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EFFECT OF SOME AGRICULTURAL AND STORAGE PRACTICES ON GARLIC BULBS ROT DISEASES

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ABSTRACT: Black, green and basal rot diseases were the most dominant diseases on garlic bulb during storage. These diseases caused by *Aspergillus niger, A. flavus, Penicillium* spp. and *Fusarium oxysporum* that proved to be the most frequent fungi. These fungi were found to be responsible for causing deleterious influence on the stored garlic bulbs either on Balady or Chinese cultivars.

Harvesting garlic bulbs after 190 days from planting resulted in a great reduction in bulb rot incidence than that harvested after 150 days. Storing at temperature ranging between 20 – 30 ˚C resulted in the highest values of infection. Percentage of infection and bulbs rot increased with increasing storage period.

Also, the deleterious effect of rot disease increased as number of irrigation of the crop was increased. Increasing level of nitrogen fertilizer increased the garlic bulb rot disease incidence. However, the disease decreased with the raise of potassium and phosphorus rates in the tested growing seasons (1999/ 2000 and 2000/ 2001). Vitavax-Thiram was the most effective fungicide against infection during storage when applied in the field.

Drying storage bulbs without neck topping for two weeks was more beneficial in reducing infection. Packing garlic bulbs before storing in perforated paper bag and/ or carton boxes resulted in the least bulb damage in comparison with the other packing materials

Key words: Garlic, Bulb, rot disease, *Aspergillus niger, Aspergillus flavus, Penicillium* sp. and *Fusarium oxysporum.*

INTRODUCTION

Garlic (*Allium sativum* L.) is one of the most important vegetable crops in Egypt and all over the world. There is an increase demand for Egyptian garlic for the local market and for export (Abdel-Sattar *et al.*, 1983). Garlic is also used as a source of certain medical substances (Mostafa, 1982).

Garlic bulbs are subjected to invasion by certain fungi during unfavorable storage conditions causing rot in garlic cloves and subsequently bulb devastation (Bottcher and Pohle, 1993; Beliard *et al.*, 1998 and Khaled *et al.*, 2003). The fungi *Aspergillus niger, A. flavus, Penicillium* spp. and *Fusarium oxysporum* (Schlecht) are the most dominant fungi responsible for garlic depletion phenomenon (Khaled *et al.*, 2003). Garlic bulbs of cv. Chinese showed some degree of resistance to fungal infection as compared with cv Balady., when examined under different storage and agricultural practices conditions (Abdel-Al *et al.*, 1991).

The present investigation was designed to survey the garlic postharvest causal organisms of bulb rot and study the effect of some storage conditions, *i.e.* plant age at harvest time, temperature and storage longevity. Field experiments including fertilization, irrigation and chemical control as well as some natural treatments, *i.e.* drying, and packing bulb during storage. Reduction in bulb weights were also investigated.

MATERIAL AND METHODS

1. Survey study:

Garlic bulbs cv. Balady were obtained from main local market in April of two successive seasons (2000 and 2001). Postharvest diseases were surveyed in different districts of three different governorates, *i.e.* El-Sharkia (Kafr Sakr, Diarb Nigm and Awlad Sakr), El-Dakahlia (Temi Elamdid, El-Senblaween and Aga) and El-Mounofia (Shebin El-Kom, El-Bagour and Monof) at two successive seasons (2000 and 2001). One hundred fifty Balady garlic bulbs from each district were randomly collected and visually inspected for presence of any disease symptoms and signs. Percentage of infection was determined according to the following formula :

$$\% \text{ infection} = \frac{\text{Number of infected bulbs}}{\text{Total count of bulbs}} \times 100$$

2. Isolation, identification and frequency of the causal pathogens:

Amputated cloves taken from diseased bulb samples were peeled off, then surface sterilized by immersing in 2% sodium hypochlorite solution for 3minutes, then wash several times with sterilized water and dried between two sterilized filter papers. The surface sterilized diseased rotted cloves were cut into small pieces using sterilized scalpel (2 mm thick). The samples were then transferred onto PDA medium in Petri-dishes. Four rotted parts were placed in each Petri dish. Plates were incubated at 28 °C for five days. The emerged fungi were picked up and purified using single spore and/ or by hyphal tip techniques suggested by Barnett and Huntter (1998). The purified microorganisms were identified according to explanation given by Barnett(1972), Ramirez (1982) and Samson and Pitt (1990). The frequency percentage of the occurrence of the isolated fungi was calculated.

