Growth and bulbing of garlic as influenced by low temperature and storage period treatments

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Abstract: The effects of pre-planting low temperature storage and period length of seed cloves on bulbing process of two garlic *Allium sativum* L genotypes were studied during two successive experiments (2009/2010 and 2010/2011). The whole bulb of garlic genotypes ('Egaseed 1 and Clone17) were stored at 10°C, 15°C (cold-treatments) or at room temperature (27°C) for 15, 21 and 30 days before planting. After storage, the effects of temperature and storage time on the sprouting of garlic cloves and internal sprout growth rate % under lab experiments were studied. Also, the subsequent effects of pre-plant storage treatments on germination %, growth behavior, cloving and yield were investigated at the Experimental Farm of Mallawy Agric. Res. Station, Horticulture Research. Inst., Giza, Egypt. The data revealed that, pre-plant low temperature treatments of bulbs significantly affected the behavior of "Egaseed1"(red bulb color) and "Clone17". (white bulb color) under laboratory conditions. Previously storage temperature (10°C) and period (30 days) treatment for the tested garlic, cv. "Egaseed1" and "Clone17" resulted in a significant increase in the internal sprout length (cm) and internal sprout growth rate %. For field studies, garlic "clone17" at 15˚C for 30 days gave the best significantly results for increasing the germination %. Significant differences between cultivars for its response to storage temperature and storage period treatments were found. The highest increase in fresh yield, cured yield, average bulb weight, bulb diameter (cm) and number of cloves/bulb were obtained with garlic, cv. "Egaseed1" at 15˚C for 15 days and at 10˚C for 21 days of garlic "Clone17". Whereas, the heaviest clove weight (g) were obtained when garlic bulbs of the two tested genotypes were stored at 10˚C for 30 days before planting. Results show that the important of cold pre-treatment (low temperature treatments (10-15^{0}C) and length of storage period for improving germination %, enhancing garlic yield, bulb weight, bulb diameter and clove weight. These results were dependent upon the cultivar behavior.
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Key words: garlic, storage temperature, storage period, germination%, bulb diameter, cured yield.

1. Introduction

Garlic yield depends on cultural practices and factors such as temperature (**Rahim and Fordham, 2001**); moisture (**Bhuiya *et al*., 2003**) and soil nutrients (**Kilgori *et al.,* 2007).** Clove sprouting and emergence are controlled mainly by temperature **(Takagi, 1990).** Garlic sprouting depends on air temperature and its storage period **(Vazquez-Barrios *et al.,* 2006 and Atashi *et al*., 2011).** Seed cloves treated with temperature at 5 or 10^{o}C for 15 to 30 days before planting accelerates initiation, development and maturity of bulbs relative to those of clove stored at 15 and 20^{o}C **(Rahim and Fordham, 2001).** Bulb initiation is promoted by previous exposure of cloves to low temperature **(Takagi, 1990).** Dormancy of garlic (*Allium sativum* L.) creates a problem in physiological and tissue culture experiments and treatments of cloves with different temperature levels have the potentiality to break dormancy and accelerate sprouting in garlic (**Rahman *et al.,* 2003**). Pre-treatment of garlic cloves help to improve its yield and ability to utilize light (**Ade-Ademilua *et al*., 2009**). The growth stages of *A. sativum* include clove sprouting, shoot growth, bulb growth and maturation (**Del Pozo and González, 2005**). Thus, there is need for cooler temperatures to enhance shoot growth (**Bhuiya *et al*., 2003**). Improved cloving resulted in a significant increase in both bulb diameter and bulb yield per plant (**Manjula *et al*., 2000**). **Silva** and **Casali (1987)** reported that cold storage for 30 and 40 days reduced the dormant period and increased field emergence. Several workers have reported increased growth (**Hwang, 1989**), higher number of clove per bulb **(Park and Lee 1989**) and early maturity (**Chang, *et al.,* 1986**) after low temperature storage. **(Lammerink, 1990**).obtained a decrease in bulb weight after 60 days of cold storage. **Volk and Ratindo, (2004)** showed that garlic bulbs stored at 0, 5, 15 or 23^{0}C exhibited a higher rate of shoot elongation within the cloves during storage than bulbs stored at -3^{o}C. Clove sprouting, emergence, bulb initiation and maturation are the main phenological stages in garlic and are controlled mainly by temperature **(Barrera *et al*., 1998)**. Pre-plant chilling treatments of cloves produced significant increases in cloving and bulb yield and improved cloving resulted in a significant increase in both bulb diameter and bulb yield per plant **(Bandara *et al.,* 2000** and

