IV. RESULTS AND DISCUSSION

IV.1. First Experiment:

Effect of seed-cold treatment on seed germination, seed and seedling chemical composition and growth of tomato transplants.

1.1. Germination of tomato seeds:

Data presented in Table (1) show the effect of seed-cold treatment on the germination percentage and the rate of germination of tomato seeds during the winter seasons of 1987/1988 and 1988/1989.

It is obvious from such data that, most of the used seed-cold treatments significantly increased percentage of seed germination and reduced number of days from sowing up to the germination of the maximum number of seeds than that of the controls. These increments were obvious at both growing seasons of this work.

The most favourable treatments which showed the highest percentage of seed germination and also the lowest number of days from sowing up to the germination of the maximum number of seeds were -1°C, -2°C or -3°C for 12 hours.

Obtained results are in confirmity with those reported by Hennart (1985) working on many vegetable crops including tomato; Scott and Jones (1986) and Coolbear <u>et al</u>. (1987) working also on tomato. They mentioned that, low temperature pre-sowing treatment of tomato seeds substantially increased germination percentage and enhanced germination rate.

Table (1): Effect of seed-cold treatment on germination of tomato seeds.

Soaking period (hrs)	Seed-cold treatment Temperature (°C)	Time (hrs)	Season 1987/1988 Germination %	Season 1987/1988 Germination rate	Season 1988/1989 Germination %	Season 1988/1989 Germination rate
Control			80.0	8.4	77.0	8.6
48	Control		80.5	6.9	78.0	7.0
48	-1	12	91.0	6.1	88.5	6.2
		24	84.0	6.5	82.5	6.5
48	-2	12	86.5	6.2	85.5	6.3
		24	84.5	6.3	81.0	6.4
48	-3	12	85.0	6.2	81.5	6.3
		24	78.5	6.3	77.0	6.4
L.S.D. at 5%			3.6	0.4	3.8	0.4

1.2. Chemical constituents of tomato seeds:

Data concerned with reducing, non-reducing and total sugars as well as activities of oxidative enzymes of tomato seeds are presented in Table (2). Such data show clearly that most of the used seed-cold treatments significantly increased reducing sugars content than that of the wetted control. Similar results were also obtained in case of non-reducing sugars compared with the dry seed control treatment. These increments were obvious at both growing seasons of 1987/1988 and 1988/1989.

The most favourable treatments which increased reducing sugars content in tomato seeds were -1°C for 12 or 24 hours compared with that of all other used treatments except that of the dry control. However, all used seed-cold treatments increased non-reducing sugars content in tomato seeds compared with dry control.

These results are in harmony with those obtained by Hennart (1985) on tomato and Pollock (1986) on pea seeds.

With regard to the effect of seed-cold treatment on enzyme activity in tomato seeds, data in Table (2) also show clearly that all treatments increased the enzyme activity in this respect. The treatments which showed the favourable effect in this respect were -1°C for 24 hours followed by -2°C for 12 hours.

Table (2): Effect of seed-cold treatment on chemical constituents of tomato seeds.

Soaking period (hrs)	Seed-cold treatment Temperature (°C)	Seed-cold treatment Time (hrs)	Reducing sugars	Non-reducing sugars	Total sugars	Peroxidase activity	Polyphenol oxidase activity	Catalase activity	Ascorbic acid oxidase activity
			mg/100 g dry weight			Changes in absorbance/minute/g fresh weight			
Season 1987/1988									
Control			61.5	23.0	84.5	1.04	0.30	0.22	0.11
48	Control		54.5	28.8	83.3	1.07	0.35	0.20	0.09
48	-1	12	57.5	25.0	82.5	1.17	0.46	0.25	0.12
		24	56.0	25.3	81.3	1.37	0.45	0.73	0.22
48	-2	12	55.0	27.3	82.3	1.30	0.60	0.73	0.20
		24	52.3	28.0	80.3	1.32	0.58	0.51	0.14
48	-3	12	55.3	27.7	83.0	1.28	0.55	0.53	0.17
		24	52.2	28.3	80.5	1.13	0.56	0.50	0.32
L.S.D. at 5%			1.3	1.5	0.8	0.03	0.05	0.07	0.03
Season 1988/1989									
Control			60.6	22.1	82.7	1.06	0.32	0.21	0.10
48	Control		53.4	27.8	81.2	1.10	0.38	0.19	0.10
48	-1	12	56.4	24.0	80.4	1.20	0.50	0.26	0.13
		24	55.1	24.5	79.6	1.41	0.50	0.70	0.23
48	-2	12	54.2	26.4	80.6	1.33	0.62	0.71	0.21
		24	51.4	27.0	78.4	1.29	0.61	0.50	0.15
48	-3	12	54.4	26.8	81.2	1.31	0.59	0.52	0.17
		24	51.3	27.5	78.8	1.15	0.58	0.48	0.32
L.S.D. at 5%			1.2	1.3	0.7	0.05	0.06	0.06	0.03

1.3. Vegetative growth of tomato transplants:

Data presented in Table (3) show clearly that different used seed-cold treatments enhanced the different studied characters of tomato transplants growth compared with the control treatments during winter seasons of 1987/1988 and 1988/1989.

It is evident from such data that, most of the used seed-cold treatments significantly increased plant height, stem diameter as well as fresh and dry weight per 20 transplants than the control treatments. However, increments in number of leaves per plant in this respect did not reach level of significancy.

Such data clearly show that, seed-cold treatment at -1°C or -2°C for 24 hours showed the highest plant height, stem diameter, fresh and dry weight per 20 transplants. This trend was the same at either 1987/1988 or 1988/1989 seasons. This may be due to that such treatment promoted reducing and non-reducing sugars content of tomato seeds as shown in Table (4) as well as N, P and K uptake as shown in Table (4).

These results are in agreement with those obtained by Abdalla *et al*. (1983) on sweet pepper. Hennart (1985) trials on tomato and some vegetable crops; Wang (1985) on cucumber and zucchini squash and Scott and Jones (1986) on tomato.

Table (3): Effect of seed-cold treatment on vegetative growth of tomato transplants.

Soaking period (hrs)	Seed-cold treatment Temperature (°C)	Time (hrs)	Plant height (cm)	Stem diameter (cm)	No. of leaves/ plant	Fresh weight/ 20 plants (g)	Dry weight/ 20 plants (g)
					Season 1987/1988		
Control			12.00	0.30	3.90	80.35	7.65
48	Control		12.50	0.31	4.00	81.25	7.78
48	-1	12	14.00	0.35	4.50	83.50	8.39
		24	15.70	0.38	4.75	109.00	11.65
48	-2	12	13.00	0.37	4.50	93.50	8.61
		24	11.75	0.37	5.25	75.50	7.63
48	-3	12	12.75	0.32	5.00	99.75	10.29
		24	16.00	0.40	4.50	111.25	12.42
L.S.D. at 5%			1.53	0.07	n.s	5.45	0.16
					Season 1988/1989		
Control			13.00	0.31	4.00	79.25	7.05
48	Control		13.75	0.32	4.10	80.00	7.67
48	-1	12	15.00	0.37	4.25	87.50	8.19
		24	16.00	0.40	4.75	103.25	10.57
48	-2	12	14.25	0.33	4.25	90.75	8.36
		24	11.85	0.35	4.25	72.75	7.35
48	-3	12	13.75	0.35	4.50	96.00	9.91
		24	16.20	0.41	4.75	108.50	11.14
L.S.D. at 5%			1.28	0.06	n.s	3.82	0.38

Table (4): Effect of seed-cold treatment on chemical constituents of tomato transplants foliage.