3. Pathogenicity test:

The isolated fungi (*Aspergillus niger, A. flavus, Penicillium* spp. *Fusarrium oxysporum, Rhizopus* spp. and *Alternaria* spp.) were individually tested for their pathogenicity to mature apparently healthy garlic bulbs of Balady cultivar. The chosen bulbs were individually weighed. Surface sterilized wounded and un-wounded garlic bulbs were inoculated with spore suspension and/ or hyphal fragments $5x10^4$ cfu/ml and 4 mml disc through wounds near the base end to a depth of about 10 mm using fine sterile needle. Control treatment was prepared in a similar way using sterilized water. Ten bulbs of each treatment were kept in polyethylene bags, then incubated at room temperature at 28 – 30 °C for a month. At the end of incubation period bulbs were re-weighed and the percentage of losses in weight in their weight was calculated. Re-isolation was carried out from the inoculated infected bulbs.

4. Effect of some storage conditions on bulb rot development :

4.1. Effect of bulb maturity:

Balady and Chinese garlic bulbs cultivars were harvested at three ages, 150 days (immature), 170 and 190 days (mature) from planting time. The bulbs were dried in open air for two weeks, then weighed. Bulbs were surface sterilized using sodium hypochlorite 5% for 2 minutes,

then inoculated with equal discs (4mm in diameter) taken from 7 days old cultures of any of *Aspergillus niger, A. flavus, Penicillium* spp. *Fusarrium oxysporum*. Sixty garlic bulbs, for each garlic cultivar, were used (20 bulbs for one age and 5 bulbs for each fungus). Treated bulbs were packed in perforated paper bags and incubated at 28 ± 2 °C for a month. After the elapse of incubation period the percentage of infection was calculated. The bulbs in each treatment were re-weighted to determine the percentage of losses in their weight.

4.2. Effect of temperature:

Apparently healthy Balady and Chinese garlic bulbs taken from stored garlic for three months at room temperature (22 – 25 °C) from harvesting time. The bulbs were divided into three groups, each group contained five treatments (thirty bulbs for each treatment) for each cultivar and replicated three times for each particular treatment. Garlic bulbs were individually weighed and surface sterilized as mentioned before , then inoculated with the pathogenic fungi (*A. niger, A. flavus, Penicillium* spp. *F. oxysporum*) using disc technique as mentioned before. In control treatment, bulbs were only injected with discs of PDA medium. All treatments were packed in perforated paper bags. The first group was stored at 10 °C, the second group kept at 20 °C and the third one stored at 30 °C for 15 days. All treatments were re-weighed after the elapse of the storing period, percentage of infection and bulb weight loss were calculated.

4.3. Effect of storage period:

This experiment was started at April to October for both seasons 2000 and 2001. Balady and Chinese garlic bulb cultivars were harvested at their mature stages (170 days) and dried in sunshade for two weeks. Garlic bulbs without neck topping were individually weighed, then packed in perforated paper bags. Ten bulbs were used for both of garlic cultivars and replicated three times. Bulbs were stored at room temperature (22 – 30°C) and re-weighed every month after 1, 2, 3, 4, 5 and 6 months from storage to calculate percentage of infection in each treatment. Losses in bulb weight were also determine.

5. Field experiments:

Field experiments were conducted for two successive winter growing seasons (2000 and 2001) at the Experimental Farm of Tag El-Ezz Agricultural Research

Station, El-Dakahlia governorate, Egypt. The experimental plats were 3 X 3.5 meters in each feddan (1/400). Apparently healthy Balady garlic cloves were sown in each plot. Normal practices of garlic cultivation were applied. A complete randomized block was applied with three replicates for each treatment. After planting, the effect of mineral fertilization, irrigation and chemical control on garlic rot development were investigated.

5.1. Effect of fertilization:

Urea (46.5 % N), calcium super phosphate (16 % P_2O_5) and potassium sulfate (48 % K) were added at three levels: 129, 258 and 487 kg/ feddan for urea, 234, 468 and 702 kg/ feddan for calcium super phosphate and 50, 100 and 150 kg/ feddan for potassium sulfate. Different combinations between the three fertilizers were used. The fertilizers were added at three intervals, *i.e.* 30, 60 and 90 days from planting. After 170 days from planting, harvested bulbs were allowed to dry and packed in perforated paper bags. Bulbs were individually weighed and stored at room temperature (25 – 30 °C) for 4 months and then re-weighed. Percentages of infection and losses in bulb weight were calculated.