Manjula *et al.*, 2000). The chilling requirement for improved bulbing in garlic can be supplemented by low-temperature treatment of mother bulbs prior to planting **(Siddique and Rabbani, 1985). Siddique and Rabbani (1985)** reported that treatment of mother bulbs at 6°C for 50 days before planting increased the bulb size and yield of garlic, particularly when the crop was planted late in the season. Seedling emergence, leaf and root growth, and clove initiation have all been enhanced by low temperature treatment **(Rahim and Fordham 1988 and Del Pozo *et al.* 1997**). According to **Rahim and Fordham (1988),** cell size of cold-treated cloves was larger than in non-cold treated control cloves. Low temperatures promote the breaking of dormancy in garlic **(Takagi, 1990 and Kamenetsky *et al.*, 2004)**. **Del Pozo and Gonzalez, (2005)** revealed that percentage of bulbing increased and the number of days from emergence to bulb initiation decreased, as storage temperature decreased and duration of storage. Garlic cultivars stored at 0◦C and 25◦C for eight weeks showed no significant differences in production of allicin **(Hughes *et al.*, 2006).**

The aim of this study was to identify pre-planting temperature and storage period requirements of mother garlic bulbs for enhancing garlic growth, cloving and bulb yield of two garlic genotypes.

2. Material and Methods

Laboratory experiments:

These experiments were conducted on September, 2009 and 2010 seasons at the Lab of Mallawy Agric. Res. Station. Horticulture Res. Inst. Giza, Egypt. Garlic (*Allium sativum* L.) bulbs of cultivar Egaseed 1 (colored- bulb type) and Clone17 (white- bulb type) were used in this study.

. The bulbs of each genotype were graded into three size classes viz. large, medium and small on the basis of weight, and the biggest and medium bulbs and also free from the all defects were chosen. The cold treatments and storage period treatments of the study included: (1) 10°C for 15, 21 and 30 days), (2) 15°C for 15, 21 and 30 days), (3) room temperature (27°C) as a control treatment. These treatments were arranged and incubated at the above mentioned temperature on 1, 8 and 15 of September. At the first week of October, ten bulbs of each genotype from each treatment were taken randomly, separated out, and the biggest and medium cloves and also free from the all defects were taken and sectioned longitudinally and the sprout length (cm) and internal percentage of sprout growth rate were recorded according to the following equation: **Internal sprout growth rate** = Internal sprout length (cm) x 100 Clove length (m).

The experiment was laid out in split –split block design. with 3 replicates Also, the pre-treated bulbs from each treatment were taken to planted under field experiments.

Field experiments

The experiment was carried out at the Experimental Farm of Mallawy Agriculture Research Station, Hort. Res. Institute, Giza, Egypt during the garlic growing seasons of 2009/2010 and 2010/2011. Soil samples were collected from the fields at depth of 0-15 cm. for determining the initial nutrient status of the soil Average soil test values over the 2 years prior to planting were as follows: Texture grade, clay loam; pH, 8.0; organic matter, 1.08 %; E.C, 1.33; $CaCO_3$, 2.0 %; total N %, 0.12; total P %, 0.7; Exch. K mg/100g, 2.41.

On October, 2, 2009 and October 1, 2010, the above mentioned treatments of garlic cloves of cv.s. "egaseed 1 and clone 17" were planted at the Experimental Farm of Mallawy Agric. Res. Station. Horticulture Res. Inst. The treatments were arranged as follows:

Genotypes	Storage temperature (^oC)	Storage period (day)
Egaseed 1	10 ^oC ±0.05	15 days
		21 days
		30 days
	15^oC ±0.05	15 days
		21 days
		30 days
	Room temp. (27 ^oC) ± 0.02	000
		15 days
		21 days
Clone 17	10 ^oC ±0.05	30days
		15 days
		21days
	15^oC ±0.05	30 days
	Room temp. (27 ^oC ± 0.02)	000

The plant spacing was 10 cm on both sides of ridges, spaced 60 cm apart on row 3m long. Each experimental plot consisted of 4 rows. The 14 treatments were arranged in split split block design with three replicates. The agricultural practices for garlic production were followed as recommended by Ministry of Agriculture and garlic requirements for fertilization in accordance to the available nutrients. 2 weeks from planting time, the percentage of emergence of garlic cloves were recorded.

Garlic was harvested on 24th and 30th of April 2010 and 2011, respectively and the fresh yield (kg/plot). was calculated as ton/fed. The harvested garlic plants were left to be cured for 28 days as curing process and the following data were recorded, cured yield (ton/fed.), average bulb weight g/plant, bulb diameter, number of cloves/bulb and average clove weight/bulb.

Statistical analysis:

The means was calculated and the significances between different treatment means were determined using the L.S.D method as reported by Gomez and Gomez (1984).

3. Results and Discussion

Laboratory experiments:

Sprouting:

Data presented in Table 1 show that "Clone17" recorded the highest significant increase in the internal sprout length (2.58cm and 2.51cm) of garlic cloves during the storage period compared to cv. "Eg1". (2.36cm and 2.48cm). Also, the storage temperature and storage -period were highly significantly affected; the highest internal sprout length of garlic cloves was recorded at 10˚C in the first season and 15˚C in the second season compared to the garlic cloves which stored at room temperature. The storage period treatments of 15, 21 and 30 days from incubation on the internal sprout length were significant and with increasing the storage period, the internal sprout length was increased. The interaction effects of garlic genotypes, temperature and storage-period were significant. The interaction data showed that storage- period at 10˚C for 30 days before planting was important for enhancing internal clove sprout length (cm) in garlic (Eg1 and Clone17) tested. These results are in harmony with that reported by Contwell *et al*. (2003) who showed that storage of garlic at temperatures of 5 to 18°C had promoted the sprouting and respiration rate during storage at 5 and 10°C than that at 25°C.

