Studies on Effect of Nitrogen Fertilization and Foliar Feeding of Calcium and Bio Stimulants on the Growth, Yield and Post-Harvest Quality of Garlic

II. Effects of Nitrogen, Chitosan and Storage Durations on Post-Harvest Quality of Garlic

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ABSTRACT

A field trial and post-harvest experiment were carried out at the Experimental Station Farm, Faculty of Agriculture, Alexandria University in Abies, Alexandria, Egypt, during the winter and summer season of 2017, respectively. This study aimes to evaluate the effect of nitrogenrates (0, 50, 100 and 150 Kg Nfed^{-1}) and chitosan (0, 1, 2 and 3 mll^{-1}) and their interaction effects on postharvest quality of garlic plants. The results showed that the percentage of weight loss and chemical composition of garlic (T.S.S , dry matter and total carbohydrates) were significantly increased as N-level increased from 0 up to 150 Kg N fed-1 as well as chitosan concentrations was increased from 0 up to 3 ml/ l. The results indicated also that there were significant interaction effect due to nitrogen levels and chitosan concentrations on all characters. The storage durations months had significant effects on weight loss of garlic bulbs. It was observed that weight loss of garlic bulbs gradually increased with the increase of storage duration up to 4 months. All minerals (N,P,K) and Protein contents of garlic bulbs were significant increased by the application of nitrogen fertilization up to 150 Kg N fed^{-1}as well as by spraying of chitosan up to 3mll^{-1}. The interaction effects of nitrogen and chitosan on N and protein contents of garlic bulbs before or after storage were significant, however, there were as no significant effects on P and K contents of garlic bulbs after storage.

keywords: Garlic, Nitrogen, chitasan, storage duration, post – harves quality.

INTRODUCTION

Garlic (*Allium sativium* L.) belongs to the family *Alliaceae*. It is one of the most important bulb vegetable crops and it is next to onion (*Allium cepa*) in economic importance (Hammam *et al.*, 2013). It is commonly used as a spice or in the medicinal purpose. The most important parts of garlic for medicinal purposes are fresh bulbs, dried bulbs, and the oil extracted. Garlic contains about 40% dry matter, 6-7% proteins, 0.2% lipids, 23-28% carbohydrates, 0.7-0.9% fiber, 1.1-1.4% ash matter and vitamins, especially A, B1, B2, B6 and C (Lošák and Wiśniowska, 2006).

In Egypt, garlic crop is produced for both local use and export. Egypt ranks the fourth leading country in the world for garlic production (260.000 MT) after China, India and Korea (FAO, 2017).

Worldwide, postharvest losses in fruit and vegetables range from 24-40% or even greater reaching up to 50% in developing countries (Iqbal, 1996). A comprehensive statistics for such losses in not available for Egypt, however, it has been estimated that the postharvest losses of horticulture crops in general may reach up to 25-50%where most of the causes of post-harvest losses may be due to pre-harvest agricultural practicesbecause the quality made in the field.

The goal of garlic production is a high bulbs yield and can be stored for a long time without deterioration. The bulbs yield and its quality of onioncan be increased by adopting a proper package of agricultural practices like: planting date, plant density, balanced nitrogen fertilization and irrigation schedule (Chung, 1989). Moreover, environmental conditions during the growth, harvesting, curing and storage as well aspremature defoliation, bulb maturation, skin integrity are the main factors that effecting on storability (Brewster, 2008). On the other hand, there is a lack of information on the effect of pre-harvest agricultural practices, which followed during the growth of plants in the field, on the bulbs quality and their storability. Therefore, this research was conducted to follow the effect of the strategy of nitrogen addition, foliar application of chitosan (as a bio-stimulant) and storage duration on the garlic bulbs quality and storability.

Nitrogen (N) is a vitally important raw material required for the growth of plants, where N is a central part of the essential photosynthetic molecule, chlorophyll (Marschner, 1994), as it is an essential constituent of metabolically active compounds such as amino acids, proteins, enzymes, coenzymes and some non-proteins compounds (Biswas and Mukherjee, 1993). Imbalanced and poor strategy of nitrogen addition limits yields and induces large losses of reactive nitrogen to the environment (Cassman *et al*., 2002); as well as could lead to increase physiological disorders of crops after harvest (Hewett, 2006). Although, addition of N was lead to increase the rates of leaf initiation and extension of garlic in early growth (Garcia, 1980; Koltunov, 1984). Moreover, it improved bulb growth and development (Fritsch *et al*., 1990 and Hossain, 1997). Excessive application of N at a late vegetative stage of onion plant can reduce the bulb yield, while inadequate N can hasten maturity and limit yield (Batal *et al*., 1994). However, with respect, the effect of nitrogen fertilization on the bulbs characteristics in the store (Kebede, 2003 and Gebrehaweria, 2007) found that bulbs produced from plants fertilized with higher amounts of N exhibited less storability with more weight loss compared to the garlic bulbs fertilized with lower amounts of N. Likewise, application of 100 Kg N/ha significantly reduced physiological weight loss, rotten and sprouted bulbs of onion bulbs by about 4, 7 and 10%, respectively, than the application of 150 Kg Nha^{-1}, at 90 days after storage periods (Benti, 2017). On the other hand,(Dankhar and Singh, 1991) found that the total sugar of onion bulbs decreased during storage and the reduction was higher at lower dose of nitrogen compared to its higher dose. They also pointed out that total sugar content during storage is considered an index of keeping quality.

