



## Efficiency of foliar application by chitosan and royal jelly on growth, yield and quality of two garlic cultivars

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### Abstract

This study was conducted to evaluate the potential effect of foliar spray with different doses of two bio-stimulants Chitosan (CS) and Royal Jelly (RJ) on growth and yield and quality of two garlic cultivars (Egaseed1 and Balady i.e(Egyptian) at two winter seasons of 2017/2018 and 2018/2019. Generally, the foliar spray of all tested bio-stimulates treatments considerably improves almost all plant growth traits of garlic cultivars which reflected on plants yield and quality. Data showed that spraying Ega1 plants with different doses of CS and RJ considerably increased total yield (TY) in both seasons as compared with control (13.39 and 14.64 tons). The highest values of TY were found in Ega1 plants treated with 0.1g/l RJ (15.29 and 15.80 tons) and 0.3g/l RJ (15.08 and 16.61 tons) at both seasons respectively. On the other side, there was clear increase in TY of Egy plants treated with different CS and RJ doses at both seasons as compared with control (7.57 and 8.69 tons, respectively). The highest values of TY were found in Egy. plants treated with 0.2g/L RJ (9.23 and 8.53 tons) at both seasons respectively as compared with all other treatments. As compared to control, foliar spray with CS and RJ reduced weight loss % and deterioration of bulbs during storage. In general, foliar application of chitosan (1000 and 1500 ppm) and Royal Jelly (0.2 and 0.3 g.L<sup>-1</sup>) could be recommended to improve productivity, quality and storability of the two garlic cultivars grown under Minia Governorate conditions.

**Keywords:** Bio-stimulates; Chitosan; Royal jelly; Total yield; Bulbing ratio.

### 1. Introduction

Garlic (*Allium sativum* L.) is considered one of the common vegetable crops grown in Egypt for both exportation and local consumption. It is belonging to the family Alliaceae with chromosome number  $2n=16$ , and is the second most widely used, cultivated *Allium* after onion due to its flavor and medicinal properties (Collin, 2004). Increasing the productivity and improving the quality of garlic bulb are the main goal for farmers (El-Morsy, 2004). Recently there is great attention to decrease pollution sources (mineral fertilization and pesticides) in

modern agriculture which reflect on environment and human health. Using natural products, such as: dry yeast, seaweed, chitosan, humic acid and amino acids in crops production become commonly use in safe agricultural system during the last years as alternative tools for mineral fertilizers (Ahmed, 2015 and Shehata *et al.*, 2012).

Chitosan is considered as one of the natural, less toxic and economical polymer which is biodegradable and environmentally safe with various agricultural applications (Basit *et al.*, 2020). It is derived from deacetylation of chitin which is found in crustaceous shells such as crabs and shrimps (Dash *et al.*, 2011). It is healthy and nutritious for both animals and plants. Chitosan has a positive effect in plant growth, yield and quality because it promotes nutrient uptake of the plant (Malerba and Cerana

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2016), its fungicidal effects and elicitation of defense mechanisms in plant tissues (Shehata *et al.*, 2012), its ability to extend the shelf life of fruits and vegetable by controlling gas exchange, reduces respiration and transpiration rates, and slows down the ripening processes. (Shehata *et al.*, 2012). It can be used as both soil treatment and foliar spray and stimulate stress tolerance and improve performances of plants (Sofy *et al.*, 2020a; Hassnain *et al.*, 2020). Many studies revealed that foliar application of chitosan increased vegetative growth, yield and quality of vegetable crops (Abdel-Mawgoud *et al.*, 2010; Ghoname *et al.*, 2010; Fawzy *et al.*, 2012).

Royal jelly (RJ) is a natural product and healing compound. It has been widely used since ancient times in diseases treatment and health improvements in many countries. It consists of water, pollen, hormones, vitamins and honey mixed with saliva. It contains 65.3% water and 34.7% dry residue. The latter is composed from 48.2% proteins, 37.8% carbohydrates, 10.4% lipids and 2% ash. It also includes vitamins (B1, B2, B5, B6, B8, B9 and C). Moreover, it contains at least 17 amino acids as well as, the important minerals, such as potassium, magnesium, calcium, iron, phosphorus, sulfur, manganese and silicon (Nation and Robinson, 1971; Lakin, 1993, El-Shaikh, 2010; Pasupuleti *et al.*, 2017). There are several studies strongly suggest the important role of RJ in improving growth, yield and quality of horticultural crops and protect plants from various stresses (El-Maziny and Hassan, 1990; El-Shaikh, 2010; Wassel *et al.*, 2015; Dalia and El-Aref, 2016; Çavuşoğlu, *et al.*, 2017).

