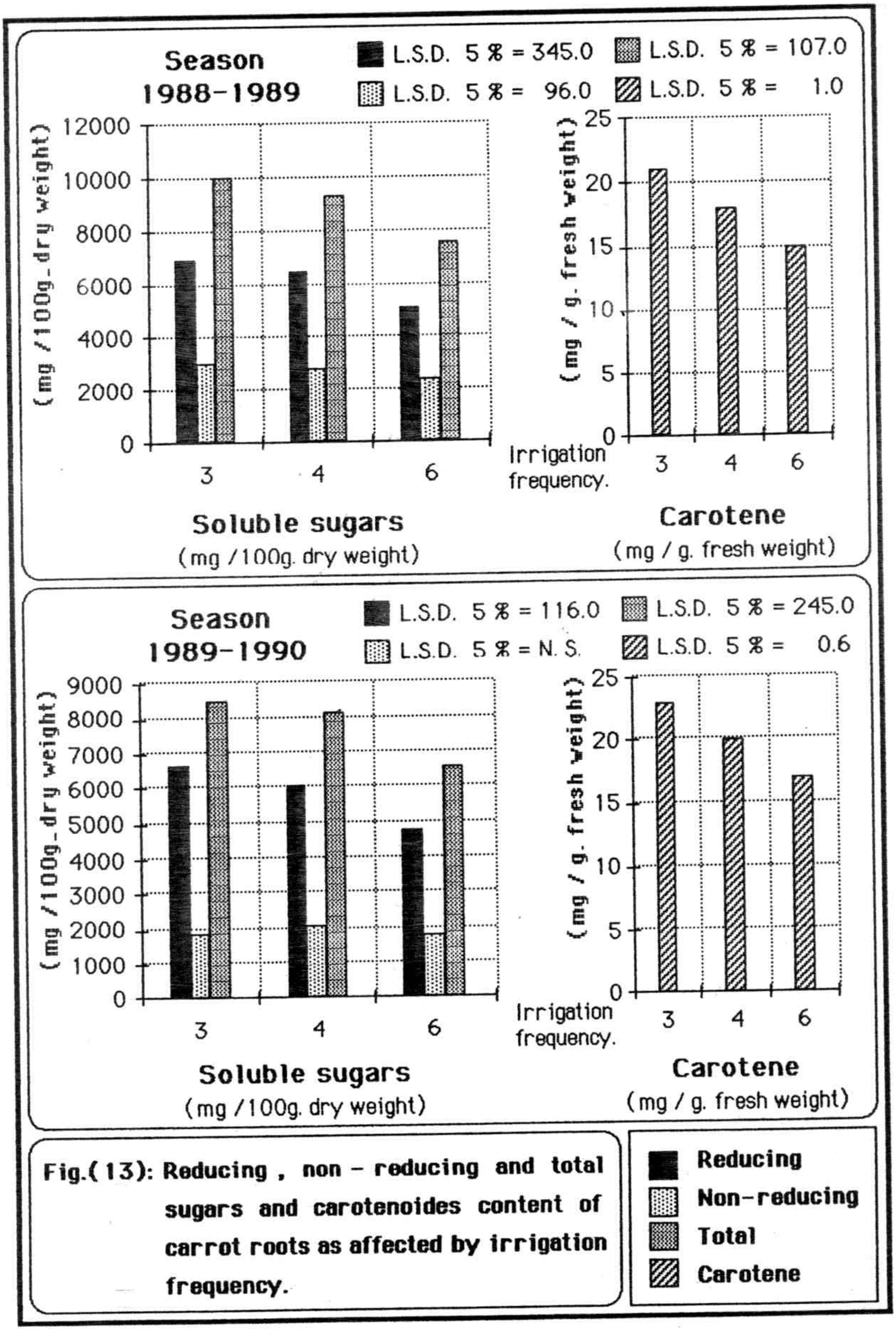

Fig.(13): Reducing , non - reducing and total sugars and carotenoides content of carrot roots as affected by irrigation frequency.

reducing, non-reducing and total sugars content. The obvious increasing concentrations of reducing, non-reducing and total sugars in plant roots of dry irrigation treatment may be due to that such constituents are determined as mg/ 100 gm dry weight but the situation will be conflected if they were estimated as mg or gm per plant root. This will be going in the same trend of dry matter per plant root. Moreover, obtained results may be attributed to that the highest irrigation treatment led to the highest respiration rate and consumption of sugars in respiration and assimilation to form different plant tissues and consequently increased plant growth (Fig. 1). Obtained results are in confirmity with those reported by Elkner and Michalik (1973), El-Mansi et al. (1975) and El-Beheidi et al. (1976) who reported that total sugars (as %) decreased in wet soil conditions but the drought conditions are favourable for the accumulation of sugars in tissues of carrots. However, Paschold (1979) found that sugars content was little affected by irrigation treatments.