Chitosan is an N-acetylated derivative of the polysaccharide chitin and mainly composed of glucosamine, 2-amino-2- deoxy-β-D-glucose (Freepons, 1991),can be extracted from the marine crustaceans (El-Miniawy *et al*., 2013). It is a natural polymer with a poly-cationic nature, which has numerous applications in agriculture e.g., as soil modifier, films, fungicide, elicitor (Deepmala *et al.,* 2014). Moreover, it contains nitrogen in the basic unit of its formula ($C_{11}H_{17}O_7N_2$), which is considered one of the most important nourishing elements in plants and soil alike (Ibraheim and Mohsen, 2015).Chitosan has manyroles in improvethe growth, productivity and storability of postharvest fruits and vegetables (Pilar *et al*., 2008 and Yumin*et al*., 2013). Where, chitosan contributes to stimulation of plants immunity against microorganisms (Patkowska *et al*., 2006 and Gornik *et al*., 2008).In addition, chitosanis enhanced plant growth, development (Ibraheim and Mohsen, 2015 and Mondal*et al.,* 2012) and improve the transportation of nitrogen (N) in the leaves; as a result of that chitosan isa key of enzymes activities of nitrogen metabolism: nitrate reductase, glutamine synthetase and protease (Khan *et al*., 2002 and Gornik *etal.,* 2008). Ahmed (2015) reported that foliar application of chitosan (4 and 6 ml l^{-1}) lead to improve productivity, quality and storability of garlic plants grown in clay loamy soil.

Therefore, this study was conducted in an attempt to follow the effect of nitrogen fertilizer rates with foliar application of chitosan on post-harvest quality and storabilitytraits in garlic throughout storage durations.

MATERIALS AND METHODS

This research is a complementary part of a series of field studies, which conducted to evaluate effects of pre-harvest nitrogenous fertilizer application and foliar application of chitosan on the postharvest quality and storability of garlic bulb. The experiments were conducted at the Experimental Station Farm of the Faculty of Agriculture, Alexandria University, Abies, Alexandria, Egypt.

Before the initiation of the field trial, some important physical and chemical properties of the experimental site soil (0–30 cm),were estimated according to the published procedures by (A.O.A.C.1992). The soil texture was clay loam (34.2 % sand, 22.3% silt and 43.5 % clay) with pH= 7.93, and EC= 3.21dS m^{-1}. Available soil N, P and K were 0.13%, 0.27 $mgkg^{-1}$and 0.39 $m.eql^{-1}$, respectively.

Planting and agronomic practices

Sids-40 garlic verity was used for the study. It is known by its big clove size, easy peer, whose mature cloves have bright white skin with purple vertical stripes. Garlic cloves were planted upright with the apical tip on the two sides of the rows 4m length and 60 cm apart with a spacing of 10 cm between plants, on September 10, 2016.All agricultural practices were done as commonly followed in the commercial production of garlic.

Treatments and experimental design

Field experiment

The field experiment included 16 treatments, which were the combinations of four levels of chitosan (0, 1, 2 and 3 mll^{-1}) under four rates of nitrogen fertilizer (0, 50, 100 and150 Kg $Nfed^{-1}$).The experimental design used was the split-plot system in a Randomized Complete Blocks Design with four replications. The N rates were, randomly, arranged in the main plots, while chitosan levels were, randomly, distributed in the sub-plots. Each sub-plot contained four rows having an area of 9.6 m^2. Nitrogen fertilizer rates were added at three applications; 30, 120 and 140 days after planting. The first dose of the nitrogen fertilizer was added as urea (46% N), while the remaining doses were added as ammonium nitrate (33.3%N). While, chitosan levels were applied twice as foliar application after 120 and 135 days from planting date.

Post-harvest experiment

At harvest, whole garlic plants of each experimental unit were harvested. Harvested garlic bulbs were cured, for 21 days, in a clean, shaded, well-ventilated and dry room, at temperature (25ºc ±2).After finishing curing process, sorting bulbs was done, where forty bulbs were selected randomly from each experimental unit and then divided into two groups,20 bulbs pergroup.

The postharvest experiment included 48 treatments, which were the combinations of three storage durations (2, 4& 6 months) under four levels of chitosan (0, 1, 2 and 3 mll^{-1}) under four rates of nitrogen fertilizer (0, 50, 100 and 150 Kg $Nfed^{-1}$).The experimental design used was the split-split-plot system in a Randomized Complete Blocks Design with four replications. The N rates were randomly arranged in the main plots, while chitosan levels were randomly distributed in the sub-plots, while storage durations were randomly distributed in the sub-sub-plots. Each sub-sub-plot consisted of 20 bulbs were devoted to the estimation of weight loss and other 20 bulbs were allocated for estimating other measurements.

Data recorded:

1-Weight loss %:

After the end of the curing process, weight of garlic bulbs for each experiment unit was recorded, at the beginning and end of each storage duration (two months, four months and six months). The weight loss of each storage duration was then calculated by subtracting the final weight of garlic bulbs at the end of each storage duration from the initial weight at the start storage. The results were then expressed in percentage using following formula:

$$WL\ \% = [(Wi - Wf)/Wi]\ (100)$$

Where: WL% = percentage weight loss for each storage duration, Wi=initial bulbs weight in g at the start storage, Wf=final bulbs weight in g at the end each storage duration.

2- Dry matter of bulb (%):

At the end each storage duration (after 2, 4, 6 months), random samples of 100 grams of cloves from each experimental unit were taken and oven dried at 70 ºC until constant weight. Dry matter of the bulb was calculated as the ratio between dry and fresh mass, and expressed as a percentage

3-Total soluble solid (T.S.S. %):

The total soluble solids in the bulbs were measured by using a digital refractmeter, at the end each storage duration (after 2, 4, 6 months). It was determined for five random bulbs obtained from each sub-plot it was taken from the juice of each bulb and the average was calculated.

4. Total carbohydrate in bulbs (%):

It was measured in dry matter of bulb, at the end storage duration (after 2, 4, 6 months), according to (A.O.A.C., 1992).

5. Nutrient concentrations (N, P, K):

Nitrogen, phosphorus and potassium contents were determined in the garlic bulbs before storage and at end storage duration i.e., after 6 months only. Where, the bulbs tissues were dried at 70 ºC until constant weight. The dried bulbs were ground, then a 0.3 g sample were digested with H_2O_2 according to (A.O.A.C., 1992). Nitrogen, phosphorus and potassium were colorimetrically determined according to the methods described in (A.O.A.C., 1992).