5.2. Effect of irrigation:

Four irrigation intervals, i.e. 15, 30, 45 and 60 days, were conducted under field conditions in two successive winter growing seasons 1999/ 2000 and 2000/ 2001. Harvested bulbs were allowed to dry as previously mentioned, then individually weighed and packed in perforated paper bags. Bulbs were re-weighed 4 months latter from their storage at room temperature (25 – 30 °C). The disease measures were calculated as mentioned before.

5.3. Effect of chemical control:

Vitavax-Thiram, Kema-Z and Redomil-MZ fungicides (Table 1) were applied as foliar sprays after three months from planting at the rate of 250 gm/ 100 liter water and repeated after 15 and 30 days from the first one to check efficacy of one, two and three sprays in controlling rots of garlic bulbs during storage. Control treatment was sprayed only by water. The same previously procedures for irrigation treatments were carried out.

Table 1: The tested fungicides , their name, active ingredient, common name, chemical composition and recommended doses.

Commercial name	Active ingredient	Common name	Chemical composition	Recommended dose
Vitavax-Thiram	75% WP	Carboxine + Thiarane	5,6 dihydro-2, 2 metyl 1, 4 oxathine-3 carboxanilide (37.5 %) + tetramethyl thiurambisulfide (37.5 %).	2.5 gm/ L water
Kema-z	50% WP	Carendazim + Metalaxyl	Carbendazim, Methyl benzamidazole-2- yl crbamate (MBC)	2.5 gm/ L water
Redomil-MZ	72% WP	Metalaxyl + Mancozeb	Methyl N. (methyoxy acetyl-N-(2, 6-xylyl)-DL-alaninate 8 % + manganese ethylenebis (dithiocarbamate) (polymeric) 64 %.	2.5 gm/ L water

6. Effect of Natural treatments before storage on bulbs decay :

6.1. Effect of drying:

Garlic bulbs of cvs. Balady and Chinese were dried in an open air in sunshade place and were divided into the following four treatments:

a. Thirty plants without neck topping were dried for a week.

b. Thirty plants with neck topping were dried for a week.

c. Thirty plants without neck topping were dried for two weeks.

d. Thirty plants with neck topping were dried for two weeks.

All treatments were weighed before storage. Plants were packed in perforated carton boxes and were left for 4 months at room temperature (25 – 30 °C). At the end of the experiment, plants were re-weighed and the percentages of infection and losses of bulb in fresh weight were determined.

6.2. Effect of packing container materials :

Apparently healthy bulbs without neck topping of Balady and Chinese garlic cultivars were packed in different eight kinds of

containers, *i.e.* paper bags, perforated paper bags, carton boxes, perforated carton boxes, polyethylene bags, perforated polyethylene bags, plastic sacks and jute sacks. Three replicates (10 bulbs for each replicate) were used for each particular treatment. Bulbs were weighted before packing, then re-weighed after the elapse of 4 months of storing at room temperature (25 – 30 °C). Percentages of bulb infection with rots, in addition to bulbs loss in fresh weight were calculated.

7. Statistical analysis:

Results were statistically analyzed according to the methods described by Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

Data in Table (2) indicate that the highest mean percentage of bulb rot infection was obtained from samples collected from El-Dakahlia governorate (10.93%), while, the lowest percentage (8.33%) was from samples of El-Mounofia governorate. Moreover, the bulbs showing symptoms of black rot disease appeared to be the most common kind of rot diseases (15.78%). On the other hand, the lowest bulb rot percentage (4.78%) was associated with bulbs exhibited symptoms of blue rot disease. These results might be due to the high moisture content in bulbs after harvesting in addition to root wounds resulted from removal of the bulbs from soil (Zayed *et al.*, 1982 and Abdel Sattar *et al.* 1983). Percentage of infection, also, differed from one season to another where it resulted the highest level in season 2000. This variation might be due to changes in the environmental conditions as well as variation of agricultural practices, garlic cultivars, pathogen races and host-pathogen relationship which affected the disease incidence (Walker, 1975).

The pathogenic fungus *A. niger* proved to be the most frequent among the examined fungal genera, isolated from both cultivars followed by *A. flavus* and *Penicillium* spp. (Table 3). Pathogenicity tests under laboratory conditions on wounded and/ or un-wounded bulbs indicated that different isolated fungi varied in their pathogenic potentiality with the lowest loss in the unwounded bulbs (Table 4). The highest percentage of decay in wounded bulbs might be due to wound break down the mechanical control of the bulbe to infect with pathogenic fungi (Radwan, 1980). Thus, these pathogenic fungi might

Table 2: Percentages of infection of cv. Balady garlic bulbs by rot diseases in three governorates (El-Shakia, El-Dakahlia and El-Mounofia) in two successive seasons (2000 and 2001).