Soaking period (hrs)	Seed cold treatment Temperature (°C)	Time (hrs)	Total nitrogen	Phosphorus	Potassium	Reducing sugars	Non-reducing sugars	Total sugars	Total indoles	Total phenols
			mg/100 seedlings			mg/100 seedlings			mg/g fresh weight	
						Season 1987/1988				
Control			1453	72.67	1109	1346	462	1808	3.86	5.73
48	Control		1552	74.29	1163	1618	424	2042	4.06	5.69
48	-1	12	1459	86.42	1298	2462	918	3380	4.75	7.30
		24	1995	142.16	1772	3584	1521	5105	4.82	7.60
48	-2	12	1446	89.15	1308	2264	960	3224	4.65	7.39
		24	1327	98.05	1228	1606	637	2243	4.79	6.95
48	-3	12	1836	136.85	1677	1641	596	2237	4.70	7.10
		24	2328	175.74	2347	2254	1117	3371	4.85	7.05
L.S.D. at 5%			69.4	4.73	60.9	60.3	35.3	79.4	0.40	0.49
						Season 1988/1989				
Control			1304	61.68	987	1138	401	1539	3.96	5.70
48	Control		1457	69.03	1092	1637	410	2047	4.10	5.62
48	-1	12	1343	81.90	1248	2457	925	3382	4.57	7.21
		24	1744	129.48	1638	3572	1543	5115	4.80	7.55
48	-2	12	1329	86.94	1254	2319	940	3259	4.56	7.30
		24	1205	88.20	1109	1602	687	2289	4.68	6.90
48	-3	12	1659	121.39	1585	1486	649	2135	4.60	7.00
		24	1949	150.39	2033	1843	1030	2873	4.80	6.95
L.S.D. at 5%			75.4	6.15	39.5	50.6	30.8	65.2	0.35	0.43

Similar results were obtained by Ledov'skii and Bondarenko (1974) who mentioned that, exposure to low temperature may be useful for hardening tomato plants against frost. This may be due to the increase in total sugars and soluble protein in the cellular level. Higazy _et al_. (1974) and (1976) on pea found that, higher contents of sucrose and reducing sugars were recorded by plants grown from vernalized seeds, especially at 5°C for 10 days pre-sowing. Moreover, Pollock (1986) and Pollock and Lloyd (1987) on pea and illuminated leaves showed that, plants grown under low temperature (5°C for 6 hours) resulted in larger quantities of sucrose and starch in plant leaves.

Concerning the effect of seed-cold treatment on total indoles and phenols content in plant tissues, the same data reveal that all used seed-cold treatments significantly increased total indoles and phenols content compared with control treatments.

Such data clearly show that, seed-cold treatments at -1°C, -2°C or -3°C for 24 hours showed the highest total indoles content in plant tissues at both successive seasons of this work. Moreover, treating seeds with -1°C for 24 hours resulted in the highest values of total phenols content in plant tissues.

These results are in harmony with those reported by Eid _et al_. (1988) on broad bean, they showed that, exposing seeds to 5°C for one week promoted the concentration of total indoles and phenols in plant tissues. Moreover, Abdalla et al. (1983) on sweet pepper found that, no significant differences in the production of total indoles and phenols content of plant leaves were detected as a result of all used seed-cold treatments.

1.5. Enzyme activity:

Data presented in Table (5) show the effect of seed-cold treatment on the activity of enzymes in tomato transplants i.e. peroxidase, polyphenol oxidase, catalase and ascorbic acid oxidase during winter seasons of 1987/1988 and 1988/1989.

It is evident from such data that, all used seed-cold treatments significantly increased enzyme activity of different studied enzymes compared with the two control treatments.

Such data clearly show that seed-cold treatment at -1°C for 24 hours followed by -2°C either for 12 or 24 hours showed the highest values of the peroxidase activity.

Regarding the effect of seed-cold treatment on each of polyphenol oxidase, catalase and ascorbic acid oxidase, the same data show that -2°C for 12 or 24 hours and -3°C for 24 hours treatments resulted in the highest values in this respect. This trend was the same at each of the two successive seasons of this work.

In general, it is obvious that, seed-cold treatments at -1°C for 24 hours, -2°C for 12 hours or -3°C for 24 hours were the most effective treatments in increasing the enzymes activity in tomato transplants.

Table (5): Effect of seed-cold treatment on enzyme activity as change in absorbance in minute/g fresh weight.

Soaking period (hrs)	Seed-cold treatment Temperature (°C)	Time (hrs)	Peroxidase	Polyphenol oxidase	Catalase	Ascorbic acid oxidase
			Season 1987/1988			
Control			1.04	0.32	0.21	0.12
48	Control		1.07	0.37	0.19	0.11
48	-1	12	2.17	0.51	0.28	0.15
		24	2.37	0.57	0.73	0.25
48	-2	12	2.30	0.70	0.73	0.23
		24	2.32	0.64	0.56	0.16
48	-3	12	2.20	0.62	0.60	0.20
		24	2.13	0.67	0.65	0.33
L.S.D. at 5%			0.06	0.07	0.04	0.05
			Season 1988/1989			
Control			1.08	0.35	0.23	0.14
48	Control		1.19	0.40	0.20	0.12
48	-1	12	2.11	0.53	0.30	0.17
		24	2.33	0.58	0.75	0.27
48	-2	12	2.22	0.69	0.74	0.25
		24	2.28	0.65	0.60	0.19
48	-3	12	2.19	0.61	0.63	0.22
		24	2.15	0.63	0.64	0.35
L.S.D. at 5%			0.06	0.08	0.05	0.04

Finally, it may be concluded that, the improving effect of seed-cold treatment on the seed germination either as percentage or rate of germination (Table 1), is mainly due to the enhancing effect of such treatments on either chemical constituents of seeds or the enzyme activity of seedlings (Table 2) which was in turn effective on each of chemical constituents (Table 4) and vegetative growth of transplants (Table 3). This improving effect of seed-cold treatment was completely true and may be explain through the effect on both of chemical constituents (Table 4) and enzyme activity of transplants (Table 5).

Hence, it is advisable to exposure tomato seeds to -1°C or -2°C for 12 hours for production of tomato transplants with good vegetative growth and quality in winter season.

IV.2. Second Experiment:

Effect of seed-cold treatment as well as rate of phosphorus and potassium fertilizers on tomato growth, chemical composition, flowering, yield and fruit quality.

2.1. Vegetative growth:

Data presented in Tables (6, 7 and 8) show the effect of seed-cold treatment, rate of phosphorus and potassium fertilizers as well as the interaction effect between such two factors on growth of tomato plants during winter seasons of 1987/1988 and 1988/1989.

It is evident that, all used seed-cold treatments significantly increased different studied characters expressed as plant height, stem diameter, number of shoots and leaves as well as fresh and dry weight per plant compared with control treatment (Data in Table 6).

Such data clearly show that, seed-cold treatment at -1°C for 24 hours showed the highest stem diameter and number of shoots per plant at both successive seasons of this work.

However, treating seeds with -3°C or -2°C for 24 hours resulted in the highest values of plant height, number of leaves, fresh and dry weight per plant. This trend was the same at either 1987/1988 or 1988/1989 seasons. This may be due to that such treatment promoted N, P and K uptake as shown in Table (9).

Table (6): Effect of seed-cold treatment on vegetative growth of tomato plants.

Seed-cold treatment: Temperature (°C)	Time (hrs)	Plant height (cm)	Stem diameter (cm)	No. of shoots/ plant	No. of leaves/ plant	Fresh weight/ plant (g)	Dry weight/ plant (g)
		Season 1987/1988					
Control		38.92	0.98	10.42	62.33	381.75	52.13
-1	12	44.00	1.10	12.08	72.17	408.08	56.75
	24	45.92	1.36	14.33	82.58	444.00	61.57
-2	12	45.25	1.05	12.25	66.67	395.17	56.64
	24	43.92	1.25	13.33	69.50	456.67	63.90
-3	12	43.25	1.08	12.25	68.67	421.17	60.17
	24	46.58	1.30	13.50	87.83	456.00	65.57
L.S.D. at 5%		0.76	0.08	0.70	1.57	6.52	3.39
		Season 1988/1989					
Control		39.25	0.91	9.67	47.50	370.00	50.71
-1	12	43.58	1.04	11.33	56.75	394.17	55.01
	24	45.58	1.33	13.58	69.17	428.75	59.28
-2	12	44.58	1.03	11.75	51.00	382.92	54.49
	24	43.83	1.23	12.75	53.58	440.83	61.96
-3	12	43.17	1.03	11.58	52.67	407.08	58.09
	24	46.75	1.26	12.83	70.91	441.67	63.60
L.S.D. at 5%		1.10	0.06	0.77	1.11	7.72	n.s

Many investigators reported such favourable effect of exposing plant organs to low temperature. They attributed this effect to that, exposure to low temperature may be useful for hardening the plant against frost. This may be due to the increase in total sugars and soluble protein in the cellular level (Ledov'skii and Bondarenko, 1974). Moreover, Chen and Li (1974) suggested that during cold acclimatization, higher abscisic acid (ABA) levels induce synthesis of specific proteins which are responsible for the increase of frost hardness. Exposure of plant leaves of tomato to low temperature may help plants afterwards to enduce frost injury through the effect on the degree of stomatal aperature (Levitt, 1980).

These results are in agreement with those obtained by Belousova (1972) on eggplant; Belousova (1973) on pepper; Abdalla et al. (1983) on sweet pepper; Zaki et al. (1982) on broad bean; Shafshak (1987) on pea and Eid et al. (1988) on broad bean.

Obtained results of the effect of seed-cold treatment on plant growth lead to the conclusion that seed-cold treatment either at -1°C or -3°C for 24 hours showed the highest vegetative growth of tomato plants.

