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ABSTRACT

Two experiments were undertaken in the Exp. Field of the Fac. agric. Moshtohor, Zagazig Univ. in winter seasons of 1987/1988 and 1988/1989 to study the effect of three different levels of P and K fertilizers in combination with seven seed-cold treatments on flowering, fruit setting and yield of tomato cv. U.C. 97-3. Obtained results showed that seed-cold treatment at -1°C for 12 hrs 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 fertilizers showed the highest percentage of fruit setting. Moreover, flowering time was enhanced by all used seed-cold treatments especially with the treatments of -2°C or -3°C or 12 or 24 hrs combined with the second used rate of fertilizers. The maximum values of number of fruits per plant and yield per faddan were obtained with seed-cold treatments of keeping tomato seeds at -1°C, -2°C or -3°C for 12 hrs combined with the medium used level of fertilizers.

INTRODUCTION

Higher production of tomato necessitates more devised methods for increasing fruit yield per unit area, this may be realized through increasing number of flowers per plant and improving the percentage of fruit setting. One of the pathways for the achievement of this goal is to apply the suitable level of phosphorus and potassium fertilizers level. Keeping seeds at low temperature to overcome the bad effect of cold weather prevailing through winter season is the main goal of this work.

It has been reported by many investigators that seed-cold treatment exerted a favourable effect on earliness

of flowering (Higazy et al., 1976; Shafshak, 1987; all working on pea). They found that storing seeds for 5 or 10 days at 3°C or 6°C was more effective in pushing plants to flower early. Flowering and fruit setting were also favourable responsed to the seed-cold treatment (Belousova, 1973; Abdalla et al., 1983 on sweet pepper). In this regard, they mentioned that exposing sweet pepper seeds to -1°C to -2°C for 12-24 hrs resulted in the development of more flowers and increased fruit setting percentage. The effect of P and K fertilization on pepper plants flowering was reported by Farag (1984), who showed that flowering time was significantly delayed but number of flowers per plant was increased by using the highest level of N, P and K fertilizers. Moreover, Adams (1978) and Jaramillo et al. (1978), showed also that number of flowers per plant and fruit setting were improved with, P_2O_5 and K_2O at 75:50:50 kg/ha. However, El-Sawy (1988), working on tomato did not find significant effect in this respect. The combination of seed-cold treatment with PK fertilization exerted a promotive influence on flowering and fruit setting as reported by Yasinska (1972) on tomato and Eid et al., (1988) on broad bean.

Fruit yield and its components were also favourably affected by seed-cold treatment especially at -1°C to -2°C for varied periods, ranged from 6 up to 36 hrs (Belousova, 1972; Yasinska, 1972; Belousova, 1973; Stamber, 1974; Abdalla et al., 1983; all working on solanaceous crops).

The enhancing effect of fertilization with P and K on fruit yield and its components has been found by Jaramillo et al. (1978) and Abed & Eid (1987) on tomato. The favourable effect of the interaction between seed-cold treatment and rate of phosphorus and potassium fertilizers on the fruit numer per plant, yield per plant, early and total yield per unit area was reported by Yasinska (1972), on tomato and Eid et al., (1988) on broad bean.

Therefore, the aim of this study is to elucidate the effect of seed-cold treatment and PK fertilization on flowering behaviour and fruit yield of tomato winter planting.

MATERIALS AND METHODS

Two field experiments were performed at the Experimental Farm of the Faculty of Agriculture, Moshtohor, Zagazig University, during winter seasons of 1987/1988 and 1988/1989. Seeds of tomato (Lycopersicon esculentum, Mill.) cv. U.C.

97-3 were soaked in distilled water for 48 hours before the previously mentioned periods of seed-cold treatment in the first part of this work. Seeds were then sown in the nursery on November 1st 1987 and October 25th 1988. Transplanting took place on December 9th and 5th in 1987 and 1988 years, respectively. Transplants were planted at 30 cm apart on one side of ridges 100 cm wide. The experiment included 21 treamtents resulted from cobmination of three different levels of phosphorus and potassium fertilizers (32 kg P_2O_5 + 36 kg K_2O/fad., 48 kg P_2O_5 + 48 kg K_2O/fad. and 64 kg P_2O_5 + 72 kg K_2O/fad.) and seven seed-cold treatments (-1, -2 or -3°C for 12 or 24 hours beside the control treatment).