Table (1): Internal sprout length (cm) of garlic cloves as affected by pre-planting storage temperature and length of storage period in the first and second seasons of 2009/2010 and 2010/2011.

Genotypes	Storage temp. (C)	Storage period (B)									
		First season			Mean	Mean A	Second season			Mean	Mean A
		15 days	21 days	30 days			15 days	21 days	30 days		
Eg1	10˚C	2.16	2.45	3.32	2.64		2.3	3.06	3.46	2.94	
	15˚C	2.32	2.53	3.28	2.71		2.44	2.6	3.35	2.8	2.48
	Room temp.	1.72	1.72	1.72	1.72	2.36	1.69	1.69	1.69	1.69	
Mean AB		2.07	2.23	2.77	2.36		2.14	2.45	2.83	2.48	
Clone17	10˚C	2.50	2.72	3.36	2.86		2.38	2.65	3.28	2.77	
	15˚C	2.43	2.61	2.69	2.58	2.58	2.41	2.48	2.55	2.48	2.51
	Room temp.	2.31	2.31	2.31	2.31		2.27	2.27	2.27	2.27	
Mean AB		2.41	2.55	2.79	2.58		2.35	2.47	2.7	2.51	
Mean BC		2.33	2.59	3.34	2.75		2.34	2.86	3.37	2.86	
		2.38	2.57	2.99	2.64		2.43	2.54	2.95	2.64	
		2.02	2.02	2.02	2.02		1.98	1.98	1.98	1.98	
Mean B		2.24	2.39	2.78	2.47	2.47	2.25	2.46	2.77	2.49	2.49
L.S.D at 0.05%	A	0.036	C	0.044			A	0.086	C	0.062	
	B	0.034	AC	0.62			B	0.054	AC	0.087	
	AB	0.049	BC	0.075			AB	0.077	BC	0.107	
	ABC	0.107					ABC	0.151			

Internal sprout growth rate (%):

Data obtained from the cloves of garlic genotypes which had been stored at room temperature, 10˚C and 15˚C for 15, 21 and 30 days is shown in Table 2 and Fig 1. Garlic clone17 gave the highest significant increase in the internal sprout growth rate (100.55% and 98.28%) compared to Eg1 (69.77% and 74.93%) in the first and second season respectively. Significant effects of the storage temperature on the internal sprout growth rate at 15˚C (92.15% and 91.53 %) compared to at room temperature (70.04% and 77.47%) in the first and second season, respectively. Data regarding the interaction effect of garlic cultivars, storage temperature and storage period showed that storage temperature of garlic "clone17" at 10˚C for 30 days was the best treatments for enhancing the percentage of internal sprout growth rate of the treated cloves under laboratory experiments. Vazquez-Barrios *et al*., (2006) reported that in storage time, sucrose and starch are consumed at a high content and a part of non-consumed carbohydrates causes glucose accumulation of garlic tissue and enhancing sprouting. However, measurement of garlic glucose content can be used as an index for physiological stage of garlic sprouting. As glucose increment means sprouting initiation of garlic, each investigation on physiological changes during storage time till sprouting can be of high importance. (Vazquez-Barrios *et al*., 2006).

Germination %:

Data on the emergence percentage of plantlets were recorded at 15 days after planting of the clove treatments. In the two seasons, the treated cloves of the tested garlic genotypes emerged earlier than untreated. Garlic "Clone17" gave the highest and significant increase in germination % than cultivar "Eg1" (Table 3 and Fig 1). Significant variation on the emergence percentage was observed between treated bulbs and the control treatment (room temp.). The highest percentage of emergence was found in bulbs stored at 15^{o}C for 30 days. The interaction effects of garlic cultivars x storage temperature x storage period showed that storage temperature of garlic "clone17" at 15˚C for 30 days was the best treatment for increasing the germination % of the garlic plants under field experiments after 15 days from planting in both seasons compared to the storage at room temperature.

After emergence, the number of leaves and plant height were recorded at 30 days after planting, the data revealed that pre-planting temperature and storage period treatments significantly influence number of leaves per plantlet and plant height (cm) (Fig2) (data not shown). Garlic sprouting at low temperature is attributed to a complex of biochemical reactions which is carried out by interposition of different enzymes (Vazquez-Barrios *et al*., 2006). Rahman *et al*. (2003) found that temperature below 10 can Also be effectively used in breaking dormancy. also, Silva and Casali (1987) reported that cold storage for 30 and 40 days, reduced the dormant period and increased field emergence.