Concerning the effect of fertilization level, data at Fig. (14) revealed that increasing NPK fertilizers level significantly increased reducing, non-reducing and total sugars contents of roots. In this respect, the maximum values of sugars were resulted from using the fourth fertilization level of NPK fertilizers compared with the other fertilization treatments during both the two seasons of growth. Obtained

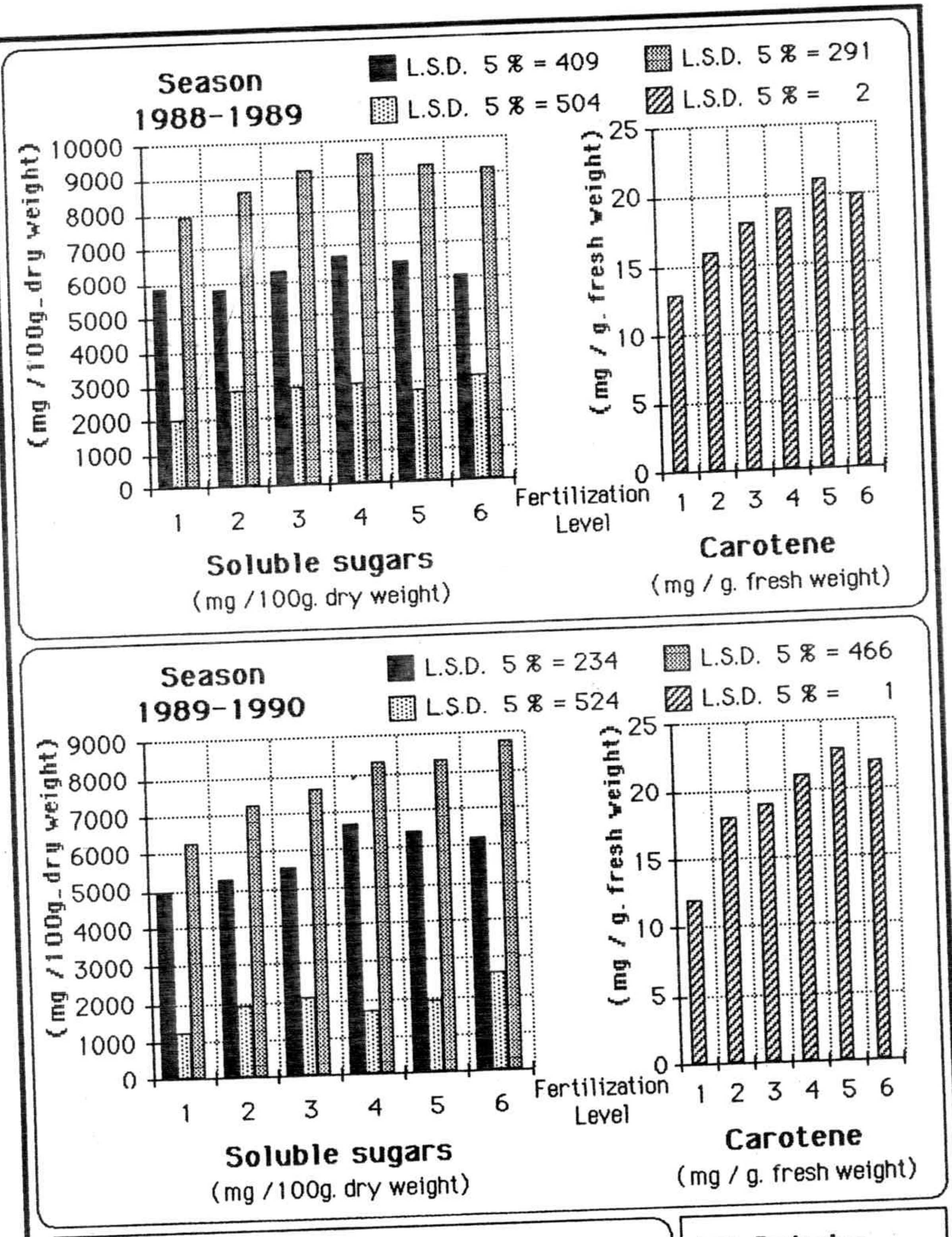

Fig.(14): Reducing , non - reducing and total sugars and carotenoides content of carrot roots as affected by level of Fertilization.