Referring to the effect of different levels of phosphorus and potassium fertilizers on tomato vegetative growth, it is obvious from data in Table (7) that medium used level (99 kg N + 48 kg P_2O_5 + 48 kg K_2O/Fad.) enhanced plant growth expressed as plant height, stem diameter, number of shoots and leaves

Table (7): Effect of rate of phosphorus and potassium fertilizers on vegetative growth of tomato plant.

Levels of fertilizer N	P_2O_5 (kg/Fad.)	K_2O	Plant height (cm)	Stem diameter (cm)	No. of shoots/ plant	No. of leaves/ plant	Fresh weight/ plant (g)	Dry weight /plant (g)
					Season 1987/1988			
99	32	36	43.11	1.14	12.71	67.96	368.18	42.71
99	48	48	45.11	1.21	12.86	77.18	479.39	66.58
99	64	72	43.68	1.12	12.21	73.32	422.21	58.47
L.S.D. at 5%			0.58	0.04	0.39	1.00	4.64	2.43
					Season 1988/1989			
99	32	36	42.71	1.08	11.85	53.89	356.96	52.34
99	48	48	45.18	1.17	12.18	61.00	461.78	63.73
99	64	72	43.57	1.08	11.75	57.21	409.28	56.69
L.S.D. at 5%			0.40	0.44	n.s	0.60	6.15	2.65

per plant as well as both of fresh and dry weight per plant as compared with either used low or high levels. However, no significant difference could be detected with number of shoots during the second season of growth.

It is also evident that obtained results are going in the same trend at both successive seasons of this work. Such results may be explained on the bases that the soil of the Experimental Farm is not so poor in its content of N, P and K minerals, as shown in the chemical analysis of the soil of the Experimental Farm at materials and methods of this work, that high used level of fertilizers was uneffective.

Many investigators found similar results where medium used level of macronutrients resulted in the highest plant growth, among them,Gupita and Shukla (1977); El-Sawah (1981); El-Beheidi et al. (1988) and El-Sawy (1988) on tomato and Farag (1984) on sweet pepper.

With regard to the effect of interaction between both of the two main factors, it is evident from data in Table (8) that second used level of fertilizers (99 kg N + 48 kg P_2O_5 + 48 kg K_2O/Fad.) combined with seed-cold treatment at -3°C for 24 hours resulted in the highest values of different studied vegetative growth characteristics. However, differences between such values did not reach the level of significancy except in the case of number of leaves per plant and fresh weight per plant which showed significant increments for above mentioned treatment than other used treatments at both successive seasons in this work.

Table (8): Effect of interaction between seed-cold treatment and fertilization on vegetative growth of tomato plants.

Levels of fertilizer N	P_2O_5 (kg/Fad.)	K_2O	Seed-cold treatment Temperature °C	Time hrs	Season 1987/1988 Plant height (cm)	Stem diameter (cm)	No. of shoots/ plant	No. of leaves/ plant	Fresh weight/ plant g.	Dry weight/ plant g.	Season 1988/1989 Plant height (cm)	Stem diameter (cm)	No. of shoots/ plant	No. of leaves/ plant	Fresh weight/ plant g.	Dry weight/ plant g.
99	32	36	Control		37.2	0.9	10.5	59.2	322.0	48.1	37.5	0.8	9.5	45.5	312.5	47.1
			-1	12	43.2	1.0	12.7	66.0	352.5	48.6	42,7	0.9	12.0	51.2	341.2	47.4
				24	45.7	1.4	15.2	79.2	384.7	54.0	45.5	1.3	14.2	70.0	370.0	52.3
			-2	12	45.0	1.0	12.2	60.7	340.2	53.5	43.5	1.0	11.7	47.7	328.7	52.2
				24	42.7	1.2	13.5	64.5	403.7	56.3	42.2	1.2	12.7	48.7	392.5	55.6
			-3	12	42.2	1.0	12.0	67.2	349.2	52.4	42.0	0.9	11.2	52.0	342.5	51.6
				24	45.5	1.2	12.7	78.7	424.7	61.7	45.5	1.2	11.5	62.0	411.2	59.9
99	48	48	Control		41.0	1.0	10.7	65.7	446.2	59.4	41.2	0.9	10.0	50.0	432.5	57.6
			-1	12	45.0	1.1	11.7	77.2	464.2	62.3	44.7	1.1	10.7	62.5	445.0	59.9
				24	46.5	1.4	14.0	87.2	504.2	69.6	46.2	1.3	13.0	70.5	487.5	66.5
			-2	12	45.7	1.0	12.5	69.5	447.5	63.7	45.7	1.0	12.0	52.5	433.7	60.0
				24	45.5	1.3	13.5	73.0	513.0	70.2	45.5	1.3	12.7	58.0	493.7	67.6
			-3	12	44.2	1.1	12.5	69.7	488.7	70.8	44.5	1.1	12.0	53.5	465.0	66.8
				24	48.0	1.3	15.0	97.7	491.7	69.7	48.2	1.3	14.7	80.0	475.0	67.4
99	64	72	Control		38.5	0.9	10.0	62.0	377.0	48.8	39.0	0.9	9.5	47.0	365.0	47.2
			-1	12	45.5	1.0	11.7	73.2	407.5	59.2	43.2	1.0	11.2	56.5	396.2	57.6
				24	45.0	1.2	13.7	81.2	443.0	60.9	45.0	1.2	13.5	67.0	428.7	51.1
			-2	12	43.5	1.0	12.0	69.7	397.7	52.5	44.5	1.0	11.5	52.7	386.2	51.1
				24	43.2	1.2	13.0	71.0	453.2	65.1	43.7	1.1	12.7	54.0	436.2	62.6
			-3	12	46.2	1.1	12.2	69.0	425.5	57.2	43.0	1.0	11.5	52.7	413.7	55.7
				24	38.5	1.2	12.7	87.0	451.5	65.8	46.5	1.2	12.2	70.7	438.7	63.4
L.S.D. at 5%					n.s	n.s	n.s	2.7	11.3	n.s	n.s	n.s	1.3	1.9	13.3	3.4

Obtained results are in confirmity with those reported by Wallace (1926) on Allium and Bedard and Therrien (1970) and Zurawicz and Stushnoff (1977) on strawberry. They mentioned that K and complete fertilizers soil application at higher rates resulted in giving plants more resistance to cold injury and promoted plant growth. Moreover, Eid et al. (1988) working on broad bean showed that, exposing seeds to low degree temperature (5°C for 7 days) with phosphorus soil application at 16 or 32 kg P_2O_5/Fad. had the most pronouncing effect on plant growth characteristics.

Generally, it may be concluded that exposing tomato seeds after soaking in distilled water for 48 hours to low temperature (-1 to -3°C) for 24 hours and using a complete fertilizer containing 99, 48 and 48 kg/Fad. of each of N, P_2O_5 and K_2O respectively resulted in plants of the highest values of different studied growth characteristics.

2. 2. Chemical composition of plant foliage:

Data concerned with total nitrogen, phosphorus, potassium as well as reducing, non-reducing and total sugars of plant foliage are presented in Tables (9, 10 and 11). Data in Table (9) show clearly that most of the used seed-cold treatments significantly increased total nitrogen, phosphorus and potassium contents of plant foliage than that of the control one. These increments were obvious at both growing seasons of 1987/1988 and 1988/1989.

Obtained results are in confirmity with those reported by Wallace (1926) on Allium and Bedard and Therrien (1970) and Zurawicz and Stushnoff (1977) on strawberry. They mentioned that K and complete fertilizers soil application at higher rates resulted in giving plants more resistance to cold injury and promoted plant growth. Moreover, Eid et al. (1988) working on broad bean showed that, exposing seeds to low degree temperature (5°C for 7 days) with phosphorus soil application at 16 or 32 kg P_2O_5/Fad. had the most pronouncing effect on plant growth characteristics.

Generally, it may be concluded that exposing tomato seeds after soaking in distilled water for 48 hours to low temperature (-1 to -3°C) for 24 hours and using a complete fertilizer containing 99, 48 and 48 kg/Fad. of each of N, P_2O_5 and K_2O respectively resulted in plants of the highest values of different studied growth characteristics.

2. 2. Chemical composition of plant foliage:

Data concerned with total nitrogen, phosphorus, potassium as well as reducing, non-reducing and total sugars of plant foliage are presented in Tables (9, 10 and 11). Data in Table (9) show clearly that most of the used seed-cold treatments significantly increased total nitrogen, phosphorus and potassium contents of plant foliage than that of the control one. These increments were obvious at both growing seasons of 1987/1988 and 1988/1989.

Table (9): Effect of seed-cold treatment on chemical composition of tomato plant foliage.