Average bulb weight (g):

Low storage temperature and length of storage period had a significant influence on average bulb weight (g) of the garlic genotypes in both years (Tables 4), cv. "Egaseed1 recorded the highest significant increase in bulb weight (89.69g and 89.95g) compared to "Clone17" (64.69 and 71.90g). Regarding to the main effects of temperature and storage period in the two seasons, storage temperature at 15^{o}C for 15 days before planting gave the best and significant increase in bulb weight (g)/plant compared to storage at room temperature. Concerning to the interaction of garlic genotypes x storage temperature x storage period, the data showed a significant effects. The responsiveness in average bulb weight g/plant was differed between the two genotypes. The highly significant increase in average bulb weight (g) was recorded with cv."Eg1" at 15˚C for 15 days in the two seasons. While, in "Clone17", the best values was recorded at 10˚C for 21 days in the first season and at 15˚C for 21 days in the second one. According to Rahim and Fordham (1988), cell size of cold-treated cloves was larger than in non-cold treated control cloves. Bulb initiation is promoted by previous exposure of cloves to low temperature (Takagi, 1990).

Clone17

Eg1

Control **15 days** **21 days** **30 days**

Fig. 1: In lab., internal sprouting of garlic cloves cv, Egaseed 1 (Eg1) and Clone17 as affected by storage period (15 days, 21 days and 30 days) at 10°C, 15°C and at room temperature (control treatment)

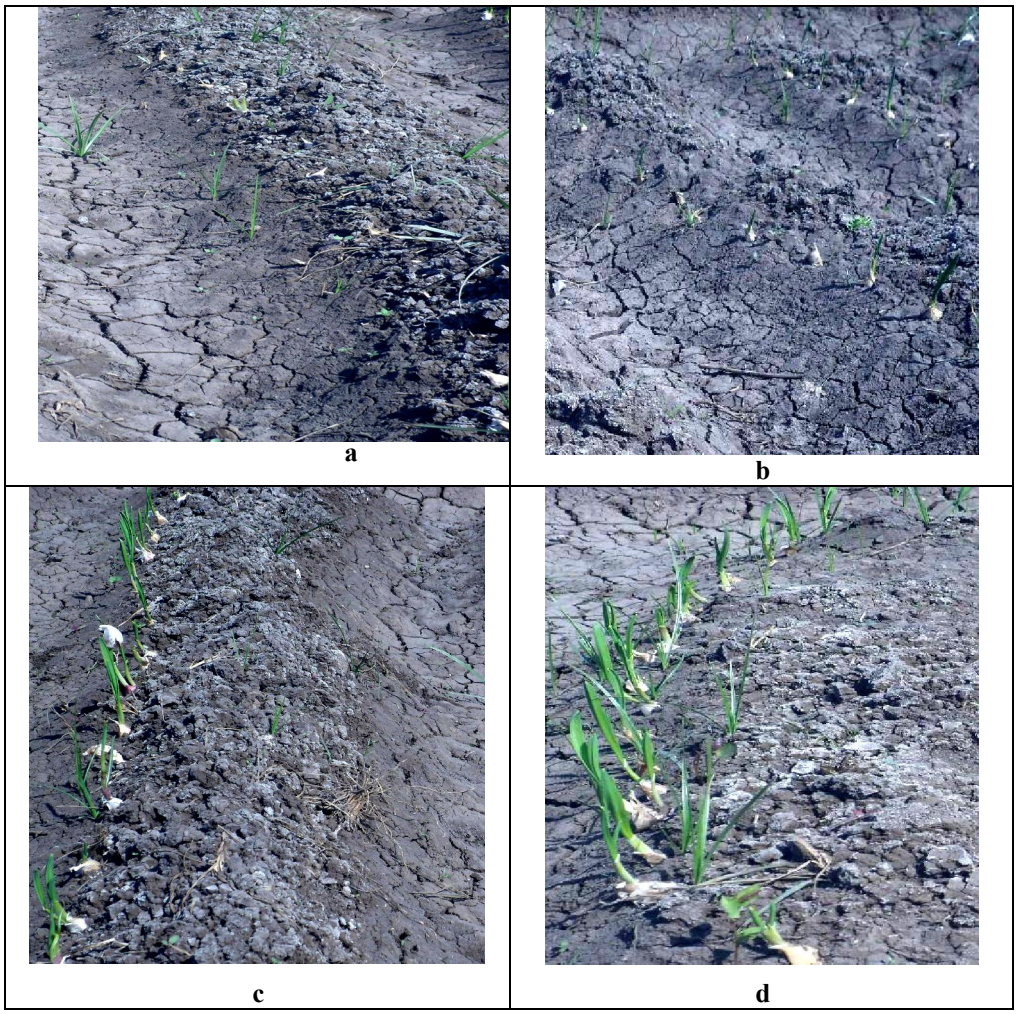

Fig 2 :In field, germination % and plant height of garlic cloves cv, Egaseed 1 as affected by storage period (at room temperature (control treatment (a), 15 days (b), 21 days (c) and 30 days (d)) at 10°C.