6. Protein content percentage:

Protein content was determined by using the previous determination of nitrogen content of garlic bulbsbefore storage and at end storage duration.

Statistical Analysis:

All obtained data was subjected to the analysis of variance techniques used the design by the Co-state computer software program (Snedecor and Cochran,1980).The comparisons among means of the different treatments were carried out, using the revised LSD test at (P>0.05).

RESULTS AND DISCUSSION

The results concerning the effects of the three studied factors as well as their interactions on the percentage of weight loss and chemical composition characters of garlic bulbs, which included T.S.S, dry matter and total carbohydrate of garlic bulbs, are shown in Figures (1-3) and Tables (1-4).

The different comparisons, obviously, indicated that percentage of weight loss and chemical composition of garlic bulbs (T.S.S, dry matter and total carbohydrate) increased significantly and successively as the N-dosewas increased up to 150 kg $Nfad^{-1}$ (Fig.1). This may be explained on the base that increase the nitrogen fertilizer rateslead to increase the water content of the garlic cloves, resulting in increased the weight loss of garlic bulbs during storage, which may bedue to increased rate of respiration, which contributes to increased T.S.S, dry matter and total carbohydrate of garlic bulbs. The current results are in harmony with those reported by (Tekalign*etal.,* 2012 and Benti, 2017). Moreover (Kebede, 2003 and Gebrehaweria, 2007) found that bulbs fertilized with higher amounts of N exhibited less storability with more weight loss compared to garlic bulbs fertilized with lower amounts of N. However, (Diriba- Shiferaw *et al.* 2013) reported that higher rates of fertilizers improved storability and quality of garlic bulbs.

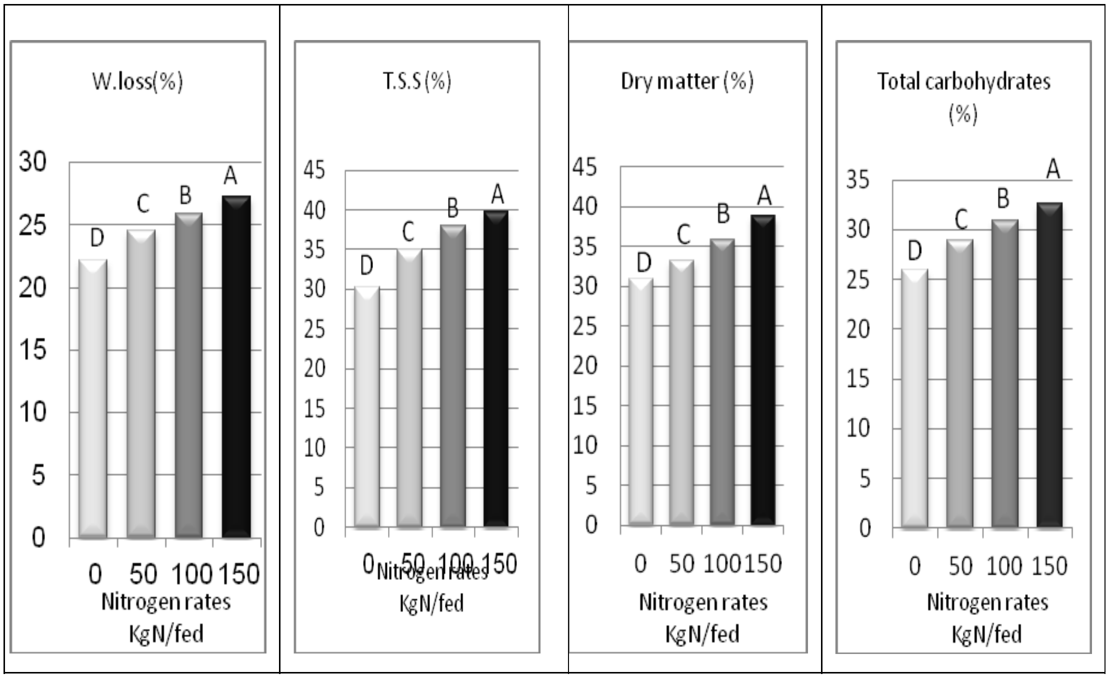

Fig.1: Effect of nitrogen rates on weight loss, T.S.S, dry matter and total carbohydrates percentages of garlic bulbs.

