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ABSTRACT

Two experiments were carried out in the laboratory of Hort. Depart. of the Fac. of Agric. at Moshtohor to elucidate the effect of seed-cold treatment on different aspects of seeds, seedlings and transplants of tomato cv. UC. 97-3 during Winter seasons of 1987/1988 and 1988/1989. Data, recorded, showed that keeping seeds at -1 to -3° for 12 hours increased germination percentage, accelerated seed germination rate and promoted reducing and non-reducing sugars accumulation in seeds. Moreover, such treatments increased their chemical constituents, i.e., N,P and K, reducing, non reducing and total sugars, indoles and phenols content as well as the enzyme activity especially oxidative enzymes.

INTRODUCTION

Many factors affect tomato plant growth and consequently total fruit yield afterwards. Among these factors is the exposure of tomato seedling to the adverse environmental conditions prevailing in Winter Season beginning from November, up to the late of January. Any treatment that is capable of inducing durability for cold injury to the tomato seedling will be of beneficial effect.

It has been reported that seed cold treatment increased the percentage and enhanced rate of germination of tomato seeds (Hennart, 1985; Scott & Jones, 1986 and Coolbear et al., 1987). Moreover, it improved the chemical constituents of seeds represented in reducing, non reducing and total sugars (Hennart, 1985 and Pollock, 1986) working on tomato and pea respectively. In addition, such treatment increased the activity of the oxidative enzymes represented in peroxidase and polyphenol oxidase (Krasnuk et al., 1975 on alfalfa). Seedling growth is positively affected by seed cold treatment and have greater chilling tolerance as compared with non treated seeds (Abdalla et al., 1983; Wang, 1985 and Scott & Jones, 1986 working on sweet pepper, cucumber and zucchini squash and tomato respectively).

Chemical constituents of seedling foliage showed increments in nitrogen, phosphorus and potassium as reported by Ledov'skii and Bondarenko (1974); on tomato Abdalla et al. (1983), on sweet pepper and Eid et al. (1988), on broad bean; Pollock (1986) and Pollock & Lloyd (1987) all working on pea as regard to reducing, non reducing and total sugars. Total indoles and phenols were decreased by seed cold treatment (Radwan et al., 1980 and Shafshak, 1987) working on strawberry and pea, respectively. However, contra results were reported by Eid et al. (1988), working on broad bean, since, they indicated that exposing seeds to 5°C for one week promoted the concentration of total indoles and phenols in plant tissues.

No available review, dealing with the activity of the oxidative enzymes in seedling foliage, are present.

The aim of this trial is to ameliorate the adverse effect of low temperature during the Winter months and to shed more light on the growth criteria of tomato seedlings as a result of seed cold treatments.

MATERIALS AND METHODS

Two experiments were conducted at the laboratory and nursery of the horticulture Department, Faculty of Agriculture at Moshtohor, Zagazig University, during the Winter seasons of 1987/1988 and 1988/1989. This study was carried out to investigate the effect of seed-cold treatment on seed germination, seed and seedling chemical composition and growth of tomato transplants cv. U.C. 97-3.

Each experiment included 8 treatments which were the combination of three seed-cold treatments, i.e. -1, -2 and -3°C within two chilling periods, i.e. 12 and 24 hours beside two control treatments i.e. neither soaked nor cold-treated seeds and soaked in distilled water but not cold-treated seeds, forming 8 treatments.

A complete randomized block design with four replicates was followed in both seasons of this experiment.

Tomato seeds were wetted, except those of the dry control treatment, in distilled water for 48 hours and then exposed to the above mentioned degree of temperature and periods of seed-cold treatment except those of the wet control treatment. Tomato seeds were sown either in Pettry dishes in the laboratory or in the nursery in the

Temperature degrees and relative humidity prevailing through growing seasons of 1987/1988 and 1988/1989 at kalubia province.

The Month	Temperature °C			Relative Humidity %
	Maximum	Minimum	Average	
	Season 1987/1988			
October	28.1	15.7	21.9	61
November	23.1	8.0	15.6	65
December	19.7	8.6	14.2	68
January	18.0	6.9	12.4	62
February	19.7	7.1	13.4	59
March	22.1	8.4	15.3	57
April	28.2	14.6	21.4	55
May	35.9	17.6	26.8	38
	Season 1988/1989			
October	27.8	14.3	21.0	64
November	22.1	7.7	14.9	64
December	19.2	8.2	13.7	67
January	16.2	5.2	10.7	74
February	19.6	7.5	13.5	62
March	22.3	7.9	15.1	64
April	29.7	11.7	20.7	54
May	31.7	14.5	23.1	48

same experimental design mentioned before on November 1st 1987 and October 25th 1988 respectively. In the nursery, irrigation and other agricultural practices were carried out as usually followed in the district. Two hundred seeds of each treatment were taken in the laboratory experiment and divided into 4 groups, each group contains 50 seeds representing 4 replicates. Measuring the percentage and rate of seed germination according to Bartlett formula (1937) took place beside determination of reducing, non reducing and total sugars in the seeds according to the methods described by Michel et al., (1956). In the germinated seeds peroxidase activity according to Allam and Hollis (1972) and each of polyphenol oxidase, catalase and ascorbic acid oxidase assay according to the methods of Maxwell and Bateman (1967), were determined. Moreover, in the nursery experiment at december 9th and 5th in 1987 and 1988 respectively, representative samples of 20 transplants from each plot were taken for measuring different studies characters, i.e., plant height, stem diameter, number of leaves per plant as well as fresh and dry weight per 20 seedlings.