Seed-cold treatment Temperature (°C)	Time (hrs)	Total nitrogen	Phosphorus	Potassium	Reducing sugar	Non-reducing sugar	Total sugars
		mg/plant			g/100 g dry weight		
Season 1987/1988							
Control		2103	404	1738	7.76	2.00	9.76
-1	12	1981	482	2080	10.81	4.45	15.26
	24	2179	419	2308	11.25	4.74	15.99
-2	12	1911	436	2012	10.31	4.19	14.50
	24	2271	523	2406	9.07	3.73	12.80
-3	12	2366	561	2405	7.06	2.93	9.99
	24	2446	608	2077	7.92	3.26	11.18
L.S.D. at 5%		80	19	102	0.08	0.06	0.15
Season 1988/1989							
Control		2023	364	1673	7.04	1.98	9.02
-1	12	1921	466	2014	9.87	4.20	14.07
	24	2074	401	2207	10.34	4.65	14.99
-2	12	1828	420	1923	9.52	4.10	13.62
	24	2174	511	2323	8.26	3.59	11.85
-3	12	2180	523	2294	6.44	2.82	9.26
	24	2349	574	1971	7.24	2.95	10.19
L.S.D. at 5%		107	21	125	0.07	0.07	0.12

The most favourable treatments which increased N and P content in tomato plants were -3°C for 24 hours followed by that at -3°C for 12 hours. However, treatment of -2°C for 24 hours and that of -3°C for 12 hours showed the highest K content in plant foliage.

Obtained results are in confirmity with those mentioned by Abdalla et al. (1983) on sweet pepper and Eid et al.(1988) on broad bean.

These results may be explained on the base that treatments showed the highest plant vegetative growth expressed as fresh and dry weight per plant (-2 or -3°C for 24 hours) were the same that resulted in the highest values of N, P and K content. This may be attributed to that such plant chemical constituents are calculated as plant uptake (mg/plant). That is why N, P and K content are possitivelly related with plant growth.

With regard to the effect of seed-cold treatment on reducing, non-reducing and total sugars content of plant foliage, it is evident from data presented in Table (9) that most of the used seed-cold treatments had an enhancing effect in comparison with control treatment in this respect. Treatments which showed the highest values in this respect were those of -1°C for 24 hours followed by that for 12 hours.

Similar results were obtained by Pollock and Lloyd (1987) who reported that exposing pea plants to low temperature (5°C for 6 hours) produced higher content of carbohydrates in leaves. Ledov'skii and Bondarenko (1974) indicated that, plant exposure to low temperature may be useful for hardening the plant against frost. This may be due to the increase in total sugars and soluble protein in the cellular level.

With regard to the effect of rate of phosphatic and potassic fertilizers on chemical constituents of tomato plants foliage, data concerned with total nitrogen, phosphorus and potassium as well as reducing, non-reducing and total sugars of plant foliage are presented in Table (10). Such data show clearly that increasing fertilizers level significantly increased the values of different studied constituents of plant foliage up to the highest used one (99 kg N + 64 kg P_2O_5 + 72 kg K_2O/Fad.) which had the most pronounced effect in this respect at both winter seasons of 1987/1988 and 1988/1989, However, no significant differences between the 2nd and 3rd levels could be detected concerning of total nitrogen in the two seasons of growth.

These results may be explained on the base that treatments showed the lowest plant growth expressed as fresh and dry weight per plant were those received the lowest fertilizers level (Table 7), which also resulted in plants of the lowest mineral and sugars contents of plant. However, plants fertilized with the highest used level of fertilizers, which were of medium fresh and dry weight (Table 7), were those containing the highest minerals and sugars content. Such findings whow

Table (10): Effect of rate of phosphorus and potassium fertilizers on chemical composition of tomato plant foliage.

Levels of fertilizer N	P_2O_5 (kg/Fad.)	K_2O	Total nitrogen	Phosphorus	Potassium	Reducing sugar	Non-reducing sugar	Total sugars
			mg/plant			g/100 g dry weight		
					Season 1987/1988			
99	32	36	1722	341	1441	8.43	3.32	11.75
99	48	48	2411	543	2341	9.12	3.56	12.68
99	64	72	2405	587	2658	9.95	3.96	13.91
L.S.D. at 5%			54	22	61	0.06	0.04	0.09
					Season 1988/1989			
99	32	36	1653	327	1378	7.74	3.18	10.92
99	48	48	2313	509	2238	8.34	3.45	11.79
99	64	72	2270	561	2558	9.08	3.88	12.96
L.S.D. at 5%			107	14	36	0.05	0.04	0.08

clearly and may be due to the balance between growth and plant uptake of N, P and K as well as sugars percentage.

With regard to the effect of interaction between seed-cold treatment as well as fertilization rate of phosphorus and potassium, it is evident from data in Table (11) that third used level of fertilizers (99 kg N + 64 kg P_2O_5 + 72 kg K_2O/Fad.) combined with seed-cold treatment at -3°C for 24 hours followed by -2°C for 24 hours resulted in the highest values of N and P contents in plant foliage. However, treatment of third used level of fertilizers combined with seed-cold exposure at -2°C for 24 hours and that of -1°C for 24 hours showed the highest K content in plant foliage.

Similar results were obtained by Zurawicz and Stushnoff (1977) on strawberry where they reported that N, P and K contents of vegetative plant parts were increased as a result of exposing plants to -2.2°C for the tender plants and received 1:1:1 or 1:2:1 ratios of NPK fertilizers. They also found that N:P:K ratio is more important than the level of any individual element. Moreover, Eid <u>et al</u>. (1988) on broad bean showed that nitrogen and phosphorus at 33.5 kg N/Fad. and 16 or 32 kg P_2O_5/Fad. as well as seed vernalization for one week at 5°C were the most effective treatment on plant foliage mineral contents of N,P and K.

Concerning the effect of interaction between both of the two main used factors on reducing, non-reducing and total sugars content of plant foliage, it is evident that the

Table (11): Effect of interaction between seed-cold treatment and fertilization on chemical composition of tomato plant foliage.

Levels of fertilizer N	Levels of fertilizer P_2O_5 (kg/Fad.)	Levels of fertilizer K_2O	Seed-cold treatment Temperature °C	Seed-cold treatment Time hrs.	Season 1987/1988 Total nitrogen (mg/plant)	Season 1987/1988 Phosphorus (mg/plant)	Season 1987/1988 Potassium (mg/plant)	Season 1987/1988 Reducing sugars (g/100 g dry weight)	Season 1987/1988 Non-Reducing sugars (g/100 g dry weight)	Season 1987/1988 Total sugars (g/100 g dry weight)	Season 1988/1989 Total nitrogen (mg/plant)	Season 1988/1989 Phosphorus (mg/plant)	Season 1988/1989 Potassium (mg/plant)	Season 1988/1989 Reducing sugars (g/100 g dry weight)	Season 1988/1989 Non-reducing sugars (g/100 g dry weight)	Season 1988/1989 Total sugars (g/100 g dry weight)
99	32	36	Control		1728	302	1275	7.20	1.57	8.77	1698	296	1250	6.49	1.60	8.09
			-1	12	1604	320	1259	10.15	4.11	14.26	1567	307	1224	9.39	3.77	13.16
				24	1680	292	1413	10.58	4.50	15.08	1606	275	1318	9.75	4.30	14.05
			-2	12	1451	309	1366	9.55	3.93	13.48	1412	301	1333	8.86	3.84	12.70
				24	1571	352	1605	8.27	3.55	11.82	1502	339	1568	7.48	3.32	10.80
			-3	12	1963	400	1468	6.39	2.70	9.09	1860	372	1323	5.90	2.63	8.53
				24	2063	412	1704	6.91	2.92	9.83	1929	400	1630	6.35	2.81	9.16
99	48	48	Control		2446	438	1827	7.76	1.98	9.74	2300	401	1723	7.07	1.83	8.90
			-1	12	2170	521	2245	10.71	4.45	15.16	2089	501	2158	9.71	4.19	13.90
				24	2479	468	2563	11.18	4.72	15.90	2316	447	2449	10.29	4.64	14.93
			-2	12	2143	497	2257	10.30	4.16	14.46	2018	464	2126	9.54	4.07	13.61
				24	2469	574	2612	9.11	3.60	12.71	2353	553	2515	8.19	3.61	11.80
			-3	12	2655	630	2844	6.95	2.88	9.83	2508	595	2829	6.35	2.74	9.09
				24	2517	676	2042	7.85	3.15	11.00	2608	606	1868	7.24	3.09	10.33
99	64	72	Control		2135	473	2113	8.32	2.47	10.79	2071	397	2047	7.57	2.51	10.08
			-1	12	2169	607	2738	11.56	4.79	16.35	2109	590	2662	10.52	4.64	15.16
				24	2378	499	2950	11.99	5.01	16.00	2301	483	2855	11.00	5.03	16.03
			-2	12	2139	502	2413	11.09	4.50	15.59	2055	496	2311	10.16	4.41	14.57
				24	2775	643	3003	9.83	4.05	13.88	2669	643	2888	9.12	3.84	12.96
			-3	12	2482	654	2905	7.85	3.21	11.06	2173	602	2730	7.07	3.09	10.16
				24	2760	737	2487	9.02	3.71	12.73	2512	717	2417	8.14	3.66	11.80
L.S.D. at 5%					139	34	176	0.25	0.03	0.20	185	37	216	0.26	0.04	0.17

highest used level of fertilizers (99 kg N + 64 kg P_2O_5 + 72 kg K_2O/Fad.) combined with seed-cold treatment at -1°C for 24 or 12 hours showed significant increments in this respect. These increments were obvious at both growing seasons of 1987/1988 and 1988/1989.