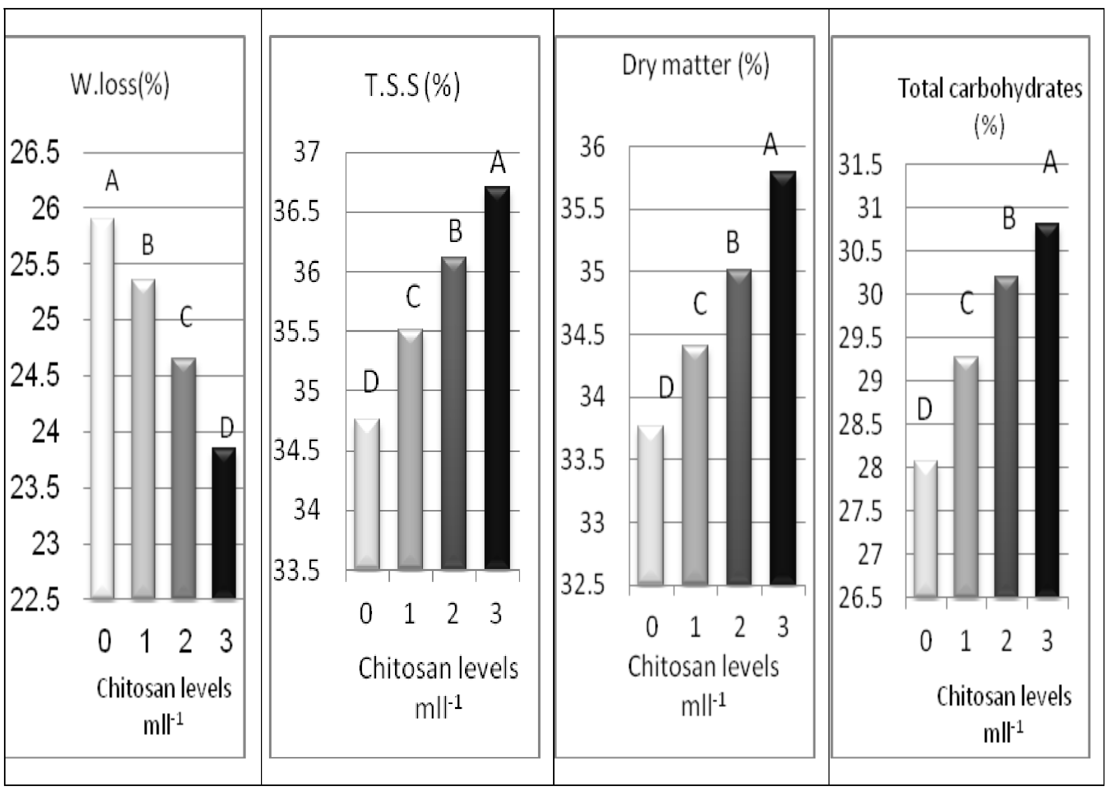

Fig. 2: Effect of chitosan levels on weight loss, T.S.S, dry matter and total carbohydrates percentages of garlic bulbs.

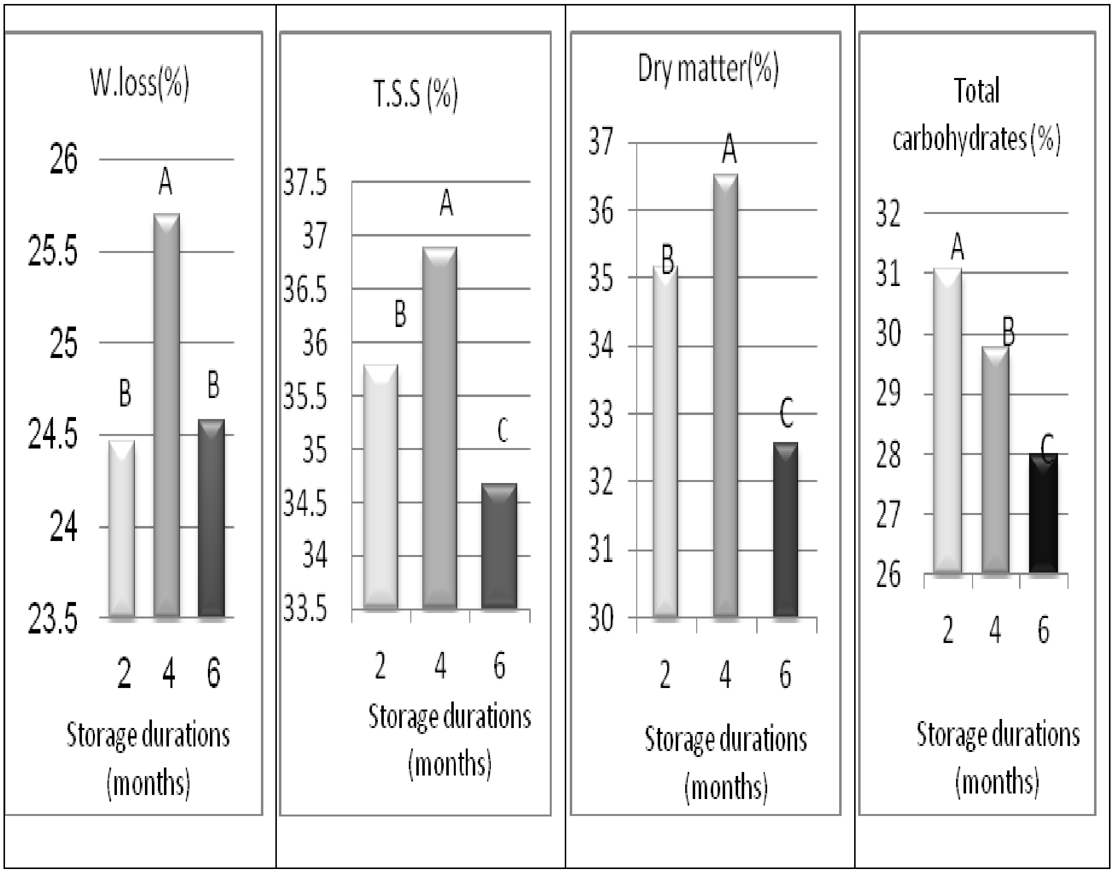

Fig. 3: Effect of storage durations on weight loss, T.S.S, dry matter and total carbohydrates percentages of garlic bulbs.

Table 1: Weight loss, T.S.S, dry matter and total carbohydrates (%) of garlic bulbs as affected by first order interaction between nitrogen rates and chitosan levels.

Treatments combination		Weight Loss (%)	T.S.S (%)	Dry Matter (%)	Total carbohydrates (%)
Nitrogen rates (Kg fed^{-1}.)	**Chitosan levels (ml l^{-1})**				
0	0	23.60gh*	29.11 l	30.28 m	25.09 i
	1	22.65 hi	29.92 k	30.65 lm	25.10 i
	2	21.62 ij	30.72 j	31.10 l	26.47 h
	3	20.78 j	31.29 j	31.81 k	27.10 h
50	0	25.22 d-f	33.58 i	32.40 jk	27.20 h
	1	24.79e-g	34.85 h	33.09 ij	29.00 g
	2	24.29 fg	35.49 gh	33.53 hi	29.18 g
	3	23.61 gh	36.05 g	34.12 gh	29.50 f-g
100	0	26.81 a-c	37.38 f	34.67 g	30.07 e-g
	1	26.21 b-d	37.79 ef	35.60 f	30.61 d-f
	2	25.58 c-f	38.23 de	36.32 e	30.80 de
	3	25.02 d-f	38.83 cd	37.06 d	31.43 cd
150	0	27.96 a	38.98 cd	37.70 cd	32.28 c
	1	27.74 a	39.49 bc	38.30 c	32.40 bc
	2	27.12 ab	39.99 ab	39.08 b	33.34 ab
	3	25.94 b-e	40.62 a	40.17 a	34.06 a

*Values marked with same alphabetical letter(s), within a comparable group of means, do not significantly differ, using revised L.S.D. test at 0.05 level.