Table (2): Internal sprouting % of garlic cloves as affected by pre-planting storage temperature and length of storage period in the first and second seasons of 2009/2010 and 2010/2011

Genotypes	Storage temp. (C)	Storage period (B)									
		First season				Mean A	Second season			Mean	Mean A
		15 days	21 days	30 days	Mean		15 days	21 days	30 days		
Eg1	10˚C	64.66	69.27	99.10	77.68	69.77	70.540	73.50	98.85	80.960	74.92
	15˚C	66.66	78.57	97.94	81.06		71.000	80.60	95.40	82.330	
	Room temp.	50.59	50.59	50.59	50.59		61.450	61.45	61.45	61.450	
Mean AB		60.64	66.14	82.54	69.77		67.66	71.85	85.23	74.920	
Clone17	10˚C	98.03	100.00	128.73	108.92	100.55	96.50	98.30	107.1	100.64	98.28
	15˚C	96.77	105.82	107.13	103.24		95.03	103.0	104.1	100.72	
	Room temp.	89.50	89.50	89.50	89.50		93.500	93.50	93.50	93.500	
Mean AB		94.76	98.44	108.45	100.55		95.010	98.28	101.8	98.280	
Mean BC		81.35	84.64	113.92	93.30		83.520	85.90	102.9	90.800	
		81.72	92.20	102.54	92.15		83.02	91.82	99.75	91.530	
		70.04	70.04	70.04	70.04		77.47	77.47	77.47	**77.47**	
Mean B		77.70	82.29	95.50	85.16	85.16	81.34	85.06	93.40	86.60	86.60
L.S.D at 0.05%	A	2.706	C	0.748			A	2.295	C	0.831	
	B	0.676	AC	1.058			B	0.604	AC	1.176	
	AB	0.960	BC	1.296			AB	0.855	BC	1.440	
	ABC	1.833					ABC	2.036			

Table (3): Germination % of garlic cloves after 15 days from planting as affected by pre-planting storage temperature and length of storage period in the first and second seasons of 2009/2010 and 2010/2011

Genotypes	Storage temp. (C)	Storage period (B)									
		First season			Mean	Mean A	Second season			Mean	Mean A
		15 days	21 days	30 days			15 days	21 days	30 days		
Eg1	10˚C	9.44	30.53	67.22	35.73	25.60	11.000	41.400	62.460	38.290	29.18
	15˚C	11.66	36.33	67.20	38.40		20.320	39.800	70.120	43.410	
	Room temp.	2.67	2.67	2.67	2.67		5.830	5.830	5.830	5.830	
Mean AB		7.92	23.18	45.70	25.60		12.380	29.010	46.140	29.180	
Clone17	10˚C	91.67	76.67	87.33	85.22	68.88	90.300	91.400	92.300	91.330	71.26
	15˚C	88.33	87.70	97.32	91.12		93.000	93.470	98.400	94.960	
	Room temp.	30.30	30.30	30.30	30.30		27.500	27.500	27.500	27.500	
Mean AB		70.10	64.89	71.65	68.88		70.270	70.790	72.730	71.260	
Mean BC		50.56	53.60	77.28	60.48		50.650	66.400	77.380	64.810	
		50.00	62.02	82.26	64.76		56.660	66.630	84.260	69.180	
		16.48	16.48	16.48	16.48		16.670	16.670	16.670	16.670	
Mean B		39.01	44.03	58.67	47.24	47.24	41.330	49.900	59.440	50.220	50.22
L.S.D at 0.05%	A	0.532	C	1.096			A	0.235	C	0.604	
	B	1.311	AC	1.550			B	0.604	AC	0.854	
	AB	1.855	BC	1.899			AB	0.854	BC	1.046	
	ABC	2.685					ABC	1.479			

Table (4): Average bulb weight (g) of garlic plants as affected by pre-planting storage temperature and length of storage period in the first and second seasons of 2009/2010 and 2010/2011

CV.s (A)	Storage temp. (C)	Storage period (B)									
		First season			Mean	Mean A	Second season			Mean	Mean A
		15 days	21 days	30 days			15 days	21 days	30 days		
Eg1	10˚C	96.30	88.53	92.90	92.58	89.69	98.10	85.83	86.57	90.17	89.95
	15˚C	110.20	98.77	97.13	102.03		116.17	93.90	92.00	100.69	
	Room temp.	74.47	74.47	74.47	74.47		79.00	79.00	79.00	79.00	
Mean AB		93.66	87.26	88.17	89.69		97.76	86.24	85.86	89.95	
Clone17	10˚C	70.87	73.77	73.30	72.64	64.69	65.13	85.00	71.70	73.94	71.90
	15˚C	65.83	78.33	75.30	73.16		80.00	90.00	87.00	85.67	
	Room temp.	48.27	48.27	48.27	48.27		56.10	56.10	56.10	56.10	
Mean AB		61.66	66.79	65.62	64.69		67.08	77.03	71.60	71.90	
Mean BC		83.58	81.15	83.10	82.61		81.62	85.42	79.13	82.06	
		88.02	88.55	86.22	87.59		98.08	91.95	89.50	93.18	
		61.37	61.37	61.37	61.37		67.55	67.55	67.55	67.55	
Mean B		77.66	77.02	76.89	77.19	77.19	82.42	81.64	78.73	80.93	80.93
L.S.D at 0.05%	A	1.466	C	0.934			A	7.345	C	0.819	
	B	0.759	AC	1.320			B	0.550	AC	1.158	
	AB	1.073	BC	1.617			AB	0.778	BC	1.418	
	ABC	2.287					ABC	2.006			