Obtained results are in agreement with those obtained by Ledov'skii and Bondarenko (1974) on tomato and Higazy et al. (1976) and Pollock and Lloyd (1987) on pea.

2.3. Flowering and fruit setting:

The data showing the effect of seed-cold treatment as well as rate of phosphorus and potassium fertilizers on number of days from sowing to the anthesis of the first flower on the first cluster, number of flowers per plant and fruit setting percentage are presented in Tables (12, 13 and 14).

Such data reveal that most used seed-cold treatments enhanced flowering either as time of anthesis or number of flowers per plant as well as fruit setting percentage in both winter seasons of 1987/1988 and 1988/1989 compared with the control.

With regard to the effect on flowering time, the same data show that keeping seeds at all used seed-cold treatments significantly enhanced plant flowering by pushing plants to early flowering. The unique exception of these results was that of the treatment of -1°C for 12 hours at both seasons. Keeping wet seeds at -2°C for 24 hours resulted in plants of

Table (12): Effect of seed-cold treatment on flowering and fruit setting of tomato plants.

Seed-cold treatment: Temperature (°C)	Time (hrs.)	Flowering time (days)	No. of flowers/ plant	Fruit setting %
		Season 1987/1988		
Control		94.08	47.84	48.70
-1	12	93.75	53.79	49.63
	24	91.50	50.66	43.43
-2	12	91.25	48.40	50.41
	24	90.58	48.28	44.11
-3	12	90.91	50.58	46.85
	24	91.16	48.61	45.88
L.S.D. at 5%		1.14	1.05	0.63
		Season 1988/1989		
Control		114.25	47.96	48.58
-1	12	113.66	53.16	49.09
	24	111.83	53.88	43.98
-2	12	111.41	53.19	47.18
	24	111.00	51.08	46.00
-3	12	111.50	51.69	47.20
	24	111.33	48.53	44.30
L.S.D. at 5%		1.15	1.63	0.64

the earliest flowering compared with the other used treatments.

Concerning the effect of used treatments on number of flowers per plant, data presented in Table (12) show that, most of these treatments significantly increased number of flowers per plant. Treatments which showed the highest significant increments in this respect were those of keeping wet seeds at -1°C for either 12 or 24 hours followed by that of -3°C for 12 hours.

With respect to fruit setting percentage, it is evident that, seed-cold treatment at -2°C for 12 hours showed the highest significant effect in this respect. Such enhancing effect was obvious at the first growing season of 1987/1988 only.

These results are in harmony with those reported by Madzarova (1962) on tomato; Belousova (1973) and Abdalla et al. (1983) on sweet pepper, Higazy et al. (1976) and Shafshak (1987) on pea.

With regard to the effect of the rate of both P and K fertilizers on number of days from sowing to the anthesis of the first flower on the first cluster, number of flowers per plant and fruit setting percentage data in Table (13), reveal that the medium used level (99 kg N + 48 kg P_2O_5 + 48 kg K_2O/Fad.) surpassed both of the 1st and 3rd used levels of fertilizers in enhancing flowering either as time of

Table (13): Effect of rate of phosphorus and potassium fertilizers on flowering and fruit setting of tomato plants.

Levels of fertilizer N (Kg/Fad.)	P_2O_5	K_2O	Flowering time (days)	No. of flowers plant	Fruit setting %
			Season 1987/1988		
99	32	36	92.88	48.65	45.83
99	48	48	91.18	50.65	47.97
99	64	72	91.63	49.92	47.07
L.S.D. at 5%			0.48	0.58	0.39
			Season 1988/1989		
99	32	36	113.03	49.97	46.62
99	48	48	111.39	52.43	47.30
99	64	72	112.00	51.68	45.85
L.S.D. at 5%			0.68	0.63	0.42

anthesis or number of flowers per plant as well as fruit setting percentage in both winter seasons of 1987/1988 and 1988/1989.

Moreover, it is clearly evident that plants received the medium used level of fertilizers and showing better flowering behaviour and higher fruit setting percentage coming in the first rank in this respect were followed by those of the highest used level of fertilizers either with or without significant differences in between. However, the plants received the lowest used level of fertilizers come in the third rank with clear significant differences in this respect. In addition, such results show the tight relationship between plant growth (Table 7), chemical constituents of plants (Table 10) and the balance status discussed before from one side and the flowering behaviour of plants and fruit setting from the other side.

Obtained results are coincided with those of Adams (1978) and Jaramillo et al. (1978) on tomato and Farag (1984) on sweet pepper.

With regard to the effect of interaction between both of the two main factors, it is evident from data in Table (14) that, seed-cold treatment at -1°C for 12 hours combined with any one of the three used rates of fertilizers resulted in the highest values of number of flowers per plant. Meanwhile, the same seed-cold treatment combined with the second used rate of

Table (14): Effect of interaction between seed-cold treatment and fertilization on flowering and fruit setting of tomato plants.

Levels of fertilizer N (kg/Fad.)	P_2O_5	K_2O	Seed-cold treatment Temperature (°C)	Time (hrs)	Season 1987/1988 Flowering time (days)	No. of flowers /plant	Fruit setting %	Season 1988/1989 Flowering time (days)	No. of flowers /plant	Fruit setting %
99	32	36	Control		95.00	44.30	44.69	114.75	47.32	44.16
			-1	12	95.00	55.37	51.11	114.50	53.40	48.68
				24	92.50	48.97	41.86	113.25	51.65	45.11
			-2	12	92.00	47.35	49.41	112.25	50.27	49.33
				24	91.00	45.50	40.65	111.25	50.42	47.40
			-3	12	92.00	51.42	47.65	112.75	50.12	49.08
				24	92.50	47.67	44.89	112.50	46.65	42.01
99	48	48	Control		93.33	50.55	51.43	114.00	48.95	51.68
			-1	12	93.00	54.30	50.09	113.25	55.97	49.31
				24	91.00	50.70	43.39	111.00	54.67	43.53
			-2	12	90.50	50.25	52.13	110.25	53.67	49.37
				24	90.50	48.97	44.72	111.00	50.32	45.50
			-3	12	90.00	49.70	45.87	110.00	49.65	48.33
				24	90.00	50.25	47.16	110.25	53.77	43.51
99	64	72	Control		94.00	48.67	49.51	114.00	47.62	49.76
			-1	12	93.33	51.70	47.58	113.25	55.12	44.99
				24	91.00	52.32	45.10	111.25	55.35	43.17
			-2	12	91.33	47.62	49.55	111.75	54.65	44.09
				24	90.33	50.37	46.45	110.75	52.52	45.31
			-3	12	90.76	50.62	46.81	111.75	51.32	48.12
				24	91.00	48.15	45.48	111.25	45.17	47.59
L.S.D. at 5%					n.s	1.82	1.09	n.s	2.56	1.11

fertilizers showed the highest percentage of fruit setting. However, flowering time enhanced by all of the used seed-cold treatments combined with all of the three used levels of fertilizers except those of -1°C for 12 hours which did not show clear variation than control treatment in this respect in both winter seasons of 1987/1988 and 1988/1989.

The most pronouncing effect of seed-cold treatment on flowering time is noticed with the treatments of -2 or -3°C for 12 or 24 hours combined with the second used rate of fertilizers. Such treatments showed the earliest flowering.

Obtained results are in confirmity with those reported by Yasinska (1972) on tomato and Eid et al. (1988) on broad bean.

2.4. Fruit yield and its components:

Data illustrated in Tables (15, 16 and 17) clearly show the effect of seed-cold treatment as well as rate of phosphorus and potassium fertilizers on fruit yield and its components during the two seasons of this work.

It is evident from such data that, the most used seed-cold treatments increased number and weight of fruits per plant as well as early and total yield per faddan compared with control.

Concerning number of fruits per plant, such data show that, seed-cold treatments with -1°C or -2°C for 12 hours, were of significant improving effect in this respect.