So, the aim of this study was to evaluate the potential effects of foliar spray with two bio-stimulants (chitosan and royal jelly) on the growth, yield and quality of two garlic cultivars under El-Minia governorate, Egypt conditions.

## 2. Materials and Methods

This study was conducted at the Experimental Farm of Horticulture Department, Faculty of Agriculture, Minia University, Minia governorate (28° 07'N and 30° 43'E), Egypt, during the two successive seasons of 2017/2018 and 2018/2019. to study the previous mentioned aims.

### 2.1. Plant materials

Two garlic cultivars (Egaseed-1 and Egyptian) were kindly provided by the vegetable Branch, Horticulture Department, Faculty of Agriculture, Minia University.

### 2.2. Experimental design and treatments

The experiment was arranged in a randomized complete block design (RCBD) with three replicates. Garlic cloves were selected uniform in shape and size. The cloves were sown on both sides of each row at a distance of 10 cm apart within the row. Each plot contains 5 rows and each row was 60 cm width and 3.5 m length, therefore the plot area was 10.5 m<sup>2</sup>. Planting dates were done on the 20<sup>th</sup> and 23<sup>th</sup> September in winter seasons of 2016/2017 and 2017/2018, respectively. The soil texture is clay-loam and physical and chemical properties of the used soil are listed in Table (1). Soil samples were collected at 25 cm below soil surface. All agricultural practices were done according to the recommendations of the Egyptian Ministry of Agriculture, Agriculture Research Center (ARC). Foliar application of garlic plants was including 14 treatments, they have been applied as follow:

- 1- Chitosan with three concentrations (500 ppm, 1000 ppm and 1500 ppm).
- 2- Royal Jelly with three concentrations (0.1, 0.2 and 0.3 g/L<sup>-1</sup> and tap water as a control treatment).
- 3- Spraying with tap water was used as control treatment.

Spraying treatments were applied twice at 90 and 120 days from the planting date. Control treatment was sprayed at the same time of all other treatments. Chemical analysis of Royal jelly is shown in Table (2).

### 2.3. Measurements

Ten garlic plants were selected randomly from each treatment, data before and after harvesting (190 days after sowing) were recorded as follow:

#### 2.3.1. Before

1. Plant height (cm)
2. Number of leaves/plant
3. Bulbing ratio after 130 and 145 from cultivation was calculated according to Mann 1952.

$$\text{Bulbing ratio} = \frac{\text{Neck diameter (cm)}}{\text{Bulb diameter (cm)}}$$

#### 2.3.2. After harvesting stage characters

1. Plant without bulb fresh weight (g)
2. Whole plant fresh weight, (g)
3. Bulb weight, (g)
4. Single clove weight, (g)
5. Number of cloves /bulb
6. Total Soluble Solids (TSS) oven dry weight with a Refractometer
7. Bulbing ratio at harvesting Percentage of weight loss after 15, 45, 75, 105 and 135 days from harvesting

**Table 1.** Physical and chemical properties of the used soil at 0-30 cm depth during the two seasons of 2017/2018 and 2018/2019.

Constituents	Value	
	1 <sup>st</sup> season	2 <sup>nd</sup> season
Sand (%)	28.20	28.98
Silt (%)	30.70	29.87
Clay (%)	40.10	41.15
Soil type	Clay loam	Clay loam
Organic matter (%)	1.59	1.57
CaCO <sub>3</sub> (%)	2.08	2.10
pH(1:2.5)	7.80	7.77
E.C.(m mhos/cm)	1.06	1.07
Total N (%)	0.07	0.08
Available P (%)	15.15	15.64
Available K <sup>+</sup> (mg/100g)	2.09	2.82
Available Ca <sup>++</sup> (mg/100g)	31.71	31.10
Available Na <sup>+</sup> (mg/100g)	2.42	2.53
Available micronutrients ( EDTA, ppm):		
Fe	8.52	8.22
Cu	2.05	2.02
Zn	2.74	2.85
Mn	8.24	8.09

### 2.4. Statistical analysis

The statistical analysis of the collected data was carried out using the MSTAT-C program (Version 4) and means were compared

using the Duncan's multiple Range Test (DMRT) according to Gomez and Gomez (1984).