Bulbs rot type	El-Sharkia governorate			El-Dakahlia governorate			El-Mounofia governorate			general mean		
	% Infection in season		Mean	% Infection in season		Mean	% Infection in season		Mean	% Infection in season		Mean
	2000	2001		2000	2001		2000	2001		2000	2001	
Black	14.00	14.67	14.34	19.33	20.67	20.00	12.67	13.33	13.00	15.33	16.22	15.78
Basal	12.00	13.33	12.67	12.66	13.34	13.00	10.67	11.33	11.00	11.78	12.67	12.23
Soft	10.00	10.66	10.33	8.67	9.33	9.00	10.00	10.00	10.00	9.56	9.99	9.78
Green	6.66	8.00	7.33	6.00	8.67	7.34	4.66	4.00	4.33	5.77	6.89	6.33
Blue	5.33	6.00	5.67	4.00	6.66	5.33	2.67	3.99	3.33	4.00	5.55	4.78
Mean	9.59	10.53	10.06	10.13	11.73	10.93	8.13	8.53	8.33	9.29	10.26	9.78

L.S.D. at 0.05 for:
L.S.D. at 0.05 for

Rot (R) = 4.21 Year (Y) = 0.85 R X Y = 5.63
Governorate (G) = 1.64 R X G = 6.38 R X G X Y = 8.45

Table 3: fungi isolated from rotted garlic bulbs of two garlic cultivars and there frequencies.

Isolated fungi	El-Sharkia				El-Dakhlia				El-Mounofia				Mean No.	Mean % fr.
	Balady		Chinese		Balady		Chinese		Balady		Chinese			
	No.	% Fr.	No.	% Fr.	No.	% Fr.	No.	% Fr.	No.	% Fr.	No.	% Fr.		
Aspergillus niger	5	17.86	4	26.67	4	20.00	6	27.27	5	23.81	3	15.79	4.50	21.60
Aspergillus flavus	5	17.86	3	20.00	3	15.00	3	13.64	6	28.57	4	21.05	4.00	19.20
Penicillium spp.	7	25.00	2	13.33	3	15.00	4	18.18	3	14.29	3	15.79	3.67	17.60
Fusarium oxysporum	4	14.29	2	13.33	2	10.00	3	13.64	5	23.81	3	15.79	3.17	15.20
Alternaria spp.	3	10.71	3	20.00	4	20.00	2	9.09	1	4.76	4	21.05	2.83	13.60
Rhizopus spp.	4	14.28	1	6.67	4	20.00	4	18.18	1	4.76	2	10.53	2.67	12.80
Mean	4.67		2.50		3.33		3.67		3.50		3.17			

Where **No.**: Number of fungal colonies, and **% Fr.**: % frequency of isolated fungi
LSD. At 5% Governorates (G) = 4.8 Cultivars (C) = 3.3 G x C = 6.7

Table 4: Pathogenicity tests of the isolated fungi from rotted Balady garlic bulbs using inoculation with disc and/ or spore suspension techniques:

Tested fungi	% loss in fresh weight of bulbs inoculated					
	With disc			With spore suspension		
	Wounded	Un-Wounded	Mean	Wounded	Un-Wounded	Mean
Aspergillus niger	35..48	6.25	20.87	31.45	8.06	19.76
Penicillium spp.	62.31	5.97	34.14	29.23	7.03	18.13
Aspergillus flavus	26.01	5.88	15.95	27.40	7.35	17.38
Fusarium oxysporum	16.95	7.38	12.13	16.67	6.78	11.73
Rhizopus spp.	10.61	5.71	8.16	15.25	9.09	12.17
Alternaria spp.	9.38	5.45	7.42	7.81	6.92	14.73
Control	7.35	3.33	5.34	7.35	6.62	6.99
Mean	26.79	6.11		21.30	7.54	
General mean	16.45			14.42		

L.S.D. at 0.05 for:

Fungi (F) = 10.63
Disc or spore suspension (D) = 11.23
Wounded or unwounded (W) = 13.66
F X D = 16.46
F X W = 18.46
D X W = 21.23
F X D X W = 28.85

be responsible for depletion of garlic bulbs during storage. These results were in full accordance with those obtained by Cho *et al.* (1995).