Table 2: Weight loss, T.S.S, dry matter and total carbohydrates (%) of garlic bulbs as affected by first order interaction between nitrogen rates and storage duration.

Treatments combination		Weight loss (%)	T.S.S (%)	Dry Matter (%)	Total carbohydrates (%)
Nitrogen rates (Kg fed^{-1}.)	**Storage duration (month)**				
0	2	21.25 f*	30.19 i	31.34 h	27.90 f
	4	24.01 e	31.34 h	32.42 g	26.35 g
	6	21.28 f	29.25 j	29.12 i	23.57 h
50	2	24.12 e	35.25 f	33.38 f	30.25 d
	4	25.19 d	36.49 g	35.16 e	28.95 e
	6	24.22 e	33.24 g	31.31 h	27.62 f
100	2	25.81 c	37.84 d	36.66 d	32.08 b
	4	26.11 c	39.02 c	37.53 c	31.00 c
	6	25.81 c	37.32 d	33.56 f	29.53 de
150	2	27.08 b	39.83 b	39.24 b	34.05 a
	4	27.45 a	40.62 a	40.95 a	32.76 b
	6	27.06 b	38.86 c	36.25 d	31.21 c

*Values marked with same alphabetical letter(s), within a comparable group of means, do not significantly differ, using revised L.S.D. test at 0.05 level.

Table 3: Weight loss, T. S. S , dry matter and total carbohydrates (%) of garlic bulbs as affected by first order interaction between chitosan levels and storage duration.

Treatment combinations		Weight loss (%)	T.S.S (%)	Dry matter (%)	Total Carbohydrate (%)
Chitosan levels (ml l^{-1})	**Storage duration (month)**				
0	2	25.71 bc*	34.63 gh	34.41 f	29.94 d
	4	26.27 a	35.80 ef	35.46 d	28.58 f
	6	25.73 bc	33.86 i	31.68 j	25.68 h
1	2	25.06 d	35.55 f	34.85 e	30.80 bc
	4	25.93 ab	36.62 cd	36.06 c	29.21 ef
	6	25.08 d	34.36 hi	32.31 i	27.83 g
2	2	24.25 e	36.15 de	35.36 d	31.48 ab
	4	25.47 c	37.26 ab	36.79 b	30.28 cd
	6	24.28 e	34.91 g	32.87 h	28.85 f
3	2	23.22 f	36.78 bc	36.26 c	32.05 a
	4	25.09 d	37.79 a	37.74 a	31.00 bc
	6	23.24 f	35.79 f	33.37 g	29.58 dc

*Values marked with same alphabetical letter(s), within a comparable group of means, do not significantly differ, using revised L.S.D. test at 0.05 level.

Table 4: Weight loss, T.S.S, dry matter and total carbohydrates (%) of garlic bulbs as affected by second order interaction of nitrogen,chitosan and storage duration.

Nitrogen rates (Kg fed^{-1})	Chitosan levels (ml l^{-1})	Storage duration (month)	Weight loss (%)	T.S.S (%)	Dry matter (%)	Total carbohydrates (%)
0	0	2	22.87p-q*	28.75 y	30.37 r-t	26.80 tu
		4	25.07 i-m	30.05 wx	31.97 q	26.74 tu
		6	22.87 pq	28.55 y	28.50 t-v	21.75 w
	1	2	21.88 qr	29.96 wx	31.07 q-s	27.37 s-u
		4	24.22 l-o	30.87 vw	32.12 pq	24.94 v
		6	21.89 qr	28.92 y	28.75 t-v	23.00 w
	2	2	20.75 rs	30.62 vw	31.57 qr	28.51 q-s
		4	23.38n-p	32.05 u	32.25 o-q	26.39 u
		6	20.75 rs	29.50 xy	29.50 s-u	24.50 v
	3	2	19.50 s	31.44 uv	32.35 o-q	28.93 o-r
		4	23.34 n-p	32.40 tu	33.35 m-o	27.33 s-u
		6	19.58 s	30.02 wx	29.75 s-u	25.05 v
50	0	2	25.00 i-m	33.76 rs	32.60 n-p	29.10 n-r
		4	25.69 e-k	34.95 pq	34.37 j-k	27.51 s-u
		6	25.00 i-m	32.05 u	30.25 r-t	24.98 v
	1	2	24.50 k-n	35.13 pq	33.05 n-p	30.22 k-n
		4	25.38 g-l	36.27 no	34.97 i-k	28.89 p-r
		6	24.51k-n	33.15 st	31.25 q-s	27.90 r-t
	2	2	23.88m-p	35.85 op	33.62 l-n	30.66 j-l
		4	25.12 h-m	37.04 l-n	35.22 g-i	24.42 l-q
		6	23.87 m-p	33.57 rs	31.75 qr	28.41 q-s
	3	2	23.12 o-q	36.25 no	34.27 j-l	31.01 jk
		4	24.59 k-n	37.72 j-m	36.10 g	30.00 k-p
		6	23.15 o-q	34.20 qr	32.00 pq	29.18 n-q
100	0	2	27.01 a-e	37.05 l-n	35.00 h-j	30.87 jk
		4	26.46 b-g	38.17 g-k	36.52 f	29.26 n-q
		6	27.45 a-d	36.92 mn	32.50 n-p	27.41 s-u
	1	2	27.00 a-e	37.57 k-m	36.20 g	31.82 g-j
		4	26.12 d-i	38.77 f-i	37.12 ef	30.61 j-m
		6	26.40 c-h	37.02 l-n	33.50 l-n	29.39 m-q
	2	2	26.12 d-i	38.05 h-l	337.15 d-f	32.46 e-h
		4	25.37 g-l	39.20 d-g	38.07 de	31.66 h-j
		6	26.02 b-g	37.45 k-m	33.75 k-n	30.16 k-o
	3	2	25.37 g-l	38.67 f-j	38.30 de	33.16 b-f
		4	24.75 j-m	39.93 b-e	38.40 de	32.48 e-h
		6	25.57 f-k	37.90 i-m	34.50 j-k	31.19 i-k
150	0	2	24.78 j-m	38.97 e-h	38.60 de	33.00 c-g
		4	28.00 a	40.02 n-m	39.00 d	30.81 jk
		6	27.89 a	37.95 hm	35.50 gh	28.59 q-s
	1	2	28.09 a	39.55 c-f	39.10 d	33.79 b-d
		4	27.78 ab	40.57 a-c	40.05 c	32.39 f-i
		6	27.74 ab	38.35 g-k	35.75 gh	31.02 jk
	2	2	27.79 ab	40.07 a-d	39.12 d	34.30 ab
		4	27.09 a-e	40.77 ab	41.62 b	33.66 b-e
		6	27.38 a-d	39.12 d-g	36.50 f	32.34 f-i
	3	2	27.08 a-e	40.75 ab	40.15 c	35.11 a
		4	25.58 f-l	41.10 a	43.12 a	34.19 a-c
		6	26.82 a-f	40.02 b-d	37.25 d-f	32.89 d-h