- Reducing
- Non-reducing
- Total
- Carotene

results may be due to the increase of photosynthetic pigments (Fig. 4) and assimilation of products i.e. carbohydrates in plant foliage (Fig. 6) and the role of macronutrients especially potassium element in increasing translocation of carbohydrates from plant foliage in the form of sugars, to be accumulated in plant roots. Obtained results are in agreement with those reported by Habben (1973), Emura and Hosoya (1979) on carrots and Said et al. (1984) on sweet potato. On the other hand Michalik (1985) reported contra-results in this respect.

With regard to the interactive effect, data at Table (7) did not, in general, show significant increments due to the interactional effects within different irrigation treatments and NPK fertilizers levels during both the two growing seasons.

Carotenoides content of carrot roots:

Data at Fig. (13) reveal that the content of carotenoides compounds in carrot roots were significantly increased with increasing the irrigation intervals during both the two seasons of growth. In this respect, the highest concentration of carotenoides compounds in root tissues resulted in case of dry irrigation treatment i.e. irrigation at 50-59% of field capacity compared with those of semi and wet irrigation treatments i.e. irrigation at 60-69% and 70-80% of field capacity respectively. These results may be explained on the base

Table (7): Reducing, non-reducing and total sugars and carotenoids content of carrot roots as affected by irrigation and fertilization treatments.

Season		1988-1989				1989-1990			
Irrigation frequency	Fert. levels	Soluble sugars (mg/100 g dry weight) Reducing	non-reducing	Total	Carotene (mg/g fresh weight)	Soluble sugars (mg/100 g dry weight) Reducing	non-reducing	Total	Carotene (mg/g fresh weight)
3	1	6706	2382	9088	16	5538	1502	7039	18
	2	6427	3504	9930	19	5929	1991	7920	19
	3	7288	3006	10294	22	6254	1876	8130	21
	4	7506	2942	10447	23	7575	1187	8762	25
	5	7259	3160	10419	25	7345	1570	8916	27
	6	6542	3360	9902	23	7334	2941	10275	25
4	1	6560	1647	8207	12	5603	1053	6656	16
	2	6476	2408	8884	15	5718	1953	7671	18
	3	6522	2879	9401	17	5871	1819	7690	19
	4	6848	3561	10409	18	6781	2292	9073	20
	5	6541	2795	9336	21	6226	2671	8896	22
	6	6216	3484	9700	22	6110	2844	8954	24
6	1	4350	2068	6418	11	3775	1225	5001	12
	2	4431	2657	7088	13	4154	1881	6035	16
	3	5096	2853	7950	15	4556	2570	7126	17
	4	5668	2358	8026	16	5656	1556	7212	18
	5	5660	2290	7949	17	5638	1489	7126	19
	6	5353	2433	7787	16	5121	2034	7155	17
L.S.D.		n.s.	n.s.	n.s.	n.s.	406	n.s.	n.s.	n.s.

that the a, b and total chlorophyll as well as carotenoides content of plant foliage are affected in the same way as carotenoides compounds in plant roots. Obtained result might owe to the decrease of dry matter content of carrot roots in wet treatments and consequently decreased the concentration of such pigments in plant roots. Nortje and Henrico (1986) came to similar result.

Regarding the effect of fertilization level, it is evident from data at Fig. (14) that increasing NPK fertilizers level led to a significant increase in carotenoides content of carrot roots during both the two growing seasons. In this regard, the maximum values of carotenoides were resulted in case of application of the fifth level of fertilization (50 kg-N + 40 kg P_2O_5 + 125 kg K_2O/Fad.) compared with the other used levels. Such result may be due to the enhancing effect of increasing macro-nutrients level on the up-take of elements and photosynthetic pigments in plant foliage and/or the plant root content of such constituents. Such explanation may be attributed to the promotive effect of this level of fertilization on the formation of photosynthetic pigments in different plant tissues. Similar results were obtained by Emura and Hosoya (1979) and Maurya and Goswami (1985) who reported that the carotene content of carrot roots was increased with increasing level of NPK fertilizers.

As for the interactional effect, no significant differences were obtained in this respect.

However, plants received three irrigations i.e. every 4 weeks by interval combined with fourth or fifth used level of fertilizers resulted in the highest values of carrot roots content of each of reducing, non-reducing and total sugars as well as carotene content.