Results in Table (5) show that percentages of infection and bulbs loss with all the tested fungi decreased during storage by increasing plant age at harvesting from 150 to 190 days, where increasing age lead to the complete of bulb maturity, decreased bulb moisture content and hence increased the dryness of the bulbs. These results might be due to that certain structural features even for either the exterior and/ or interior, which might affect the ability of the pathogen to penetrate or invade the bulbs at this growth stage (El-Ali and El-Yamany, 1977; Zayed *et al.* 1982; and Shabrawy *et al.*, 1997).

Data in Table (6) indicate that increasing temperature degree from 10-30°C accelerated infection percentage and bulbs loss in fresh weight of both garlic cultivars. *A. niger* gave the highest percentages of infection and loss in bulbs fresh weight when garlic bulbs stored at 30 °C. On the other hand, both *Penicillium* spp. and *F. oxysporum* had the highest results at 20 °C. This observation might be due to that these temperatures were the optimum ones for the growth of these pathogenic fungi (Abdel-Rhaman *et al.* 2000). These results had the same harmony of those of Mostafa (1982), Zayed *et al.* (1982) and Folchi and Mari (1984).

Data presented in Table (7) reveal that there is no infection on Chinese garlic cultivar after one month of storage in both tested seasons. Also, increasing storage period increased percentages of infection and bulb loss in fresh weight for stored garlic bulbs. It was also clear that both percentages rapidly increased after 3 months of storage and the maximum values were recorded after six months. These results might be due to the biochemical changes in clove contents such as increasing sugars and/ or decreasing volatile and phenolic compounds which enhanced cloves invasion by the pathogenic fungi Ragab *et al.* (1984). These results had confirmation of those of Furthermore, antimicrobial materials from cloves, hence predisposed cloves to infection by many pathogenic fungi (Bottcher and Gunther, 1994).

Results presented in Table (8) indicate that the highest percentages of infection (43.33 and 46.67% for 2000 and 2001 growing seasons respectively) were detected in soil fertilized by

Table 5: Effect of harvesting time on rot disease measurements of garlic cultivars:

Age of plant at harvest time (days)	cv. Balady										cv. Chinese									
	A. niger		*A. flavus*		*F. oxysporum*		*Penicillium* spp.		Mean		*A. niger*		*A. flavus*		*F. oxysporum*		*Penicillium* spp.		Mean	
	I	L	I	L	I	L	I	L	I	L	I	L	I	L	I	L	I	L	I	L
150	100.0	55.56	100.0	52.94	100.0	46.58	100.0	40.00	100.0	48.477	100.0	40.00	80.00	33.33	80.00	25.33	60.00	24.00	80.00	30.67
170	100.00	35.0	80.00	34.04	80.00	29.63	60.00	26.49	80.00	31.29	80.00	22.67	60.00	22.67	40.00	21.33	60.00	20.27	60.00	22.74
190	80.00	23.08	40.00	22.09	60.00	16.92	20.00	16.07	50.00	19.54	60.00	20.00	40.00	16.07	20.00	14.29	40.00	12.96	40.00	15.83
Mean	9.33	37.88	73.33	36.36	80.00	31.04	60.00	27.52	76.67	33.10	80.00	27.56	60.00	24.02	46.67	20.32	53.33	19.08	6.000	23.08

Where **I** = % Infection and **L** = % loss in bulbs fresh weight.

L.S.D. at 0.05 for:

Age (A) = 14.03. Fungi = 12.43. Cultivar (C) = 10.11.

A X F = 18.44. A X C = 17.07 A X F X C = 22.55.

Table 6: Effect of different storage temperatures on rot disease measurements of garlic cultivars:

Storage Temperature (°C)	cv. Balady										cv. Chinese									
	A. niger		*A. flavus*		*F. oxysporum*		*Penicillium* spp.		Control		*A. niger*		*A. flavus*		*F. oxysporum*		*Penicillium* spp.		Control	
	I	L	I	L	I	L	I	L	I	L	I	L	I	L	I	L	I	L	I	L
10	33.33	8.35	26.67	7.82	26.67	7.83	36.67	9.26	6.67	2.26	26.67	7.43	20.00	6.58	20.00	6.95	30.00	7.51	3.33	1.98
20	53.33	11.09	40.00	9.13	80.00	12.74	36.67	9.35	10.00	4.13	46.67	8.52	33.33	8.09	66.67	10.54	30.00	8.30	6.67	2.90
30	80.00	12.96	36.67	8.70	40.00	9.13	33.33	8.52	10.00	4.43	73.33	11.55	30.00	7.90	33.33	7.90	26.67	6.98	6.67	3.20

Where **I** = % Infection and **L** = % loss in bulbs fresh weight.

