

## EFFECTS OF STORAGE TEMPERATURE ON GROWTH AND BULB FORMATION IN FOUR GARLIC (*ALLIUM SATIVUM* L.) CULTIVARS

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### Abstract

Studies on the effect of storage temperature of 0, 7 and 25°C before planting were conducted on four garlic cultivars with respect to their leaf initiation, clove differentiation, development and yield under field conditions during 1990/91 season. All cultivars, except Omani, showed less leaf initiation at 25°C than at either 0 or 7°C. In contrast, Omani garlic produced more leaves at 25°C than at lower storage temperatures. A varied cultivar response to temperature was noticeable in leaf development over a 15 weeks period from planting. Bulb diameter was greater at low temperatures. Clove differentiation was higher in Omani cultivar and least in Indian cultivar. Single clove bulbing was found to increase with temperature, reaching 80% at 25°C. Bulb weight and number of days to reach maturity were both favoured by low storage temperature. Bulb yield showed progressive decrease with the increase in storage temperature. However, all cultivars, except Indian, attained a 3 fold increase in bulb yield at 0°C than at 25°C.

### Introduction

Garlic, *Allium sativum*, is a popular bulb crop in the high altitudes of the Jebel Akhdar Region of Oman. The growth and bulbing of local varieties, known as Omani, is favoured by the cool weather and light sandy soils. The cloves used for planting are exposed to a warm temperature in traditional storage. The shelf life of Omani garlic is relatively short due to the decay and deterioration that results from high humidity and the thicker outer scales of local bulbs. Screening for longer storage and early maturity seem to be an important objective for those involved in the production of garlic in Oman.

The effect of storage temperature on the initiation and development of garlic cloves in a local cultivar from Bangladesh showed that clove primordia were initiated 21 and 35 days after planting, and differentiation and development was completed respectively in 87 and 117 days in cold-treated and control plants (Rahim & Fordham, 1988). Silva & 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 free sugar and sucrose (Park, 1989), higher number of cloves per bulb (Park & Lee, 1989), and early maturity (Chang, 1986) after low temperature storage. Lammerink (1990) obtained a decrease in bulb weight, yield and a generally low quality bulb after 60 days of cold storage. The objective of the present study was to investigate the effects of pre-plant storage temperature on initiation, growth, bulbing and maturity of four garlic cultivars.

### Materials and Methods

The experiment was conducted at the Agricultural College farm, Sultan Qaboos University during 1990-1991 season. Four garlic cvs., viz., Omani, Iranian, Indian, and

**Table 1. Number of leaves initiated per clove in relation to storage temperature.**

Cultivar	Storage Temperature (°C)			Mean
	0	7	25	
Omani	11.77	11.93	15.60	13.10 b
Iranian	30.75	19.98	17.40	22.71 a
Indian	22.07	20.83	20.35	21.08 a
Chinese	24.13	23.67	22.13	23.31 a
Mean	22.18 a	19.10 a	18.87 a	---

\*\* Mean within column and row, having the same letter are not significantly different from each other at 5% level (LSD).

Chinese were stored at 0, 7 and 25°C for 30 days. The cloves were planted in 0.5 m<sup>2</sup> plots on 5 November, 1990, in double rows spaced 10 cm apart on raised beds. A randomized complete block design with four replication was used. Data on number of foliage leaves per clove, number of sprouting cloves, leaf weight, number of cloves per bulb, bulb diameter and bulb weight were recorded.

At the emergence of sprouts a count was made of the number of cloves with sprouts above soil level and percentages were computed in relation to the total number of cloves planted in any one treatment. Leaf dry weight was obtained after oven drying samples at 70°C for 72 h. Bulbs were harvested when 80 percent of plant leaves collapsed and became light yellow. Harvested bulbs were wind dried, trimmed of roots, and weighed. Data was analyzed using the analysis of variance procedure and the Least Significant Difference (L.S.D) was used for testing variations among garlic types and storage temperature effects on the measured characteristics.

**Table 2. Leaf development and final stand.**

Cultivar	Storage Temperature (°C)	Number of leaves Weeks after planting			
		3	7	11	15
Omani	0	4.47	10.38	11.77	11.77
	7	4.93	10.63	11.93	11.93
	25	4.67	09.20	13.07	13.60
Iranian	0	4.13	10.62	19.67	30.75
	7	4.87	11.40	15.47	20.13
	25	4.47	9.27	12.80	17.40
Indian	0	5.07	11.13	15.93	22.07
	7	4.93	10.00	15.68	20.83
	25	5.80	10.93	14.93	20.35
Chinese	0	5.87	13.07	18.20	24.13
	7	5.80	12.07	18.13	23.67
	25	6.33	12.00	16.87	22.13

**Table 3. Bulb diameter (cm) in response to storage temperature.**

Cultivar	Storage Temperature ( $^{\circ}\text{C}$ )			Mean
	0	7	25	
Omani	4.17	4.22	2.47	3.62 a
Iranian	4.24	3.33	2.21	3.26 ab
Indian	2.92	2.59	1.84	2.45 c
Chinese	3.56	3.36	2.52	3.15 b
Mean	3.72 a	3.38 a	2.26 b	---

\*\* Mean within column and row, having the same letter are not significantly different from each other at 5% level (LSD).