**Table 2.** Chemical analysis of royal jelly (Townsend and Lucas, 1966).

Constituents	Values mg/ 100 g F.W.
Water	65.3
Dry matter	34.7
Portents	48.2
Carbohydrate	37.8
Lipids	10.4
Ash	2.0
Sugar	23.0
Glucose	4.0
Fructose	4.0
Sucrose	5.0
<b>Nutrients (ppm)</b>	
K	220
Mg	105
Ca	112
Fe	50
P	118
S	44
Mn	32
Si	5
<b>Vitamins (mg/ 100 g F.W.)</b>	
Vitamins B1	0.4
Vitamins B2	0.3
Vitamins B5	0.4
Vitamins B6	0.3
Vitamins B8	0.3
Vitamins B9	0.4
Vitamins B12	0.3
A	0.4
C	0.9
D	0.5
K	0.4
E	0.3
Essential amino acids	110

### 3. Results and discussion

#### 3.1. Vegetative parameters

The potential effect of foliar spray with different chitosan (CS) and royal jelly (RJ) doses on some vegetative traits was shown in Table (3). Generally, garlic cultivars Egaseeds1(Ega1) and Egyptian (Egy) treated with different doses of CS and RJ exhibited considerable increase in plant height (PH) and leaves number / plant (LN) traits at the two tested time (130 and 145 days) during both seasons as compared with control. The highest values of PH at 130 days were recorded in Ega1 plants sprayed with 1500 ppm CS (78.34 and 81.30 cm) and 0.03g/l RJ

(79.67 and 78.73 cm) In both seasons, respectively. While Egy cultivar plants treated with 1500ppm CS (83.13 and 83.43cm) and 0.2g/l RJ (85.20 and 84.80cm) gave the highest values with a significant increase with almost all other treatments during both seasons respectively. The results of PH trait at 145 days were in harmony with the previous finding.

High doses (1500ppm CS and 0.3g/l RJ) gave the highest values of LN/plant (7.17 and 7.17) and (7.23 and 7.33) at 130 days, respectively. In the case of the Egy cultivar, results showed that plants sprayed with 1500ppm CS and 0.2g/l RJ outperformed all other treatments during both seasons (9.10 and 8.70), respectively (9.67 and 9.11). The obtained LN/plant data at 145 days were consistent with our previous results from both seasons. Table 3 shows that at 130 days, there were no significant differences in bulbing ratio (BR) trait between all treatments and the control. At both seasons, Ega 1 plants sprayed with 1000ppm CS (0.236 and 0.268) and 0.2g/L RJ (2.63 and 2.60) produced the best results when compared to control (2.81 and 2.79). Plants of the Egy cultivar sprayed with 1000ppm CS (0.361 and 0.360) and 0.2g/L RJ (0.371 and 0.351) at 130 days in both seasons produced the best results in the BR trait. At 145 days, the results of BR were similar to those obtained in our previous findings.

Many investigators reported that using chitosan as foliar spray increased vegetative growth (Abdel-Mawgoud *et al.*, 2010; Kamal and Ghanem, 2011; Sheikha and Al-Malki, 2011; Fawzy *et al.*, 2012; Ahmed, 2015 ).The promoting effect of chitosan on plant growth may be attributed to increase the availability of water and essential nutrients uptake by adjusting cell osmotic pressure, in addition to, decrease the accumulation of harmful free radicals (ROS) by increasing antioxidants and enzyme activities (Guan *et al.*, 2009). Many authors (Chibu and Shibayama, 2003; Gornik *et*

*al.*, 2008; Said *et al.*, 2012) reported that chitosan enhance plant growth and development by increasing the activation nitrogen metabolism enzymes (nitrate reductase, glutamine synthetase and protease) and improve the transportation of nitrogen (N) in the functional leaves which enhanced plant growth and development. On the other hand, the positive effect of royal jelly on plant growth may be due to its contents of hormones and nutrition elements (Nation and Robinson, 1971; Wassel *et al.*, 2015). These findings are supported by those obtained by El-Maziny and Hassan (1990) and Dalia and El-Aref, (2016).