L.S.D. at 0.05 for:

Temperature (T) = 9.02. Fungi (F) = 5.16

Cultivar (C) = 7.33. T X F = 11.44

Table 7: Effect of storage period on rot disease measurements of garlic cultivars in two successive seasons (2000 and 2001):

Storage period (month)	2000				2001			
	cv. Balady		cv. Chinese		cv. Balady		cv. Chinese	
	I	L	I	L	I	L	I	L
1	3.33	3.25	0.00	2.52	3.33	3.50	0.00	3.15
2	6.67	7.35	3.33	7.14	13.33	8.88	3.33	7.69
3	13.33	14.17	3.33	10.00	23.33	21.26	6.67	16.78
4	30.00	27.32	10.00	23.70	46.67	34.11	10.00	23.78
5	56.67	40.34	20.00	28.90	60.00	47.90	26.67	31.82
6	63.33	40.49	26.67	32.14	70.00	50.00	30.00	36.01

Where **I** =% Infection and **L** = % loss in bulbs fresh weight.

L.S.D. at 0.05 for:

Storage period (S) = 8.04 S X Y = 10.36

Cultivar (C) = 6.35 C X Y = 8.13

Years (Y) = 3.12 S X C X Y = 15.11

S X C = 12.55

Table 8: Effect of fertilization with different NPK levels on rot disease measurements of Balady garlic cultivar in two successive growing seasons (1999/ 2000 and 2000/ 2001):

Treatments*			1999/ 2000		2000/ 2001	
N	P	K	I	L	I	L
N1	P1	K1	26.67	16.46	26.67	19.49
N1	P1	K2	26.67	16.46	26.67	19.86
N1	P1	K3	23.33	16.25	23.33	18.99
N1	P2	K1	23.33	17.72	26.67	19.74
N1	P2	K2	20.00	15.19	23.33	17.33
N1	P2	K3	20.00	15.82	23.33	17.24
N1	P3	K1	20.00	15.19	20.00	17.31
N1	P3	K2	16.67	16.00	20.00	18.67
N1	P3	K3	16.67	17.09	20.00	18.75
N2	P1	K1	30.00	18.99	26.67	21.64
N2	P1	K2	26.67	20.25	33.33	25.42
N2	P1	K3	26.67	18.99	33.33	22.22
N2	P2	K1	26.67	18.35	30.00	21.95
N2	P2	K2	13.33	14.56	20.00	16.00
N2	P2	K3	13.33	13.92	16.67	15.85
N2	P3	K1	23.33	15.79	20.00	17.07
N2	P3	K2	20.00	15.82	20.00	17.31
N2	P3	K3	16.67	18.89	20.00	18.13
N3	P1	K1	43.33	22.78	46.67	29.27
N3	P1	K2	40.00	21.52	46.67	27.78
N3	P1	K3	33.33	20.25	30.00	26.82
N3	P2	K1	33.33	19.62	30.00	22.67
N3	P2	K2	36.67	18.99	33.33	21.11
N3	P2	K3	26.67	17.72	33.33	22.35
N3	P3	K1	23.33	17.47	33.33	21.05
N3	P3	K2	23.33	17.22	30.00	20.00
N3	P3	K3	26.67	16.67	33.33	21.95
Without NPK			50.00	25.88	53.33	38.46
L.S.D. at 0.05			9.36	5.83	10.12	7.25

Where **I** = % Infection, and **L** = % loss in bulbs fresh weight.

* : Treatments/ feddan:

N1= 129 kg	N2 = 258 kg	N3 = 487 kg
P1 = 234 kg	P2 = 468 kg	P3 = 702 kg
K1 = 50 kg	K2 = 100 kg	K3 = 150 kg

N3P1K1. On the other hand, plants fertilized by N2P2K3 showed that the lowest percentages of bulb infection by rots. The same trend was obtained concerning percentages of bulbs weight loss of garlic Balady cultivar during storage. These results might be due to the balance of potassium (K) and phosphorus (P) contents in bulb scales that might prevent or even decrease fungal penetration. Both elements have been claimed in many diseases to be responsible for plant resistance against certain pathogens (Kottunvon, 1984 and Abdel-Rafei, 2000).