The nitrogen fertilizer was added at the rate of 99 kg N/fad. for each of the previously mentioned levels of P and K fertilizers. Fertilizers were applied in the form of ammonium nitrate (33.5% N), calcium superphosphate (16.5% P_2O_5) and potassium sulphate (48% K_2O). Fertilizers were added as three equal portions at 3, 7 and 11 weeks after transplanting for the first, second and third doses respectively. A split plot design with four replicates was adopted. The plot area was about 1/380 faddan. Other cultural practices were carried out as commonly followed in the district. the temperature degrees (°C) and relative humidity (%) prevailing at Kalubia Governorate at the growing seasons of this work are presented at the following table.

Four uniform plants at each plot were randomly chosen and labelled for determining flowering characteristics expressed as time of flowering (number of days from sowing till the first flower anthesis), number of flowers per plant and fruit setting percentage.

The fruit yield and its components were calculated from all harvested fruits of each experimental plot to determine each of number of fruits and total yield per plant as well as total yield per faddan or as relative yield. Early yield was meausred from the first three pickings and then calculated either as Ton/fad. or as percentage of total yield.

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

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

RESULTS AND DISCUSSION

1- Flowering and fruit setting:

The data presented in Table (1) obviously reveal that most used seed-cold treatments enhanced flowering either as time till the first flower 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 treatment.

With regard to the effect on flowering time such 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 the 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 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 (1) 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 improving 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 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 (2) 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 anthesis or number of flowers per plants as well as fruit setting percentage in both winter seasons of 1987/1988 and 1988/1989.

Table (1) : 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

Table (2) : Effect of rate of phosphorus and potassium fertilizers on flowering and fruit setting of tomato plants.

Levels of fertilizer (Kg/Fad.) N	P_2O_5	K_2O	Flowering time (days)	No. of flower/ 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

Moreover, it is clearly evident that plants received the medium used level of fertilizers and showing better flowering behaviour and higher fruit setting percentage comming 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 came in the third rank with clear significant differences in this respect. In addition, such results show a tight relationship between plant growth, chemical constituents of plants and the balance status between plant growth and its chemical contnet from one side (as previously shown in the first part of this work) 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 (3) that seed-cold treatment at -1°C for 12 or 24 hrs combined with any one of the three used rates of fertilizers resulted in the highest values of number of flowers per plant. Meanwhile, the two seed-cold treatments of -1°C or -2°C for 12 hrs only combined with the first used rate of fertilizers or that of -2°C for 24 hrs combined with the second used rate of fertilizers showed higher percentage of fruit setting than that of the control or other used treatments. However, flowering time was 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 hrs 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°C or -3°C for 12 or 24 hrs combined with the second or the third used rate of fertilizers. Moreover, such treatments showed the earliest flowering were the second rate of fertilizers. Obtained results are in confirmity with those reported by Yasinska (1972) on tomato and Eid et al., (1988) on broad bean.

2- Fruit yield and its components:

Data illustrated in Table (4) clearly show that the most used seed-cold treatments increased number and weight of fruits per plant as well as early and total yield per

Table (3): Effect of interaction between seed-cold treatment and fertilization level on flowering and fruit setting of tomato plants.

Levels of fertilizer P_2O_5 (kg/Fad.)	K_2O (kg/Fad.)	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

Table (4): Effect of seed-cold treatment on fruit 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	-

faddan compared with control treatment during the two seasons of this work.

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

Regarding yield parmeters per plant data in Table (4) show clearly that, seeds exposed to -1°C, -2°C or -3°C for 12 hrs resulted in plants of significantly higher yielding ability than those of control or other treatments. This result is expected since the two treatments of -1°C or -2°C for 12 hrs showed the highest fruit setting percentage and to some extent, high number of flowers per plant (Table 1). Moreover, the treatment of -1°C for 12 hrs resulted in the highest yield per plant and per faddan where it increased the total yield with about 50% and 45% over the control in 1987/1988 and 1988/1989 years respectively. Such results show the tight relationship between these characters and number of fruits per plant which showed the highest values as a result of the effect of the same treatment. It is also evident that all studied yield components are of positive correlation with percentage of fruit setting (data at Table 1) which showed the highest values at the same treatments (-1°C and -2°C for 12 hrs).