### 3.2. Yield, yield components and quality

The effect of foliar spray with different doses of chitosan (CS) and royal jelly (RJ) on some yield and quality traits of garlic plants were shown in Tables (4 and 5). The present results showed spraying Ega1 plants with different doses of CS and RJ decreased the bulbing ratio at harvesting time BRH at both seasons as compared with control (0.181 and 0.187, respectively). It was observed that BRH decreased with increasing doses of both CS and RJ. The best values of BRH were found in Ega 1 plants sprayed with 1500 ppm CS (0.120 and 0.164) and 0.3g/L RJ (0.160 and 0.169) at both seasons respectively. On the other side, all CS and RJ treatments decreased the BRH of Egyptian cultivar plants (Egy) in both seasons as compared with control (0.233 and 0.224, respectively). The best results were found in Egy plants sprayed with 1000ppm CS (0.185 and 0.200) and 0.1g/L RJ (0.1901 and 0.195) during both seasons respectively. According to data in Table (4), Ega1 plants sprayed with 0.3g/L RJ exhibited the highest values of plant without bulb fresh weight TFW (41.33 and 41.44g) at both seasons respectively as compared with all other treatments and control (36.93 and 37.04g).

Spraying Egy plants with various doses of CS and RJ increased TFW, with the exception of

1500 ppm CS, which produced the lowest values (19.24 and 20.00g) in both seasons when compared to all other treatments. In general, all CS and RJ spraying treatments increased bulb weight BW of Ega1 and Egy plants in both seasons when compared to control. Plants sprayed with 0.1g/l RJ had the highest BW values of Ega1 (92.28 and 99.31g). In the Egy cultivar, 0.2g/l RJ produced the highest BW values (58.02 and 63.06g) in both seasons.

The promoting effects of both CS and RJ spraying treatments on TFW and BW have been reflected on plant fresh weight PFW of the two garlic cultivars (EGA1 and EGY). The obtained results showed the clear increase in PFW in all plants treated different doses of CS and RJ. The highest values of PFW were found in Ega1 plants treated with 0.1g/l RJ (128.48 and 132.87g) at both seasons respectively while, 0.2g/l RJ gave the highest values of PFW in Egy plants (86.55 and 83.06g) during both seasons respectively. Data showed that spraying Ega1 plants with different doses of Cs and RJ considerably increased total yield TY at both seasons as compared with control (13.39 and 14.64 tons). The highest values of TY were found in Ega1 plants treated with 0.1g/l RJ (15.29 and 15.80 tons) and 0.3g/l RJ (15.08 and 16.61 tons) at both seasons respectively. On the other side, there were clear increase in TY of Egy plants treated with different CS and RJ doses at both seasons as compared with control (7.57 and 8.69 tons, respectively). The highest values of TY were found in Egy plants treated with 0.2g/L RJ (9.23 and 8.53 tons) at both seasons respectively as compared with all other treatments.

As shown in Table (5) spraying Ega1 plants with different doses of CS and RJ gave quite close results in No. cloves/bulb trait. The highest values were found in plants treated with 0.2g/L RJ at the both seasons (19.54 and 20.48, respectively). On the other hand, there was significant increase in No. Cloves/bulb in Egy

cultivar treated with almost all CS and RJ treatments as compared with control at both seasons. The highest values of No. cloves/bulb were obtained in plant treated with 0.3g/L RJ at both seasons (38.98 and 39.03, respectively). Regarding clove weight (g) trait, data showed that all Cs and RJ treatments increased significantly clove weight of Ega1 plants as compared with control. The highest values of clove weight were found in Ega1 plants sprayed with 0.3g/L RJ at both seasons (4.40 and 4.63g, respectively). On the other side, there were insignificant increase between all tested treatments and control in clove weight trait of Egy cultivar plants.

The obtained results in Table (5) showed that there were no significant differences between all tested treatments and control in percentages of TSS in both Ega1 and Egy cultivars in both seasons. It was found that spraying Ega1 plants with all CS and RJ concentrations decreased the moisture% content in cloves in both seasons as compared with control (54.75 and 55.10%, respectively) except 0.3g/L RJ treatment which gave high values (55.99 and 55.60%) at both seasons respectively. Similar results were recorded on Egy cultivar. Among all tested treatments, only 500ppm CS gave high values of percentages of moisture in cloves during both seasons (59.16 and 60.06%, respectively) as compared with control and all other spraying treatments.