Table (15): Effect of seed cold treatment on yield and its components of tomato plants.

Seed-cold treatment Temperature (°C)	Time (hrs.)	No. of fruits/ plant	Yield/ plant (kg)	Early yield Ton/Fad.	Early yield %	Total Yield Ton/Fad.	Relative total yield
Season 1987/1988							
Control		23.3	1.391	2.310	14.75	15.653	100.00
-1	12	26.7	1.781	4.655	19.78	23.529	150.31
	24	22.0	1.432	3.829	18.81	20.348	129.99
-2	12	24.4	1.615	4.868	22.15	21.974	140.38
	24	21.3	1.380	4.636	23.87	19.418	124.05
-3	12	23.7	1.506	4.793	23.21	20.645	131.89
	24	22.3	1.469	3.651	18.60	19.628	125.39
L.S.D. at 5%		1.0	0.054	0.366	-	0.635	-
Season 1988/1989							
Control		23.3	1.409	2.544	16.71	15.220	100.00
-1	12	26.1	1.730	4.591	20.75	22.125	145.36
	24	23.7	1.565	3.981	19.85	20.051	131.74
-2	12	25.1	1.719	4.655	21.07	22.088	145.12
	24	23.5	1.488	4.541	23.87	19.016	124.94
-3	12	24.4	1.542	4.598	23.02	19.968	131.19
	24	21.5	1.533	3.702	18.89	19.590	128.71
L.S.D. at 5%		1.0	0.052	0.377	-	0.564	-

This result is expected since these two treatments of -1°C or -2°C for 12 hours showed the highest fruit setting percentage and, to some extent, high number of flowers per plant (Table 15).

Regarding yield per plant as well as early and total yield per faddan, it is obvious, from data in Table (15) that, seeds exposed to -1°C, -2°C or -3°C for 12 hours resulted in plants of significantly higher yielding ability than those of control or other treatments.

It is also evident that, both of early yield percentage (as percentage of total yield) and relative total yield (as compared to the control treatment) behaved the same as other studied characters, where the highest values of different yield characteristics were obtained as a result of using -1°C, -2°C or -3°C for 12 hours treated seeds. Moreover, the treatment of -1°C for 12 hours increased the total yield with about 50% and 45% over the control in 1987/1988 and 1988/1989 years respectively.

The highest total yield either in kg/plant, in Tons/Fad. or as a relative yield which was about 140-150 of that of the control treatment were those of the treatments of -1°C or -2°C for 12 hours. Such results show the tight relationship between these characters and number of fruits per plant which showed the highest values at the same treatments. It is also evident that all studied yield components are of positive correlation with percentage of fruit setting (data at Table

12) which showed the highest values at the same treatments (-1°C and -2°C for 12 hours).

Moreover, it is also evident that the highest early yield (ton/Fad.) was that of treatments of -2°C for 12 or 24 hours or that of -3°C at 12 hours and such treatments resulted in the earliest flowering of plants (Table 12). This result is logically true and expected since early yield has to be positively related with flowering time.

Obtained results on yield and its components are in accordance with those of Belousova (1972) on eggplant; Yasinska (1972) on tomato and Belousova (1973); Stamber (1974) and Abdalla et al. (1983) all on sweet pepper.

Generally, it may be stated that under such experimental conditions, the improving effect of used seed-cold treatments on tomato yield and its components would be expected since such treatments promoted vegetative growth (Table 6), increased NPK uptake as well as reducing, non-reducing and total sugars percentages in plant foliage (Table 9), and enhanced flowering time, number of flowers per plant and fruit setting percentage (Table 12) as previously mentioned and discussed in this work.

Regarding effect of phosphorus and potassium fertilizers level on fruit yield and its components during the two seasons of growth, it is evident from data in Table (16) that plants received the medium used level of fertilizers (99 kg N + 48 kg P_2O_5 + 48 kg K_2O/Fad.) produced the highest number and weight

Table (16): Effect of rate of phosphorus and potassium fertilizers on yield and its component of tomato plants.

Levels of fertilizer N	P_2O_5 (Kg/Fad.)	K_2O	No. of fruits/ plant	Yield/ plant (kg)	Early yield Ton/Fad.	Early yield %	Total yield Ton/Fad.	Relative total yield
					Season 1987/1988			
99	32	36	22.3	1.404	3.809	20.23	18.833	100.00
99	48	48	24.3	1.666	4.756	21.46	22.153	117.62
99	64	72	23.5	1.499	3.752	19.21	19.526	103.67
L.S.D. at 5%			0.5	0.035	0.141	-	0.472	-
					Season 1988/1989			
99	32	36	23.3	1.377	3.738	20.22	18.484	100.00
99	48	48	24.8	1.793	4.710	21.82	21.583	116.76
99	64	72	23.7	1.550	3.812	19.95	19.099	103.32
L.S.D. at 5%			0.4	0.056	0.270	-	0.654	-

of fruits per plant as well as early and total yield per faddan.

It is also evident that both of early yield percentage and relative total yield behaved the same as other studied characters, where the highest values of yield and its components were obtained as a result of the medium used level of fertilizers followed by those of the highest used one. However, the lowest used level came in the third rank in this respect at most cases.

These results are similar to those mentioned by Jaramillo et al. (1978); Dimitrov and Rankov (1979); El-Sawah (1981); Abed and Eid (1987) and El-Sawy (1988) all working on tomato, who found a favourable effect of macronutrients application on fruit yield and its components.

Generally, under such experimental conditions, the improving effect of used medium level of NPK fertilizer on tomato yield and its components would be expected since such treatment promoted vegetative growth (Table 7), increased NPK uptake (Table 10) as well as number of flowers per plant and fruit setting percentage (Table 13) as previously mentioned and discussed.

With regard to the effect of interaction between seed-cold treatment and rate of phosphorus and potassium fertilizers on yield and its components, it is evident from data in Table (17) that second used level of fertilizers (99 kg N

Table (17): Effect of interaction between seed-cold treatment and fertilization on yield and its components of tomato plants.

Levels of fertilizer N	P_2O_5 (kg/Fad.)	K_2O	Seed-cold treatment Temperature (°C)	Time (hrs.)	Season 1987/1988 No. of fruits/plant	Yield/plant (kg)	Early yield Ton/Fad.	Early yield %	Total yield Ton/Fad.	Relative total yield	Season 1988/1989 No. of fruits/plant	Yield/plant (kg)	Early yield Ton/Fad.	Early yield %	Total yield Ton/Fad.	Relative total yield
99	32	36	Control		19.8	1.123	2.109	16.76	12.682	100.00	20.9	1.100	2.318	16.99	13.642	100.00
			-1	12	28.3	1.715	4.413	18.55	23.778	188.98	26.0	1.723	4.323	19.90	21.717	159.19
				24	20.5	1.388	3.841	20.51	18.724	148.81	23.3	1.467	3.747	20.14	18.603	136.36
			-2	12	23.4	1.543	4.467	21.13	20.964	166.61	24.8	1.556	4.323	21.56	20.045	146.93
				24	18.5	1.259	4.441	25.54	17.446	138.65	23.9	1.429	4.394	25.58	17.171	125.86
			-3	12	24.5	1.409	3.871	19.81	19.537	155.27	24.6	1.521	3.705	19.35	19.142	140.31
				24	21.4	1.374	3.525	18.75	18.800	149.41	19.6	1.181	3.363	17.63	19.071	139.79
99	48	48	Control		26.0	1.592	2.636	14.62	18.021	100.00	25.3	1.612	2.869	17.11	16.761	100.00
			-1	12	27.2	1.854	5.700	22.52	25.308	140.43	27.6	2.017	5.662	23.30	24.297	144.96
				24	22.0	1.578	4.560	21.15	21.560	119.63	23.8	1.681	4.897	22.59	21.671	129.29
			-2	12	26.2	1.785	5.372	22.00	24.410	135.45	26.5	1.931	5.130	20.76	24.700	147.36
				24	21.9	1.570	4.840	22.54	21.470	119.13	22.9	1.609	4.717	22.64	20.827	124.25
			-3	12	22.8	1.628	5.581	25.07	22.258	123.51	24.0	1.802	5.197	24.33	21.359	127.43
				24	23.7	1.624	4.603	20.88	22.044	122.32	23.4	1.745	4.303	20.97	21.470	128.09
99	64	72	Control		24.1	1.458	2.185	13.35	16.356	100.00	23.7	1.423	2.446	16.02	15.259	100.00
			-1	12	24.6	1.642	3.852	17.91	21.503	131.46	24.8	1.571	3.791	18.61	20.360	133.42
				24	23.6	1.529	3.087	14.86	20.760	126.92	23.9	1.484	3.296	16.58	19.879	130.27
			-2	12	23.6	1.526	4.764	23.18	20.548	125.62	24.1	1.508	4.513	20.97	21.518	141.01
				24	23.4	1.485	4.624	23.91	19.337	118.22	23.8	1.508	4.513	23.69	19.050	124.64
			-3	12	23.7	1.483	4.925	24.45	20.140	123.13	24.7	1.554	4.892	25.21	19.403	127.15
				24	21.9	1.407	2.826	15.66	18.040	110.29	21.5	1.515	3.239	17.76	18.228	119.45
L.S.D. at 5%					1.8	0.093	0.635	-	1.101	-	1.8	0.090	0.654	-	0.977	-

+ 48 kg P_2O_5 + 48 Kg K_2O/Fad.) combined with seed-cold treatment at -1°C, -2°C or -3°C for 12 hours resulted in the highest values of different studied characteristics i.e, number of fruits per plant (except seed-cold treatment at -3°C for 12 hours), yield per plant as well as early and total yield per faddan.