*Values marked with same alphabetical letter(s), within a comparable group of means, do not significantly differ, using revised L.S.D. test at 0.05 level.

Results in Fig. (2) showed that concentration of chitosan had marked and significant effects on the weight loss and chemical composition characters of garlic bulbs. Increasing chitosan concentration up to 3 ml l^{-1} was accompanied by successive and significant increases in the percentage T.S.S, dry matter and total carbohydrate, as well as successive and significant decreases in the weight loss of garlic bulbs. These results may be due to the stimulatory effect of chitosan on growth parameters, where chitosan was added through enlargement bulb stage, which may be led to an increase in the content of the total soluble solids, dry matter and carbohydrates percentages of garlic bulbs, which contributed to the reduction of weight loss during storage. These obtained results seemed to be in general agreements with those reported by (Abdel-Mawgoud *et al*. 2010, Shehata *et al*. 2012 and Ahmed 2015) who reported that weight loss of the garlic bulbs was the least and total carbohydrate was the highest with the application of chitosan (6 and 4 ml l^{-1}).

The results presented in Fig. (3) showed that weight loss, total soluble solids (T.S.S) and dry matter percentages of garlic bulbs gradually increased with increase the storage duration up to 4 months and then found to be decreased at the end of the storage duration (6 months).While, increasing the storage duration from 2 to 4 and 6 months reflected corresponding and significant decreases in percentage of carbohydrate. This result can be explained based on increased respiration rate and bioactivity of garlic bulbs, especially, during the second storage duration (2-4 months), which leads to the consumption of carbohydrate and increase water loss. This result is agreement with reported by (Brewster ,2008) who found that in storage, as time progresses, the rate of respiration increases of garlic bulbs. Moreover, Hansen (1999) who found that carbohydrate content is significantly decreased during storage, mostly due to increased respiration, which consequently results in higher nitrogen and protein contents in the dry matter.

The statistical comparisons listed in Table (1) illustrated the presence of significant interaction effects between nitrogen fertilizer rates and chitosan levels on the stored garlic bulbs characters, where increase chitosan level up to 3 ml l^{-1}under any rate of nitrogen was associated with significant decrease in the percentage of weight loss of garlic bulbs. However, the combination between the nitrogen at rate 150 kg fed^{-1} and control treatment of chitosan (0 ml l^{-1})or used 1 ml l^{-1} of chitosan gave the highest mean values of weight loss of the stored garlic bulbs. Moreover, the results presented in Table (1) showed that the highest values of T.S.S, dry matter, and total carbohydrate characters of stored garlic bulbs were recorded from treatment combinations involving the highest nitrogen fertilizer rate (150 kg fed $^{-1}$) and the highest level of chitosan (3 ml l^{-1}).

With respect to the interaction effects between nitrogen rates and storage durations, the results in Table (2) showed that the highest estimated values of the weight loss, T.S.S. and dry matter percentages were obtained from the treatment combinations of the highest nitrogen rate (150 kg fed^{-1}) with the second storage duration (2-4 months).In addition, the treatment combination of the highest nitrogen level (150 kgfed^{-1}) with the first storage duration (2 months) gave a high value of total carbohydrate percentage.

Concerning the interaction effects between foliar application of chitosan and storage durations, the results in Table(3) illustrated that the lowest value of the weight lossof garlic bulbs was achieved with the treatment combination that involved foliar application of chitosanat rate 3 ml l^{-1} and storage duration two months or six months. While, the results indicated that the highest estimated values of the T.S.S. and dry matter percentages were obtained from the treatment combinations of the foliar application of chitosanat rate 3 ml $l^{-1}$with the second storage duration (2-4 months).Furthermore, the treatment combination of the highest chitosan concentration (3 ml l^{-1}) with the first storage duration (2 months) gave a high value of total carbohydrate percentage.

Results presented in Table 4 showed the second–order interaction effects for the three studied factors on the weight loss, T.S.S, dry matter and total carbohydrate. The results showed that the highest mean value of weight loss of stored garlic bulbs was obtained from garlic plants that fertilized by high level of nitrogen (150 kg fed^{-1}), untreated by chitosan and stored to 2-4 months. However, in the case of T.S.S., dry matter percentages, the treatment combination of nitrogen at rate 150 kg fed^{-1} with the use of the highest concentration of chitosan 3 ml l^{-1} and storage duration up to 4 months gave the highest means. While, the highest value of total carbohydrate percentage was given by highest N rate 150kg fed^{-1} with the use of the highest concentration of chitosan 3 ml l^{-1} and the first storage duration (2 months).