Fresh yield (ton/fed.):

Data obtained of the fresh yield (ton/fed.) of garlic which had been stored at room temperature, 10 ^{o}C and 15 ^{o}C for 15, 21 and 30 days is shown in Table 5. In both seasons, garlic cv. "Eg1" and clone17 were affected significantly by storage temperature and length of storage period treatments. The highest significant increase in fresh yield (ton/fed.) was recorded with cv. "Eg1" (11.66 and 11.24 ton/fed.) in the first and second seasons respectively,. The best storage pre-planting temperature and storage period treatments for increasing garlic fresh yield as ton/fed. was found at 15˚C for 15 days in both seasons. The interaction effects of A x B x C showed that pre-planting storage temperature (15˚C) for 15 days before planting of garlic cv. "Eg1" gave the highest significant increase in fresh yield (13.58 and 12.82 ton/fed.) in the first and the second season respectively. While, clone17 gave a significant increase in fresh yield. When its garlic bulbs were stored at 10˚C for 21 days before planting. These results are in agreement with those reported by Sati and Lopez, (1994) who showed that bulb yield showed progressive decrease with the increase in storage temperature.

Table 5: Fresh yield (ton/fed.) of garlic plants as affected by pre-planting storage temperature and length of storage period in the first and second seasons of 2009/2010 and 2010/2011

CV.s (A)	Storage temp. (C)	Storage period (B)									
		First season			Mean	Mean A	Second season			Mean	Mean A
		15 days	21 days	30 days			15 days	21 days	30 days		
Eg1	10˚C	12.47	10.85	10.61	11.31	11.66	12.56	10.66	9.93	11.05	11.24
	15˚C	13.58	11.79	11.06	12.14		12.82	11.39	11.15	11.78	
	Room temp.	11.53	11.53	11.53	11.53		10.89	10.89	10.89	10.89	
Mean AB		12.53	11.39	11.07	11.66		12.09	10.98	10.66	11.24	
Clone17	10˚C	8.46	8.92	7.68	8.35	7.71	7.97	**9.64**	8.10	8.57	8.28
	15˚C	7.67	8.52	7.92	8.04		8.38	8.97	8.55	8.63	
	Room temp.	6.75	6.75	6.75	6.75		7.63	7.63	7.63	7.63	
Mean AB		7.63	8.07	7.45	7.71		7.99	8.75	8.09	8.28	
Mean BC		10.46	9.89	9.14	9.83		10.27	10.15	9.02	**9.81**	
		10.62	10.16	9.49	10.09		10.60	10.18	9.85	**10.21**	
		9.14	9.14	9.14	9.14		9.26	9.26	9.26	9.26	
Mean B		10.08	9.73	9.26	9.69	9.69	10.04	9.86	9.38	9.76	9.76
L.S.D at 0.05%	A	1.187	C	0.217			A	0.695	C	0.203	
	B	0.335	AC	0.306			B	0.200	AC	0.287	
	AB	0.474	BC	0.375			AB	0.284	BC	0.352	
	ABC	0.530					ABC	0.497			

Cured yield (ton/fed.):

Data presented in Table 6 show that cured yield (ton/fed.) was significantly affected by pre-planting garlic genotypes, storage temperature and storage period treatments. The highly significant increase in cured yield (ton/fed.) was recorded with cv Eg1 in both seasons (7.19 and 6.95 ton/fed.). The lowest storage temperature (10˚C) had the highest significant increase in cured yield in both seasons. The best storage period length before planting for increasing cured yield was recorded at 21 days before planting. Regarding the interaction effects among genotypes and storage temperature and storage period treatments, there were a highly significant effect. Garlic genotypes were differed significantly for the response to storage temperature and storage period. Garlic cv.. Eg1 at 15˚C for 15 days and Clone17 at 10˚C for 21 days gave the best cured yield as ton/fed. in the two seasons. The highest yield in the Eg1 cultivar, 13 tons/fed. was associated with its higher bulb weight, and its positive response to low temperature before planting. These results are in the agreement with those reported by Sati and Lopez (1994).

Bulb diameter (cm):

Results in Table 7 indicate that the mean values of bulb diameter (cm) were high for all studied treatments and differed significantly from the control treatment. In the two seasons garlic cv. "Eg1" recorded the highest values for bulb diameter (cm) compared to "Clone17" with insignificant differences between them. Also, the storage temperature treatments (15˚C) in the first season and (10˚C) in the second season gave the best values compared to the room temperature. Regarding to various storage period and storage temperature treatments, data revealed not significant response. The interaction effects of A x B x C, data show that pre-planting storage period for 15 days at 15˚C for garlic cv. "Eg1" and 21 days at 10˚C for garlic "Clone17" recorded the highest significant increase in bulb diameter (cm). Park and Lee (1989) reported that low temperature stimulated clove differentiation which resulted in the development of larger bulbs than at the warmer storage temperature. This possibility due to higher auxin and gibberellin content at low temperature. According to Rahim and Fordham (1988), cell size of cold-treated cloves was larger than in non-cold treated control cloves.