Obtained results are in accordance with those of Yasinska (1972) on tomato, Stamber (1974) on sweet pepper and Eid et al. (1988) on broad bean.

2.5. Tomato fruit quality:

2.5.1. Physical characteristics of tomato fruits:

Data concerned with weight, length, diameter and shape index of fruits are presented in Tables (18, 19 and 20). Such data clearly indicate that, most of the used seed-cold treatments increased average weight, length, diameter and shape index of fruit compared with the control treatment.

It is also evident from data in Table (18) that, seed-cold treatment at -1°C or -2°C for 12 hours and -3°C for 24 hours resulted in the highest values of average fruit weight. However, treatment of -3°C for 24 hours showed the highest fruit length. Meanwhile, that of -1°C for 12 hours resulted in the highest fruit diameter and the lowest values of shape index (nearly round fruits). Such improving effect of these treatments than others was statistically significant at both seasons of this work.

Table (18): Effect of seed-cold treatment on physical characteristics of tomato fruits.

Seed-cold treatment Temperature (°C)	Time (hrs)	Average fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Shape index (L/D)
		Season 1987/1988			
Control		59.34	6.13	5.10	1.20
-1	12	68.78	6.22	5.64	1.10
	24	64.54	6.23	5.10	1.22
-2	12	67.63	6.62	5.41	1.22
	24	65.41	6.73	5.34	1.26
-3	12	63.81	6.80	5.30	1.28
	24	65.71	6.92	5.25	1.31
L.S.D. at 5%		0.87	0.08	0.18	0.04
		Season 1988/1989			
Control		58.82	6.06	5.02	1.20
-1	12	67.58	6.28	5.45	1.15
	24	65.24	6.33	5.03	1.25
-2	12	66.07	6.62	5.35	1.23
	24	64.49	6.73	5.25	1.28
-3	12	66.63	6.63	5.40	1.22
	24	68.44	6.98	5.25	1.32
L.S.D. at 5%		2.38	0.12	0.17	0.04

It is obvious from such data that seed-cold treatments at -1°C or -2°C for 12 hours, which resulted in plants produced fruits of the most suitable and standard physical characteristics are the same that showed the highest total yield as shown in Table (15). Obtained results may lead to the conclusion that increments of total yield in this respect is due to increments in average weight, length and diameter of fruits (Table 18) more than those of number of fruits per plant (Table 15).

These results are in agreement with those of Yasinska (1972) who reported that, chilling tomato seed increased mean fruit weight. Moreover, Abdalla et al. (1983) mentioned that, average fruit weight was significantly increased due to exposure of pepper seeds to -1°C or -2°C for 12 or 24 hours, meanwhile, no significant differences were detected between the various used treatments, regarding length, diameter and shape of fruits.

Concerning the effect of phosphorus and potassium fertilizers rate, data in Table (19) clearly indicate that, the medium level of fertilizers resulted in the highest values of average fruit weight, fruit length and fruit shape index at both seasons. Such increments were significant at both successive growing seasons of this work. However, fruit diameter was increased with the first level of fertilizers and such increment was significant as compared with the third level of fertilizers only.

Table (19): Effect of rate of phosphorus and potassium fertilizers on physical characteristics of tomato fruits.

Levels of fertilizer N	P_2O_5 (kg/Fad.)	K_2O	Average fruit weight (g.)	Fruit length (cm)	Fruit diameter (cm)	Shape index (L/D)
			Season 1987/1988			
99	32	36	62.97	6.43	5.37	1.19
99	48	48	68.59	6.82	5.30	1.27
99	64	72	63.82	6.31	5.17	1.22
L.S.D. at 5%			1.54	0.13	0.12	0.04
			Season 1988/1989			
99	32	36	60.93	6.43	5.34	1.20
99	48	48	71.47	6.76	5.28	1.28
99	64	72	63.56	6.36	5.13	1.23
L.S.D. at 5%			1.92	0.14	0.13	0.04

It is obvious from such data that treatment of medium levels of fertilizers, which resulted in the highest average fruit weight and length, is the same that showed the highest total yield as shown in Table (16). Obtained results may lead to the conclusion that increments of total yield in this respect is due to increments of average weight and length of fruits (Table 19) more than those of number of fruits per plant (Table 16).

These results are in accordance with those of Jaramillo et al. (1978) and El-Sawy (1988) on tomato and Farag (1984) on sweet pepper. Moreover, Abed and Eid (1987) mentioned that tomato average fruit weight, fruit length and diameter were affected by level of fertilizers. Meanwhile, fruit shape index (L/D) did not significantly response to used fertilizers level.

Data showing the combined effect of the seed-cold treatment and P, K fertilizers level on fruit physical characters (Table 20) indicate obviously that differences between different used treatments were significant.

Such data reveal that the seeds exposed to low degrees of temperature (1°C, -2°C or -3°C for 12 hours) which resulted in plants, if received the second level of fertilizers (99 kg N + 48 kg P_2O_5 + 48 kg K_2O/Fad.), produced fruits with the highest average weight and diameter. The highest values of fruit length and fruit index were due to the exposure of seeds to -2°C or -3°C for 24 hours in combination with the second used level of fertilizers.

Table (20): Effect of interaction between seed-cold treatment and fertilization on physical characteristics of tomato fruits.

Lever of fertilizer			Seed-cold treatment		Season 1987/1988				Season 1988/1989			
N	P_2O (kg/Fad.)	K_2O	Temperature °C	Time hrs	Average fruit weight (g)	Fruit length (cm)	Fruit dia-meter (cm)	Shape index (L/D)	Average fruit weight (g)	Fruit length (cm)	Fruit dia-meter (cm)	Shape index (L/D)
99	32	36	Control		56.71	6.12	5.22	1.17	52.67	6.00	5.12	1.17
			-1	12	67.90	6.27	6.07	1.03	66.29	6.30	5.57	1.13
				24	60.65	6.12	5.35	1.14	62.97	6.25	5.22	1.19
			-2	12	68.08	6.62	5.40	1.22	62.76	6.55	5.47	1.19
				24	65.62	6.40	5.37	1.19	59.80	6.45	5.42	1.19
			-3	12	57.59	6.57	5.25	1.25	61.84	6.50	5.25	1.23
				24	64.29	6.87	5.25	1.30	60.23	6.95	5.35	1.29
99	48	48	Control		61.13	6.23	4.95	1.25	63.73	6.20	4.85	1.27
			-1	12	71.55	6.23	5.45	1.14	73.10	6.35	5.47	1.16
				24	68.24	6.95	5.30	1.31	70.64	6.85	5.27	1.29
			-2	12	71.39	7.03	5.47	1.28	72.88	6.93	5.37	1.29
				24	68.13	7.15	5.45	1.31	70.30	7.10	5.22	1.36
			-3	12	71.34	7.10	5.35	1.32	75.10	6.80	5.50	1.23
				24	68.37	7.05	5.35	1.31	74.58	7.13	5.27	1.35
99	64	72	Control		60.17	6.03	5.12	1.17	60.07	6.00	5.10	1.17
			-1	12	66.89	6.15	5.40	1.13	63.35	6.23	5.32	1.19
				24	64.73	5.60	4.67	1.19	62.12	5.88	4.60	1.27
			-2	12	63.41	6.20	5.37	1.15	62.58	6.38	5.22	1.22
				24	62.49	6.65	5.20	1.27	63.39	6.63	5.10	1.30
			-3	12	62.49	6.73	5.30	1.26	62.93	6.58	5.47	1.20
				24	64.47	6.83	5.17	1.32	70.50	6.87	5.15	1.23
L.S.D. at 5%					1.50	0.14	0.32	0.07	4.13	0.21	0.30	n.s

2.5.2. Chemical constituents of tomato fruits:

Data showing the tomato fruit contents expressed as vitamin C, titratable acidity, total soluble solids as well as reducing, non-reducing and total sugars as affected by seed-cold treatment are presented in Tables (21, 22 and 23).