### Results and Discussion

There was no significant effect of preplant storage temperature on initiation of leaves in all garlic cultivars tested, however, the Omani cultivar had the lowest number of leaves initiated at 0, 7 and  $25^{\circ}\text{C}$  storage temperature (Table 1). Low temperature for 30-40 days before planting was found to reduce the dormant period and increase field emergence (Silva & Casali, 1987) rather than influencing the total number of leaves developed. All cultivars, except Omani, showed decreased leaf initiation at  $25^{\circ}\text{C}$  compared to that at either 0 or  $7^{\circ}\text{C}$ . In contrast, Omani garlic produced 30% more leaves at  $25^{\circ}\text{C}$  than at lower storage temperatures.

The four cultivars of garlic tested in this study showed varied response to temperature in leaf formation over a period of 15 weeks from planting (Table 2). Local Omani garlic initiated an equal number of leaves at all temperatures at 3 weeks from planting. At 7 weeks, the number of leaves tended to increase more rapidly at

**Table 4. Clove differentiation in garlic cultivars in response to storage temperature.**

Storage Temperature ( $^{\circ}\text{C}$ )	Number of Bulbs per $\text{M}^2$			Percent Clove Formation	Mean Bulb Weight (gm)
	With Multiple Cloves	With Single Clove	Total		
0	53.00 a	07.16 b	60.16 a	75.83 a	23.54 a
7	62.84 a	10.00 b	72.84 a	73.68 a	18.30 a
25	08.00 b	32.16 a	40.16 b	21.98 b	12.08 b
<b>Cultivars</b>					
Omani	53.34 a	01.76 c	55.12 a	96.77 a	11.21 b
Iranian	44.12 a	13.56 bc	58.00 a	76.24 b	12.42 b
Indian	21.78 b	35.78 a	57.56 a	37.84 c	15.75 b
Chinese	45.56 a	14.66 b	60.22 a	75.66 b	34.33 a

\*\* Means within a column, having the same letter are not significantly different from each other at 5% level (LSD).

**Table 5. Number of days from planting to bulb maturity.**

Cultivar	Temperature (°C)			Mean
	0	7	25	
Omani	131	131	180	147
Iranian	141	141	180	154
Indian	180	180	180	180
Chinese	180	180	180	180
Mean	158	158	180	---

cooler temperatures (0 and 7°C) than at 25°C. Later, the growth of leaves was much greater, during the 11-15 weeks after planting at 25°C, whereas at cooler temperature no further increase was noticeable. The Iranian cultivar showed a higher increase in leaf initiation at 0°C (644%) than at 7°C and 25°C where the increase was 313% and 289%, respectively. Leaf initiation and final stand, in the Indian and Chinese cultivars, showed very small variation dependent on storage temperature. This reflects the adaptability of these cultivars to a wide range of temperatures.

Growth in bulb diameter in all garlic cultivars was significantly higher when bulbs were stored at 0°C than at 25°C (Table 3). Omani garlic produced larger bulbs than the other cultivars in all storage temperature.

The percentage of bulbs differentiating out with cloves was highest in the Omani cultivar (96%) followed by those of Iranian (78%), Chinese cultivar (75%) and the least by the Indian cultivar (37%) (Table 4). The Indian cultivar had the highest number of bulbs with single clove bulbing. Hwang & Park (1989) reported that at high soil temperature of 20°C in contrast to 5°C, single clove bulbing, secondary growth and lack of bulbing were prevalent. Single clove bulbing was minimal in Omani garlic, possibly due to earlier clove differentiation and bulb maturity when the prevailing temperature was low. The mean bulb weight was significantly higher in the Chinese cultivar than in other cultivars. The incidence of single clove bulbing increase with temperature, reaching almost 80% at 25°C (Table 4). Multiple clove formation and

**Table 6. Total bulb yield (tons/ha).**

Cultivar	Storage Temperature (°C)			Mean
	0	7	25	
Omani	08.09	07.12	3.31	06.17 b
Iranian	09.93	08.59	3.10	07.21 b
Indian	10.91	11.54	4.75	09.06 b
Chinese	27.69	26.06	8.26	20.67 a
Mean	14.16 a	13.33 a	4.86 b	

Mean within column and row, having the same letter are not significantly different from each other at 5% level (LSD).

mean bulb weight were significantly higher at 0 and 7°C than at 25°C. Low temperature stimulated clove differentiation which resulted in the development of larger bulbs than at the warmer storage temperatures. This was possibly due to a higher auxin and gibberellin content at low temperature (Park & Lee, 1989).

Earliness in bulb maturity and harvesting was favoured by low storage temperature in Omani and Iranian cultivars, both reaching maturity after 131 and 141 days, respectively (Table 5). The Indian and Chinese cultivars took 180 days to reach maturity and were not sensitive to temperature. Rahim & Fordham (1988) reported that cold treated garlics, 5°C in contrast to 20°C, differentiated and completed development 30 days earlier in a local tropical cultivar from Bangladesh.

Bulb yield obtained at 0°C storage temperature was significantly higher than at 25°C in all cultivars (Table 6). However, all cultivars except the Indian, attained a 3 fold increase in garlic yield when stored at 0°C over that at 25°C. The highest yield in the Chinese cultivar, 20 tons/ha was evidently shown because of its higher bulb weight, multiple clove differentiation and response to low temperature storage before planting.

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