With respect to the effect of nitrogen rates on protein, N, P, and K percentages of garlic bulbs, the results in Fig.(4) indicated that increasing the applied level of nitrogen fertilization from 50 to 100 and 150 kg fed^{-1} reflected corresponding and significant increases on protein, N, P, and K percentages of garlic bulbs whether before or after storage.

The effects of the different levels of chitosan on the protein, N, P, and K percentages of garlic bulbs are showed in Fig.(5). The results illustrated that protein, N, P, and K percentages of garlic bulbs whether before or after storage reflected significant increases with each increase in applied chitosan concentrations. These results agreed, in general, with those reported by (Fawzy *et al.*2012) clearly revealed that foliar spraying chitosan at rate of 3 cm l^{-1} had significantly effected on contents of protein and nitrogen of Chinese garlic. Similar results were also obtained by (Saif El-deen *et al.* 2014) on artichoke plants.

The results in Table 5 showed that the interaction effect between nitrogen fertilizer and chitosan treatments had significant effects on N and protein contents of garlic bulbs whether before or after storage. The highest mean values for N and protein contents of garlic bulbs whether before or after storage and K content before storage were obtained when garlic plants were fertilized with 150 Kg N fed^{-1} and sprayed with 3 ml l^{-1} chitosan. On the other hand, there were no significant effects due to interaction between nitrogen and chitosan on P whether before or after storage and K contents after storage of garlic bulbs.

Generally, it could be concluded that pre-harvest applications of nitrogen and chitosan reduced the percentage of weight loss and improve storability of garlic bulbs.

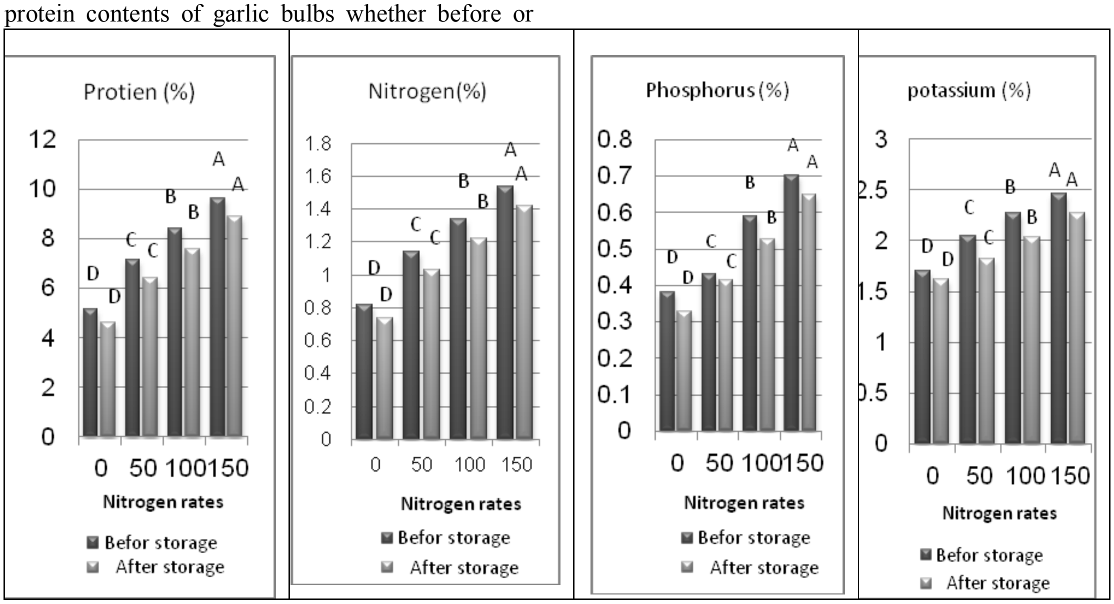

Fig. 4: Effect of nitrogen rates on protein, N, P, and K percentages of garlic bulbs before and after storage.

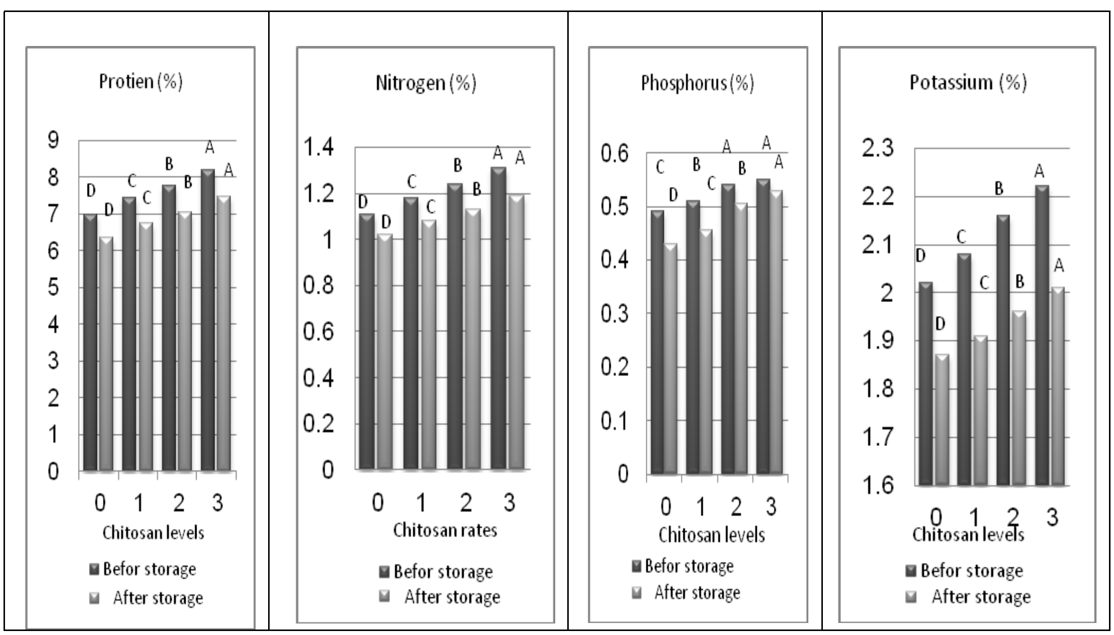

Fig. 5: Effect of chitosan levels on protein, N, P, and K percentages of garlic bulbs before and after storage.