Chitosan is widely used for increasing vegetative growth, yield and quality of vegetable crops (Sheikha and Al-Malki, 2011; Farouk *et al.*, 2011; Mona, 2015; Zayed *et al.*, 2017; Abeer *et*

*al.*, 2018; Parvin *et al.*, 2019), and to improve storability of fruits and vegetables (El Ghaouth *et al.*, 1991). Chitosan enhances both qualitative and quantitative characteristics of crops because it promotes nutrient uptake of the plant (Malerba and Cerana, 2016). as well as, plant resistance to diseases in several vegetable and fruit crops (Shehata *et al.*, 2012). The increase in bulbs yield could be attributed to the increase in some amino acids and nutrients required for growth (Ahmed, 2015). The positive effect of royal jelly on total yield (ton/feddan) may be attributed to its higher content from nutrients, amino acids, lipids, fructose, glucose, sucrose, vitamins and fats (El-Shaikh, 2010; Ibrahim *et al.*, 2015). Our results are in accordance with previously reported results of (El-Shaikh, 2010; Dalia and El-Aref, 2016; Çavuşoğlu, *et al.*, 2017).

### 3.3. Percentages of weight loss

Data presented in Figure (1) showed that weight loss % after 15, 45, 75, 105 and 135 days from harvesting. Results revealed that highest values were found in untreated (control) Ega1 and Egy plants (52.04 and 51.05%, respectively) followed by Ega1 plants sprayed with 0.1g/l royal jelly 49.69%. The lowest values of weight loss character was found in Egy cultivar treated with 1500ppm chitosan (35.7%) followed by Egy cultivar sprayed with 0.2g/l royal jelly (36.04%) these results for both 1<sup>st</sup> and 2<sup>nd</sup> seasons, the results are no different than before for the highest and the lowest values. for weight loss percent after 45 day from

**Table 3.** Effect of foliar spray with chitosan (CS) and royal jelly (RJ) on plant height (P.H.), Number of leaves per plant (L.N.) and bulbing ratio (B.R.) at 130 and 145 days from planting in two garlic cultivars Egaseed1 (Ega1) and Egyptian (Egy.) at two successive seasons 2017/2018 and 2018/2019.

Bio-stimulates	P.H. at 130 days (cm)		L.N. at 130 days		B.R. at 130 days		P.H. at 145 days (cm)		L.N. at 145 days		B.R. at 145 days	
	1 <sup>st</sup> season	2 <sup>st</sup> season	1 <sup>st</sup> season	2 <sup>st</sup> season	1 <sup>st</sup> season	2 <sup>st</sup> season	1 <sup>st</sup> season	2 <sup>st</sup> season	1 <sup>st</sup> season	2 <sup>st</sup> season	1 <sup>st</sup> season	2 <sup>st</sup> season
Control Ega1	70.933 e	72.13 c	6.40 g	6.33 h	0.281 b	0.279 b	77.87 d	79.33 e	7.20 f	6.90 f	0.238 cdef	0.239 d
Ega1+500ppm CS	72.20 e	71.63 c	6.63 g	6.80 ef	0.278 b	0.271 b	79.17 d	78.30 e	7.40 ef	7.50 e	0.223 efg	0.233 de
Ega1+ 1000ppm CS	73.14 e	71.43 c	6.43 g	6.13 gh	0.263 b	0.268 b	78.20 d	80.10 de	7.76 e	7.30 ef	0.213 h	0.199 g
Ega1+1500ppm CS	78.34 c	81.30 abc	7.17 f	7.17 df	0.274 b	0.275 b	78.40 d	79.80 de	8.76 d	8.23 cd	0.226 efg	0.219 f
Ega1+0.1g/L RJ	71.47 e	75.27 abc	6.50 g	6.60 fg	0.274 b	0.282 b	77.90 d	79.37 e	7.40 ef	7.86 de	0.221 fgh	0.228 e
Ega1+0.2g/L RJ	77.47 cd	78.13 abc	6.47 g	6.50 fgh	0.263 b	0.260 b	78.37 d	80.47 de	7.40 ef	7.33 ef	0.218 gh	0.218 f
Ega1+0.3g/L RJ	79.67 bc	78.73 abc	7.23 f	7.33 d	0.267 b	0.295 b	82.63 b	83.60 bc	8.70 d	7.83 de	0.227 efgh	0.233 de
Mean	74.75	74.80	6.69	6.69	0.273	0.277	78.93	80.14	7.80	7.56	0.271	0.224
Control Egy.	74.25 de	74.48 bc	7.37 f	7.50 d	0.382 a	0.280 b	78.20 d	79.50 de	8.73 d	8.47 bc	0.280 a	0.279 a
Egy. + 500ppm CS	78.80 c	79.23 abc	7.67 f	7.93 c	0.374 a	0.375 a	82.50 b	83.53 bc	8.73 d	8.66 bc	0.252 bcd	0.264 b
Egy. +1000ppm CS	79.74 bc	79.47 abc	7.93 de	7.27 d	0.361 a	0.360 a	82.23 bc	84.00 bc	8.96 cd	8.67 bc	0.245 cde	0.261 bc
Egy. +1500ppm CS	83.13 ab	83.43 ab	9.10 b	8.70 b	0.362 a	0.377 a	90.87 a	91.10 a	10.23 b	10.13 a	0.268 ab	0.269 b
Egy. +0.1g/L RJ	78.40 c	78.97 abc	8.27 c	8.17 c	0.372 a	0.359 a	84.43 b	84.93 b	9.33 c	9.00 b	0.265 ab	0.266 b
Egy. +0.2g/L RJ	70.93 e	79.37 abc	8.00 cd	7.93 c	0.371 a	0.351 a	91.33 a	91.53 a	11.07 a	10.46 a	0.235 defg	0.255 c
Egy. +0.3g/L RJ	85.20 a	84.80 a	9.67 a	9.11 a	0.377 a	0.368 a	80.20 cd	81.77 cd	8.97 cd	8.78 b	0.277 a	0.278 a
Mean	78.636	79.964	8.287	8.087	0.377	0.368	84.251	85.194	9.431	9.167	0.260	0.267