The obtained results showing the highest early yield (Ton/fad.) was that of seed-cold treatments of -2°C for 12 or 24 hrs or that of -3°C at 12 hrs, this may be attributed to that such treatments resulted in the earliest flowering of plants (Table 1). 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; Belousova(1973), Stamber (1974) and Abdalla et al., (1983), 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, increased NPK uptake as well as reducing, non-reducing and total sugars percentages in plant foliage as shown in other part of this work and enhanced flowering time, number of flower per plant and fruit setting percentage (Table 1) as previously mentioned and discussed in this work.

Table (5): Effect of rate of phosphorus and potassium fertilizers on yield and its components of tomato plants.

Levels of fertilizer (Kg/Fad.) N	P_2O_5	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	-

Table (6): Effect of interaction between seed-cold treatment and fertilization level on yield and its components of tomato plants.

Levels of fertilizer (kg/Fad.)			Seed-cold treatment		Season 1987/1988						Season 1988/1989					
N	P_2O_5	K_2O	Temperature °C	Time hrs.	No. of fruits/plant	Yield/plant (kg)	Early yield Ton/Fad.	Early yield %	Total yield Ton/Fad.	Relative total yield	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	12.582	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	4.503	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	124.84
			-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	-

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 (5) that plants received the medium used level of fertilizers (99 kg N + 48 kg P_2O_5 + 48 K_2O/fad.) produced the highest values of all studied measurements in this respect, i.e., number and weight of fruits per plant, early and total yield per faddan as well as early and relative yields percentages. The medium used level of fertilizers ranked the first followed by those of the highest used one while the lowest used level was of the third rank in this respect at most cases.

These results are similar to those mentioned by Jaramillo et al., (1978), Abed & 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, increased NPK uptake, as presented at the first part of this work, as well as number of flowers per plant and fruit setting percentage (Table 2) as previously mentioned and discussed in this work.

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 (6) that second used level of fertilizers (99 kg N + 48 kg P_2O_5 + 48 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 charcteristics, i.e., number of fruits per plant (except seed-cold treatment at -3°C for 12 hours), yield per plants 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.

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تأثير معاملة بذور الطماطم بالبرودة ومعدل الأسمدة الفوسفاتية والبوتاسية على الأزهار وعقد الثمار والمحصول

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أجريت تجربتان حقليتان بمزرعة كلية الزراعة بمشتهر جامعة الزقازيق خلال الموسم الشتوى لعامى ١٩٨٨/٨٧ و ١٩٨٩/٨٨ على الطماطم صنف يو سى ٩٧ــ ٣ لدراسة تأثير تداخل فعل ثلاث مستويات مختلفة من الأسمدة الفوسفاتية والبوتاسية مع سبعة معاملات للبذور بالبرودة على الأزهار وعقد الثمار والمحصول وقد اتضح من النتائج المتحصل عليها أن تعريض البذور لدرجة حرارة ــ١ °م لمدة ١٢ ساعة مع أى من المستويات الثلاثة المستخدمة الى زيادة عدد الأزهار للنبات بينما كان لنفس درجة الحرارة مع المستوى السمادى الثانى الفضل فى الحصول على أعلى نسبة عقد للثمار • وقد أدت معظم معاملات البذور بالبرودة وخاصة معاملة ــ ٢°م أو ــ ٣° م لمدة ١٢ أو ٢٤ ساعة مع استخدام المستوى الثانى من التسميد الى الاسراع والتبكير من أزهار النباتات • كما أدى تعريض البذور لدرجات الحرارة ــ ١ °م ، ــ٢°م أو ــ٣° م لمدة ١٢ ساعة مع استخدام المستوى السمادى الثانى (٩٩ كجم ن + ٤٨ كجم فو٢أ٥ + ٤٨ كجم بو٢ أ / فدان) الى زيادة عدد ومحصول ثمار النبات الواحد وكذلك المحصول المبكر والكلى للفدان •