Number of cloves/bulb:

Results in Table 8 showed that number of cloves/bulb of garlic were 15.2 for cv."Eg1" and 27.4 for "Clone17". Both storage temperature and duration had a great effect on umber of cloves/bulb. The number of cloves/bulb was decreased as the storage temperature decreased. But, with increasing the pre-planting storage time, it was observed that the number of cloves/bulb was decreased. Regarding to the interaction effect of A x B x C, data obviously that garlic cv. "Eg1" at 15^{o}C for 30 days recorded the least number of cloves/bulb (12.2 and 13.00 cloves/bulb). While, the recorded data of garlic "Clone17" was differed in the two seasons. The best treatment for decreasing the number of cloves/bulb was at 15^{o}C for 21 days in the first season and 30 days in the second season. Rahim and Fordham (1994) reported that pre-plant treatment with a growth retardant such as cycocel or paclobutrazol accelerated initiation, development and maturity of garlic bulbs and reduced the number of cloves per bulb, whereas gibberellic acid produced the opposite impact on crop growth and cloving. They concluded that a growth retardant could be used to substitute for the cold treatment in garlic.

Average clove weight (g):

The results in Table 9 show that there were a significant differences in clove weight in the tested garlic genotypes. Garlic cloves of "Eg1" were the heaviest (4.78g and 4.74g), compared to the cloves of garlic"Clone17" (1.79g and 1.8g) in both growing seasons. The effect of temperature treatments and storage time were significantly affected. Data recorded that with decreasing the temperature treatments (10˚C) and increasing storage period was to 30 days, clove weight was increased significantly. The effect of interaction among garlic cultivars, storage temperatures and storage period on clove weight were significant. The highest and significant values were obtained by bulbs incubated at 15˚C and 10˚C for 30 days before planting of garlic cv. "Eg1" and for 21 days of garlic "Clone17" respectively. According to Rahim and Fordham (1988), cell size of cold-treated cloves was larger than in non-cold treated control cloves, and they suggested that gibberellin production may have been increased by the chilling treatment, proving a possible explanation for cell expansion. Rahim and Fordham (1994) reported that pre-plant treatment reduced number of cloves per bulb.

Table (6): Cured yield (ton/fed.) of garlic plants as affected by pre-planting storage temperature and length of storage period in the first and second seasons of 2009/2010 and 2010/2011

Genotypes	Storage temp. (C)	Storage period (B)									
		First season			Mean	Mean A	Second season			Mean	Mean A
		15 days	21 days	30 days			15 days	21 days	30 days		
Eg1	10˚C	7.62	7.64	7.54	7.60		7.64	7.41	7.06	7.37	
	15˚C	8.22	7.65	6.85	7.57	7.19	7.63	7.12	6.85	7.20	6.95
	Room temp.	6.41	6.41	6.41	6.41		6.28	6.28	6.28	6.28	
Mean AB		7.42	7.23	6.93	7.19		7.18	6.94	6.73	6.95	
Clone17	10˚C	5.62	6.37	5.92	5.97		5.26	6.69	6.16	6.03	
	15˚C	5.21	5.83	5.73	5.59	5.18	5.41	6.22	6.20	5.94	5.61
	Room temp.	3.99	3.99	3.99	3.99		4.84	4.84	4.84	4.84	
Mean AB		4.94	5.40	5.21	5.18		5.17	5.92	5.73	5.61	
Mean BC		6.62	7.01	6.73	6.78		6.45	7.05	6.61	6.70	
		6.71	6.74	6.29	6.58		6.52	6.67	6.53	6.57	
		5.20	5.20	5.20	5.20		5.56	5.56	5.56	5.56	
Mean B		6.18	6.32	6.07	6.19	6.19	6.18	6.43	6.23	6.28	6.28
L.S.D at 0.05%	A	0.295	C	0.139			A	0.281	C	0.069	
	B	0.159	AC	0.197			B	0.084	AC	0.097	
	AB	0.225	BC	0.241			AB	0.119	BC	0.119	
	ABC	0.341					ABC	0.169			

Table (7): Bulb diameter (cm) of garlic bulbs as affected by pre-planting storage temperature and length of storage period in the first and second seasons of 2009/2010 and 2010/2011