Note: In each column mean of each treatment followed by the same letter (s) are not significant at 0.05 level of probability by Duncan's Multiple Range Test (DMRT)

**Table 4.** Effect of foliar spray with chitosan (CS) and royal jelly (RJ) on plant without bulb fresh weight TFW (g), bulb weight BW(g), plant fresh weight PFW (g), bulbing ratio at harvesting B.R.H and total yield TY (tone/fed.) in two garlic cultivars Egaseed1 (Ega1) and Egyptian (Egy) at two successive seasons 2017/2018 and 2018/2019.

Bio-stimulates	B.R.H		TFW (g)		BW (g)		PFW (g)		TY (tone/fed.)	
	1 <sup>st</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	2 <sup>nd</sup>
Control Eg1	0.181 bc	0.187 ef	36.93 ab	37.04 b	74.85 d	84.90 b	111.78d	121.94b	13.39 b	14.64 d
Ega1+500ppm CS	0.181 bc	0.184 f	36.13 ab	36.53 d	85.21 b	85.54 b	121.10b	122.06b	14.56 ab	14.63 d
Ega1+ 1000ppm CS	0.174 bc	0.178 f	31.37 bcd	34.34 f	89.33 b	93.74 ab	122.70b	126.87ab	14.52 ab	15.22 c
Ega1+1500ppm CS	0.120 c	0.164 g	35.89 ab	36.72 c	91.33 a	92.53 ab	121.46b	130.45a	14.72 ab	15.65 c
Ega1+0.1g/L RJ	0.178 bc	0.182 f	35.18 ab	33.56 g	92.28 a	99.31 a	128.48a	132.87a	15.29 a	15.80 c
Ega1+0.2g/L RJ	0.166 bc	0.181 f	36.20 ab	35.63 e	81.16 c	85.75 b	116.34c	121.38b	13.96 ab	14.80 d
Ega1+0.3g/L RJ	0.160 bc	0.169 g	41.33 a	41.44 a	84.41 b	88.64 cd	125.74a	130.08a	15.08 a	16.61 a
Mean	0.166	0.178	36.147	36.466	84.939	85.770	121.09	122.24	14.474	15.336
Control Egy.	0.233 a	0.224 a	20.97 fg	21.08 m	42.22 i	49.96 d	63.19h	73.46c	7.57 d	8.69 i
Egy. + 500ppm CS	0.218 b	0.204 b	24.70 efg	25.77 i	45.26 h	49.54 d	69.96g	75.31c	8.38 cd	8.90 hi
Egy. +1000ppm CS	0.185 bc	0.200 b	22.31 fg	22.24 l	54.52 g	53.52 cd	73.83d	75.76c	8.70 cd	9.94 ef
Egy. +1500ppm CS	0.206 bc	0.213 a	19.24 g	20.00 n	53.37 f	61.80 c	72.61g	81.88c	8.49 cd	9.13 gh
Egy. +0.1g/L RJ	0.190 bc	0.195 de	25.23 bc	23.03 j	48.89 g	54.05 cd	81.12c	77.08c	8.51 cd	9.24 gh
Egy. +0.2g/L RJ	0.193 bc	0.198 de	28.52 cde	22.50 k	58.03 e	63.06 c	86.55c	83.06c	9.23 c	9.53 fg
Egy. +0.3g/L RJ	0.206 bc	0.208 bc	25.67 def	26.38 h	48.65 g	53.14 cd	74.32g	79.52c	8.92 cd	9.97 e
Mean	0.231	0.206	24.806	23.000	54.420	55.010	79.23	78.01	8.543	9.343