In the digested dry matter of such samples of seedlings total nitrogen, phosphorus and potassium as (mg/100 seedlings) were determined acording to the methods described by Pregl (1945), Murphy and Riely (1962) as modified by John (1970) and Brown and Lilleland (1946), respectively and also reducing, non reducing and total sugars according to methods of Michel et al., (1956).

Total indoles and phenols according to the methods described by Gordon and Weber (1950) as modified by Filiosson (1969), respectively as well as the activities of the oxidative enzymes were determined in the seedling leaves as previously mentioned in the germinated seeds.

All collected data were subjected to the statistical analysis as mentioned by Snedecor and Cochran (1968).

RESULTS AND DISCUSSION

1- Germination of Tomato Seeds:

It is obvious from data presented at Table (1) 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 control. These increments were obvious at both growing seasons of this work. It is also evident that the most favourable treatments which showed

the highest percentage of seed germination and also the earliest germination rate, arranged in a descending order, were -1°C, -2°C or -3°C for 12 hours respectively.

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

Soaking Period (hrs)	Seed-Cold Treatment Temperature (°C)	Time (hrs)	Season 1987/88 Germination %	Season 1987/88 Germination rate	Season 1988/89 Germination %	Season 1988/89 Germination rate
Control			80.0	8.4	77.7	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

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

2- Chemical Constituents of Tomato Seeds:

Data presented in Table (2) 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 treatments. 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 incresed 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.

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

Soaking period (hrs)	Seed-cold treatment Temperature (°C)	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	0.26	0.12
		24	56.0	25.3	81.3	1.37	0.46	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	1.51	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

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 and the highest values in this respect were -1°C for 24 hours in case of both of peroxidase and catalase activity and -2°C for 12 hours for polyphenol oxidase, meanwhile the treatment of -3 for 24 hours resulted in the highest activity of the ascorbic acid oxidase.

3- Vegetative Growth of Tomato Transplants:

Data presented in Table (3) show clearly that during winter seasons of 1987/1988 and 1988/1989, 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 significance.

Such data clearly show that, seed-cold treatment at -1°C or -3°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 treatments promoted reducing and non-reducing sugars content of tomato seeds as shown in Table (2) 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.

4- Chemical Constitutents of Transplants Foliage:

Data concerned with total nitrogen, phosphorus, potassium, reducing, non reducing and total sugars of transplants foliage as mg/100 seedlings and total indoles and phenols of tomato transplants (mg/100g fresh weight) are presented in Table (4). Such data show clearly that most of the used seed cold treatments significantly increased the values of such constituents compared with the control ones. These increments were at their highest level with the treatment of -3°C for 24 hours concerning N,P and K content at both seasons of this work.

Obtained results, of N,P and K plant content, are in confimity with those mentioned by Abdalla et al. (1983) on sweet pepper and Eid et al., (1988), on broad bean.

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

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

With regard to the effect of seed-cold treatment on reducing, non-reducing and total sugars content as well as total indoles and phenols content of plant foliage, it is evident from the same data presented in Table (4) that treatment which showed the highest values in this respect was that of -1°C for 24 hours.

Regarding the previous studies on the effect of seed Cold treatments on plant content of sugars, 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. They attributed this to the increase in total sugars and soluble protein in the cellular level. 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. The obtained results of the total indoles and phenols are in harmony with those reported by Eid *et al.* (1988), on broad bean who found that exposing seeds to 5°C for one week promoted the concentration of total indoles and phenols in plant tissues. However, 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.

5- Enzyme Activity:

Data presented in Table (5) showing the effect of seed-cold treatment on the activity of enzymes in tomato transplants indicate that all used seed-cold treatments significantly increased the values of activity of different studied enzymes compared with the two control treatments at both seasons of this work.

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

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

Finally, it may be conoluded that, the improving effect of seed-cold treatment on the seed germination either as percentage or rate of germination (Table 1), is mainly

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

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 tranplants (Table 3). This improving effect of seed-cold treatments was completely true and may be explained through the effect on both of chemical constituents (Table 4) and enzyme activity of transplants (Table 5).

Hence, it is advisable to expose tomato seeds to -1°C or -2°C for 12 hours to increase the percentage of seed germination and to -1°C or -3°C for 24 hours for production of tomato transplants with good vegetative growth and quality in winter season.

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ظواهر النمو لشتلات الطماطم الناميـــة

تحت تأثير معاملات البذور بالبرودة

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الملخص العربي

أجريت تجربتان معمليتان بقسم البساتين ، كلية الزراعة بمشتهر لدراسة تأثير معاملة البذور بالبرودة على الجوانب المختلفة للبذور والبادرات وشتلات الطماطم صنف يوس ٩٧ - ٢ أثناء الموسم الشتوى لعامى ١٩٨٧/١٩٨٨ ، ١٩٨٨/١٩٨٩ . وقد أظهرت النتائج أن حفظ البذور عند درجة - ١ ، - ٢ ، - ٣ ولمدة ١٢ ساعة عمل على زيادة نسبة وسرعة الإنبات والمحتوى الكيماوى من السكريات المختزلة والغير مختزلة وكذلك النشاط الانزيمى فى البادرات . والتى نتج عنها نمو خضرى قوى للشتلات الناتجة مصحوباً بزيادة المحتوى النتروجينى والفوسفاتى والبوتاسى والسكريات المختزلة والغير مختزلة والكلية والاندولات والفينولات وكذلك النشاط الانزيمى للشتلات خاصة إنزيمات الأكسدة .