Data presented in Table (9) revealed that percentages of infection and loss in bulbs fresh weight of stored garlic decreased with increasing the intervals between irrigation from 15 to 60 days. Whereas, infection percentage decreased from 53.33 to 6.67 % and from 60.00 to 10.0 % in 1999/ 2000 and 2000/ 2001 growing seasons respectively. Such increase in storage decay might be due to the increase of moisture content of garlic bulbs as a result of irrigation once every 15 days, which might increase susceptibility of stored bulbs to be infected by rot fungi. These results are in agreement with some extent with those of Ashour *et al.* (1973) and El-Shabrawy *et al.* (1987).

Data presented in Table (10) show that application of different fungicide as sprayer treatment reduced percentages of infection and loss bulbs in fresh weight during storage in both two growing seasons (1999/ 2000 and 2000/ 2001). Vitavax-Thiram was the most effective fungicide in reducing the percentage of infection. However, Ridomil-MZ-72 was the least effective one. These results had confirmation of those of Mazur (1991) and Soares and Kurozawa (1998). The differences in the obtained results might be due to the different groups of fungicides that varying in their active ingredient and mode of action. Furthermore, the explanation might be due to the prolonged protection for garlic bulbs from infection for certain period of storage (El-Shehabay *et al.*, 1997). It was also clear that three sprays with any of the tested fungicides were more effective than the other numbers. Such results are in the harmony with those of Aly *et al.* (1997), Soares and Kurozawa (1998) and Abdel-Rafei (2000).

Data presented in Table (11) show that drying garlic bulbs without neck topping significantly reduced the bulbs loss in fresh weight during storage than those dried with neck topping for both

Table 9: Effect of irrigation intervals on rot disease measurements of cv. Balady garlic in two successive growing seasons (1999/ 2000 and 2000/ 2001):

Irrigation intervals (days)	1999/ 2000		2000/2001	
	I	L	I	L
15	53.33	30.56	60.00	33.75
30	16.67	12.66	26.67	16.25
45	13.33	1159	16.67	12.92
60	6.67	10.53	10.00	12.14

Where **I** = % Infection, and **L** = % loss in bulbs fresh weight.

L.S.D. at 0.05 for:

Irrigation intervals (I) = 6.23 I X Y = 9.11
Years (Y) = 3.96

Table 10: Effect of spraying garlic plants (cv. Balady) during growth at two successive seasons (1999/ 2000 and 2000/ 2001)with three different fungicides on rot diseases affecting bulbs during storage:

Fungicide	Number of sprays	1999/ 2000		2000/ 2001	
		I	L	I	L
Vitavax-Thiram	1	33.33	29.15	36.67	29.36
	2	26.67	27.14	23.33	26.09
	3	23.33	25.35	20.00	24.51
Kema-Z 50	1	36.67	31.78	40.00	33.55
	2	30.00	29.86	26.67	30.30
	3	26.67	27.27	23.33	28.23
Rimdomil-MZ-72	1	33.33	38.52	46.67	37.41
	2	33.33	33.33	46.67	31.82
	3	26.67	31.42	40.00	29.40
Control (without fungicides)		53.33	42.67	56.67	43.48

Where **I** = Infection %, and **L** = loss of weight bulb %.

L.S.D. at 0.05 for:

Fungicides (F) = 8.25 Number of sprays (N) = 7.43
Years (Y) = 2.41 F XN = 13.65
F X Y = 10.44

Table 11: Effect of drying period on percentage of bulbs loss in fresh weight of Balady and Chinese garlic cultivars after 4 months of storage in two successive seasons (2000 and 2001):

Drying period (week)	Balady cultivar						Chinese cultivar					
	2000		Mean	2001		Mean	2000		Mean	2001		Mean
	A	B		A	B		A	B		A	B	
1	49.28	53.31	51.49	52.02	67.00	59.51	36.62	40.25	38.69	37.50	41.67	39.59
2	40.30	51.35	45.83	41.56	60.42	50.99	28.00	38.94	33.47	28.90	39.68	34.29
Mean	44.79	52.33	48.66	46.79	63.71	55.25	32.31	39.85	36.08	33.20	40.68	36.94

Where: **A** = Bulbs without neck topping and **B** = Bulbs with neck topping.