Table 5: Nitrogen, phosphorus, potassium and protein content (%) of garlic bulbs, before and after storage, as affected by interaction between nitrogen rates and chitosan levels.

Treatments		N %		P %		K %		Protein%	
Nitrogen rates (Kg fed^{-1})	Chitosan levels (ml l^{-1})	Before Storage	After Storage	Before Storage	After Storage	Before Storage	After Storage	Before Storage	After Storage
0	0	0.74m*	0.67 k	0.37 a	0.28 a	1.61 k	1.56 a	4.64 m	4.07 k
	1	0.78 l	0.70 jk	0.38 a	0.31 a	1.65 k	1.58 a	4.92 l	4.39 jk
	2	0.84 k	0.75 j	0.40 a	0.35 a	1.73 j	1.62 a	5.25 k	4.71 j
	3	0.93 j	0.84 i	0.39 a	0.38 a	1.83 i	1.70 a	5.82 j	5.23 i
50	0	1.02 i	0.91 h	0.41 a	0.38 a	1.90 h	1.77 a	6.39 i	5.68 h
	1	1.13 h	1.02 g	0.42 a	0.41 a	2.00 g	1.80 a	7.09 h	6.39 g
	2	1.15 h	1.08 f	0.44 a	0.43 a	2.11 f	1.82 a	7.23 h	6.75 f
	3	1.26 g	1.11 f	0.44 a	0.44 a	2.19 e	1.91 a	7.92 g	6.95 f
100	0	1.28 fg	1.17 e	0.52 a	0.46 a	2.20 e	1.97 a	8.00 fg	7.32 e
	1	1.31 f	1.20 e	0.55 a	0.50 a	2.27 d	2.01 a	8.21 f	7.53 e
	2	1.38 e	1.22 e	0.63 a	0.54 a	2.31 d	2.08 a	8.64 e	7.62 e
	3	1.40de	1.30 d	0.65 a	0.60 a	2.31 d	2.10 a	8.75 de	8.14 d
150	0	1.42 d	1.32 d	0.65 a	0.60 a	2.37 c	2.19 a	8.92 d	8.28 d
	1	1.52 c	1.39 c	0.71 a	0.61 a	2.41 c	2.24 a	9.50 c	8.67 c
	2	1.59 b	1.46 b	0.72 a	0.70 a	2.49 b	2.30 a	9.96 b	9.10 b
	3	1.65 a	1.53 a	0.73 a	0.71 a	2.56 a	2.33 a	10.32 a	9.56 a

*Values marked with same alphabetical letter(s), within a comparable group of means, do not significantly differ, using revised L.S.D. test at 0.05 level.

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دراسات على تأثير التسميد النيتروجيني والتغذية الورقية بالكالسيوم والمنشطات الحيوية على النمو والمحصول وجودة ما بعد الحصاد في الثوم.

II. تأثير النيتروجين والشيتوزان وفترات التخزين علي جودة مابعد الحصاد في الثوم.

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الملخص العربي

أجريت تجربة حقلية وتجربة تخزين بمحطة البحوث الزراعية بأبيس التابعة لكلية الزراعة–جامعة الإسكندرية خلال موسمي الشتاء والصيف لعام ٢٠١٧ على التوالي.لتقييم تأثير معدلات النيتروجين (٠، ٥٠، ١٠٠ و ١٥٠ كجم نيتروجين/ لفدان) والشيتوزان (٠ ، ١، ٢ و٣ مل /لتر) وتأثيرهما المتداخل على جودة نباتات الثوم ما بعد الحصاد. وقد أظهرت النتائج أن النسبة المئوية للفقد فى الوزن والمحتوى الكيميائي للثوم (المواد الصلبة الكلية، المادة الجافة والكربوهيدرات الكلية) قد ازدادت بشكل ملحوظ مع زيادة معدل N– من صفر حتى ١٥٠ كجم للفدان وكذلك تركيزات الشيتوزان من صفر تصل إلى ٣ مل/ لتر. وأظهرت النتائج أيضا وجود تأثير واضح بين تداخل مستويات النيتروجين وتركيزات الشيتوزان على جميع الصفات. كذلك فترة التخزين عدة اشهر كان لها آثار كبيرة على فقدان الوزن رؤوس الثوم. ولوحظ أن فقدان الوزن لرووس الثوم قد ذادت زيادة تدريجية مع زيادة فترة التخزين تصل إلى ٤ أشهر. وكان محتوى الكيميائي من العناصر (N، P، K) ومحتويات البروتين فى رووس الثوم زادت زيادة كبيرة من خلال الإضافة الأرضية من التسميد النيتروجين تصل إلى ١٥٠ كجم نيتروجين للفدان و كذلك عن طريق رش الشيتوزان تصل إلى٣مل /لتر. وكانت التأثيرات المتداخلة بين النيتروجين والشيتوزان على محتوي النيتروجين والبروتين فى رووس الثوم سواء قبل أو بعد التخزين تأثير معنوي واضح، بينما، وكان هناك تأثير معنوى فى محتوى كلا من البوتاسيوم والفوسفور لرووس الثوم بعد التخزين.

الكلمات الدليلية: الثوم– النيتروجين والشيتوزان– فترات التخزين– جودة مابعد الحصاد.