Regarding the effect of seed-cold treatment on vitamin C, T.S.S as well as reducing, non-reducing and total sugars, data presented in Table (21) show clearly that most of the used seed-cold treatments significantly increased these constituents of the fruits as compared with the check treatment. However, no significant differences could be detected with respect to titratable acidity. These results are worthy true during both seasons of growth 1987/1988 and 1988/1989.

In this respect the tomato fruits containing the highest content of different studied chemical constituents were picked from plants grown by seeds treated with -1°C or -2°C for 24 hours. Moreover, reducing, non-reducing and total sugars were significantly increased also in case of treating tomato seeds with -1°C or -2°C but for 12 hours.

The beneficial effect of seed-cold treatment on vitamin C content which was previously recorded by Tropina and Nezhdanova (1975) is in quite confirmity with the results of this study. However, Abdalla et al. (1983) reported that, no significant differences were detected between the various used treatments, regarding vitamin C, titratable acidity and T.S.S contents of sweet pepper fruits.

Table (21): Effect of seed-cold treatment on chemical constituents of tomato fruits.

Seed-cold treatment Temperature (°C)	Time (hrs.)	Vitamin C (mg/100 cm^3 juice)	Titratable acidity	T.S.S %	Reducing sugars (g./100 g dry weight)	non-reducing sugars	Total sugars
				Season 1987/1988			
Control		34.3	666	6.37	4.13	0.89	5.02
-1	12	39.2	650	6.60	5.75	1.98	7.73
	24	39.8	671	6.99	5.98	2.10	8.08
-2	12	39.1	664	6.66	5.48	1.87	7.35
	24	39.9	668	6.86	4.83	1.66	6.49
-3	12	38.3	645	6.75	3.76	1.30	5.06
	24	38.8	657	6.82	4.22	1.45	5.67
L.S.D. at 5%		1.6	n.s	0.20	0.09	0.07	0.12
				Season 1988/1989			
Control		34.6	665	6.49	3.93	0.87	4.86
-1	12	40.3	654	6.66	5.52	1.85	7.37
	24	40.5	677	7.03	5.78	2.03	7.81
-2	12	39.7	672	6.73	5.32	1.79	7.11
	24	40.3	679	6.93	4.62	1.57	6.19
-3	12	38.6	647	6.76	3.60	1.23	4.83
	24	39.0	658	6.91	4.05	1.39	5.44
L.S.D. at 5%		1.7	18	0.15	0.07	0.06	0.14

From data presented in Table (22), it is evident that level of soil application of P and K fertilizers significantly affected vitamin C, total soluble solids as well as reducing, non-reducing and total sugars fruit contents. These variations were obvious at both growing seasons of 1987/1988 and 1988/1989. Meanwhile, acidity fruit content did not show any response to the used fertilizers levels. In this respect, the highest values, which showed the highest significant differences, were produced from plants fertilized with the highest level of fertilizers (99 kg N + 64 kg P_2O_5 + 72 kg K_2O/Fad.).

The increase in vitamin C and T.S.S. content of tomato fruits, due to supply of plants with macronutrients, was reported by Dimitrov and Rankov (1979); Abed and Eid (1987) and El-Sawy (1988) all working on tomato and Aliev (1971) on eggplant.

With regard to the effect of interaction between both of the two main factors, it is evident from data in Table (23) that, third used level of fertilizers (99 kg N + 64 kg P_2O_5 + 72 kg K_2O/Fad.) combined with seed-cold treatment at -1°C or -2°C for 24 hours resulted in the highest values of vitamin C, titratable acidity and T.S.S. contents of tomato fruits at both growing seasons.

In this respect the tomato fruits containing the highest content of reducing, non-reducing and total sugars were

Table (22): Effect of rate of phosphorus and potassium fertilizers on chemical constituents of tomato fruits.

Levels of fertilizer			Vitamin C	Titratable acidity	T.S.S	Reducing sugars	Non-reducing sugars	Total sugars
N	P_2O_5	K_2O	(mg/100 cm^3 juice)		%	(g./100 g dry weight)		
	(Kg/Fad.)							
Season 1987/1988								
99	32	36	36.4	656	6.57	4.48	1.48	5.96
99	48	48	38.4	657	6.68	4.85	1.58	6.43
99	64	72	40.8	667	6.92	5.29	1.76	7.05
L.S.D. at 5%			0.7	n.s	0.16	0.06	0.04	0.07
Season 1988/1989								
99	32	36	36.9	660	6.64	4.33	1.39	5.72
99	48	48	38.7	664	6.75	4.66	1.51	6.17
99	64	72	41.4	669	6.97	5.07	1.69	6.76
L.S.D. at 5%			1.1	n.s	0.17	0.05	0.04	0.08

Table (23): Effect of interaction between seed-cold treatment and fertilization on chemical constituents of tomato fruits.

Levels of fertilizers (kg/Fad.)			Seed-cold treatment		Season 1987/1988						Season 1988/1989					
N	P_2O_5	K_2O	Temperature °C	Time hrs.	Vitamin C (mg/100 cm^3 juice)	Titratable acidity (mg/100 cm^3 juice)	T.S.S %	Reducing sugars (g/100 g dry weight)	Non-reducing sugars (g/100 g dry weight)	Total sugars (g/100 g dry weight)	Vitamin C (mg/100 cm^3 juice)	Titratable acidity (mg/100 cm^3 juice)	T.S.S %	Reducing sugars (g/100 g dry weight)	Non-reducing sugars (g/100 g dry weight)	Total sugars (g/100 g dry weight)
99	32	36	Control		32.3	655	6.35	3.83	0.75	4.53	32.8	666	6.45	3.63	0.70	4.33
			-1	12	37.3	633	6.43	5.40	1.83	7.23	38.0	651	6.48	5.25	1.65	6.90
				24	39.3	661	6.93	5.63	2.00	7.63	40.0	663	7.00	5.45	1.88	7.33
			-2	12	36.5	669	6.40	5.08	1.75	6.83	37.3	665	6.48	4.95	1.68	6.63
				24	38.3	672	6.75	4.40	1.58	5.98	38.8	669	6.83	4.18	1.45	5.63
			-3	12	33.8	648	6.48	3.40	1.20	4.60	34.3	646	6.40	3.30	1.15	4.45
				24	32.3	654	6.65	3.68	1.30	4.98	37.3	664	6.85	3.55	1.23	4.78
99	48	48	Control		36.3	665	6.45	4.13	0.88	5.01	36.0	655	6.60	3.95	0.80	4.75
			-1	12	39.8	647	6.80	5.70	1.98	7.68	40.8	639	6.85	5.43	1.83	7.26
				24	37.3	656	6.90	5.95	2.10	8.05	37.3	674	6.95	5.75	2.03	7.78
			-2	12	40.0	661	6.50	5.48	1.85	7.33	41.0	685	6.63	5.33	1.78	7.11
				24	39.3	663	6.60	4.85	1.60	6.45	39.5	694	6.70	4.58	1.58	6.16
			-3	12	39.8	644	6.80	3.70	1.28	4.98	39.8	647	6.83	3.55	1.20	4.75
				24	36.5	665	6.68	4.18	1.40	5.58	37.0	658	6.70	4.05	1.35	5.40
99	64	72	Control		34.5	677	6.30	4.43	1.10	5.53	35.3	676	6.43	4.23	1.10	5.33
			-1	12	41.5	669	6.58	6.15	2.13	8.28	42.0	672	6.65	5.88	2.03	7.91
				24	43.0	695	7.15	6.38	2.23	8.61	44.3	696	7.13	6.15	2.20	8.35
			-2	12	40.8	661	7.10	5.90	2.00	7.90	41.0	666	7.10	5.68	1.93	7.61
				24	42.3	670	7.23	5.23	1.80	7.03	42.5	675	7.28	5.10	1.68	6.78
			-3	12	41.3	645	6.98	4.18	1.43	5.61	41.8	648	7.05	3.95	1.35	5.30
				24	42.5	652	7.13	4.80	1.65	6.45	42.8	653	7.18	4.55	1.60	6.15
L.S.D. at 5%					2.8	n.s	0.35	0.15	n.s	n.s	3.0	n.s	0.26	0.13	n.s	n.s

produced from plants of the seeds treated with -1°C for 12 or 24 hours and then plants were fertilized with the third level of fertilizers. However, such differences did not reach the level of significancy except in the case of vitamin C, T.S.S. and reducing sugars which showed significant increments for the above mentioned treatments at both successive seasons of this work.