L.S.D. at 0.05 for:

Treatment (T) = 5.06 Period (P) = 2.49 Years (Y) = 2.80
T X P = 6.34 T X Y = 5.59 P X Y = 3.36
T X P X Y = 8.51

Table 12: Effect of packing container materials on rot disease measurements of Balady and Chinese garlic cultivars after 4 months of storage:

Packing containers		Balady cultivar		Chinese cultivar	
		I	L	I	L
Paper bags	P	20.00	22.46	13.33	15.27
	N	26.67	31.25	20.00	18.16
Carton boxes	P	23.33	25.18	16.67	17.51
	N	30.00	32.09	23.33	24.18
Polyethylene bags	P	60.00	47.87	46.67	38.94
	N	70.00	51.82	60.00	43.60
Plastic sacks		43.33	41.80	33.33	35.75
Jute sacks		36.67	38.28	26.67	28.75

Where **P** = Perforated and **N** = Non-perforated.

Where **I**: Infection % and **L**: Bulbs loss weight %.

L.S.D. at 0.05 for:

Treatment (T) = 8.43
Perforation (P) = 6.27
Cultivar (C) = 3.36
T X P = 10.32
T X C = 9.22
P X C = 8.11
T X P X C = 12.46

the two tested garlic cultivars (cvs. Balady and Chinese). The reduction in bulb weight of cv. Chinese was lesser than that occurred in bulbs of cv. Balady. This observation might be due to prevention or decrease invasion by the different pathogens during storage as a result of dryness leading to formation of closed tissues (Werner, 1986 and Gargi, Roy, 1986). Moreover, prolonging drying period to 2 weeks after harvesting led to a reduction in the loss percentage of bulb fresh weight in both seasons than drying for one week. These results are in agreement with those of Hussen *et al.* (1976) and Bottchr and Gunther (1994).

Packing of bulbs of Balady and Chinese garlic cultivars in perforated containers showed lower percentages of rot disease measurements when compared with the non-perforated ones (Table 12). Packing bulbs of both cultivars tested in perforated paper bags and perforated carton boxes revealed the lowest percentages of infection (20.00 and 23.33% respectively) and loss in bulbs fresh weight (22.46 and 25.18% respectively). On the other hand, bulbs packed in non-perforated polyethylene bags exhibited the highest values of rot disease measurements. Chinese garlic cultivar revealed the same trend but with lower corresponding values of rot disease measurements. Probably, these results might be due to less ventilation leading to accumulation of high humidity, which encourages germination fungal spores, infection and further development (Khaled *et al.*, 2003).

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تأثير بعض العمليات الزراعية و ظروف التخزين على حدوث أعفان رؤوس الثوم

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كانت أمراض العفن الأسود ، الأخضر و القاعدي الأكثر تأثيراً على رؤوس الثوم التي تم تخزينها ، و المسببات لهذه الأمراض هي الأسبرجيلس نيجر ، و الأسبرجيلس فلافس ، و البنسيليوم و الفيوزاريم اكسبوريم ، وقد كان فطر الأسبرجيلس نيجر أكثر الفطريات تواجداً وأكثرها تدميراً لرؤوس الثوم المخزنة لصنفي الثوم البلدي و الصيني.

و قد أدى حصاد المحصول بعد ١٩٠ يوم إلى تخفيض مقاييس الإصابة بأمراض أعفان الرؤوس عن الحصاد بعد ١٥٠ يوم ، كما أعطى التخزين عند درجة حرارة تتراوح من ٢٠ إلى ٣٠ °م أعلى قيم للإصابة ، كما زادت مقاييس الإصابة بزيادة مدة التخزين ، و زيادة عدد مرات ري المحصول ، و كذلك زادت مقاييس الإصابة بزيادة مستوى التسميد النيتروجيني ، بينما نقصت قيم هذه المقاييس بزيادة مستويات سماد البوتاسيوم والفسفور في كل من الموسمين ١٩٩٩/ ٢٠٠٠ ، و ٢٠٠٠/ ٢٠٠١ ، و أيضاً كان المبيد فيتافاكس – ثيرام عند الاستعمال في الحقل أكثر المبيدات المستخدمة في الدراسة تثبيطاً للإصابة أثناء التخزين.

و قد كان تجفيف رؤوس الثوم المخزنة بدون قطع العرش لمدة أسبوعين أكثر ملائمة لتقليل الإصابة عما لو تم التخزين لرؤوس قطعت أعناقها ، كما أدى التخزين في أكياس ورق أو صناديق كرتون مثقبة دور كبير في تخفيض مقاييس الإصابة.