Genotypes	Storage temp. (C)	Storage period (B)									
		First season			Mean	Mean A	Second season			Mean	Mean A
		15 days	21 days	30 days			15 days	21 days	30 days		
Eg1	10˚C	7.05	6.55	6.25	6.62		7.23	6.60	6.65	6.83	
	15˚C	7.10	6.60	6.44	6.71	6.48	7.26	6.92	6.35	6.84	6.61
	Room temp.	6.12	6.12	6.12	6.12		6.17	6.17	6.17	6.17	
Mean AB		6.76	6.42	6.27	6.48		6.89	6.56	6.39	6.61	
Clone17	10˚C	6.49	6.65	6.50	6.54		6.53	6.77	6.62	6.64	
	15˚C	6.27	6.56	6.66	6.50	6.26	6.22	6.57	6.37	6.39	6.27
	Room temp.	5.74	5.74	5.74	5.74		5.78	5.78	5.78	5.78	
Mean AB		6.17	6.32	6.30	6.26		6.18	6.37	6.26	6.27	
Mean BC		6.77	6.60	6.37	6.58		6.88	6.69	6.64	6.73	
		6.69	6.58	6.55	6.61		6.74	6.75	6.36	6.62	
		5.93	5.93	5.93	5.93		5.98	5.98	5.98	5.98	
Mean B		6.46	6.37	6.29	6.37	6.37	6.53	6.47	6.32	6.44	6.44
L.S.D at 0.05%	A	0.289	C	0.146			A	1.054	C	0.255	
	B	0.237	AC	0.206			B	0.154	AC	0.360	
	AB	0.335	BC	0.253			AB	0.217	BC	0.441	
	ABC	0.358					ABC	0.624			

Table (8): Number of cloves/bulb of garlic as affected by pre-planting storage temperature and length of storage period in the first and second seasons of 2009/2010 and 2010/2011

CV.s (A)	Storage temp. (C)	Storage period (B)									
		First season			Mean	Mean A	Second season			Mean	Mean A
		15 days	21 days	30 days			15 days	21 days	30 days		
Eg1	10˚C	16.63	13.90	12.60	14.38	15.20	16.23	13.80	12.80	14.28	14.96
	15˚C	16.73	16.40	12.20	15.11		16.80	15.80	13.00	15.20	
	Room temp.	16.10	16.10	16.10	16.10		15.40	15.40	15.40	15.40	
Mean AB		16.49	15.47	13.63	15.20		16.14	15.00	13.73	14.96	
Clone17	10˚C	28.30	26.77	27.50	27.52	27.40	26.00	25.70	25.27	25.66	25.90
	15˚C	27.10	26.10	26.83	26.68		25.00	24.30	23.10	24.13	
	Room temp.	28.00	28.00	28.00	28.00		27.90	27.90	27.90	27.90	
Mean AB		27.80	26.96	27.44	27.40		26.30	25.97	25.42	25.90	
Mean BC		22.47	20.33	20.05	20.95		21.12	19.75	19.03	19.97	
		21.92	21.25	19.52	20.89		20.90	20.05	18.05	19.67	
		22.05	22.05	22.05	22.05		21.65	21.65	21.65	21.65	
Mean B		22.14	21.21	20.54	21.30	21.30	21.22	20.48	19.58	20.43	20.43
L.S.D at 0.05%	A	1.946	C	0.521			A	1.278	C	0.356	
	B	0.478	AC	0.737			B	0.336	AC	0.503	
	AB	0.675	BC	0.903			AB	0.475	BC	0.616	
	ABC	1.277					ABC	0.871			

Table (9): Average clove weight/bulb (g) of garlic as affected by pre-planting storage temperature and length of storage period in the first and second season of 2009/2010 and 2010/2011

CV.s (A)	Storage temp. (C)	Storage period (B)									
		First season			Mean	Mean A	Second season			Mean	Mean A
		15 days	21 days	30 days			15 days	21 days	30 days		
Eg1	10˚C	4.68	5.48	5.86	5.34	4.78	4.62	5.65	5.80	5.36	4.74
	15˚C	4.79	4.73	5.82	5.11		4.84	4.69	5.80	5.11	
	Room temp.	3.89	3.89	3.89	3.89		3.74	3.74	3.74	3.74	
Mean AB		4.45	4.70	5.19	4.78		4.40	4.69	5.11	4.74	
Clone17	10˚C	1.91	2.02	2.12	2.02	1.79	1.87	2.35	1.87	2.03	1.80
	15˚C	1.71	**2.18**	2.15	2.01		1.77	2.11	1.89	1.92	
	Room temp.	1.35	1.35	1.35	1.35		1.46	1.46	1.46	1.46	
Mean AB		1.66	1.85	1.87	1.79		1.70	1.97	1.74	1.80	
Mean BC		3.30	3.75	3.99	3.68		3.25	4.00	3.84	3.69	
		3.25	3.46	3.99	3.56		3.31	3.40	3.85	3.52	
		2.62	2.62	2.62	2.62		2.60	2.60	2.60	2.60	
Mean B		3.05	3.28	3.53	3.29	3.29	3.05	3.33	3.43	3.27	3.27
L.S.D at 0.05%	A	0.699	C	0.151			A	0.139	C	0.092	
	B	0.146	AC	0.213			B	0.077	AC	0.131	
	AB	0.206	BC	0.261			AB	0.109	BC	0.160	
	ABC	0.369					ABC	0.227			

Conclusion:

Pre-plant low storage temperature treatments response of new garlic genotypes for storage length time were differed. The great response for increasing germination %, fresh and cured yield, bulb diameter were found with "Egaseed1" at 15^{o}C for 15 days and 10^{o}C for 21 days length of storage period for "Clone17". While, the clove weight of the two garlic genotypes were high at 10^{o}C for 30 days of storage period.

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