Note: In each column mean of each treatment followed by the same letter (s) are not significant at 0.05 level of probability by Duncan's Multiple Range Test (DMRT)



**Table 5.** Effect of foliar spray with chitosan (CS) and royal jelly (RJ) on number of cloves/bulb, Single clove weight (g), T.S.S % and moisture in cloves in two garlic cultivars Egaseed1 (Ega1) and Egyptian (Egy) at two successive seasons 2017/2018 and 2018/2019.

Bio-stimulates	No. Cloves/bulb		Single clove weight (g)		T.S.S%		Moisture in Cloves%	
	1 <sup>st</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	2 <sup>nd</sup>
Control Ega1	17.06 hi	18.47 hi	3.21 d	3.55 d	37.64 a	37.97 a	54.75 cd	55.10 cd
Ega1+500ppm CS	17.40 hi	17.74 ij	3.70 c	4.04 c	37.70 a	37.68 a	53.32 efg	53.63 d
Ega1+ 1000ppm CS	18.44 fg	18.88 h	4.37 a	3.84 c	38.76 a	39.08 a	53.23 efg	54.150 cd
Ega1+1500ppm CS	17.81 gf	17.74 ij	3.56 c	4.37 ab	40.66 a	40.26 a	54.57 cd	54.32 cd
Ega1+0.1g/L RJ	16.70 i	17.40 j	4.10 b	4.60 ab	38.12 a	38.90 a	54.04 de	54.34 cd
Ega1+0.2g/L RJ	19.54 e	20.48 g	4.24 ab	4.34 b	36.84 a	38.00 a	52.33 g	48.36 e
Ega1+0.3g/L RJ	18.89 ef	19.80 g	4.40 a	4.63 a	40.10 a	39.96 a	55.99 b	55.60 bcd
Mean	17.977	18.644	3.940	4.196	38.546	37.121	54.033	53.643
Control Egy.	32.32 d	32.85 d	0.810 e	0.800 e	36.45 a	37.12 a	58.34 a	53.80 cd
Egy. + 500ppm CS	37.21 b	36.73 cd	0.850 e	0.890 e	37.00 a	38.21 a	59.16 a	60.06 a
Egy. +1000ppm CS	37.29 b	37.42 bc	0.750 e	0.793 e	38.57 a	38.57 a	54.96 def	54.05 cd
Egy. +1500ppm CS	35.43 c	35.83 e	0.883 e	0.923 e	38.83 a	41.71 a	56.450 b	56.00 bc
Egy. +0.1g/L RJ	37.31 b	38.08 b	0.923 e	0.950 e	38.09 a	41.23 a	53.34 efg	57.49 b
Egy. +0.2g/L RJ	35.87 c	36.40 de	0.850 e	0.873 e	38.54 a	38.38 a	55.52 bc	54.88 cd
Egy. +0.3g/L RJ	38.98 a	39.03 a	0.823 e	0.860 e	38.78 a	39.58 a	52.83 fg	53.53 d
Mean	36.344	36.620	0.841	0.870	36.609	39.257	55.800	55.687

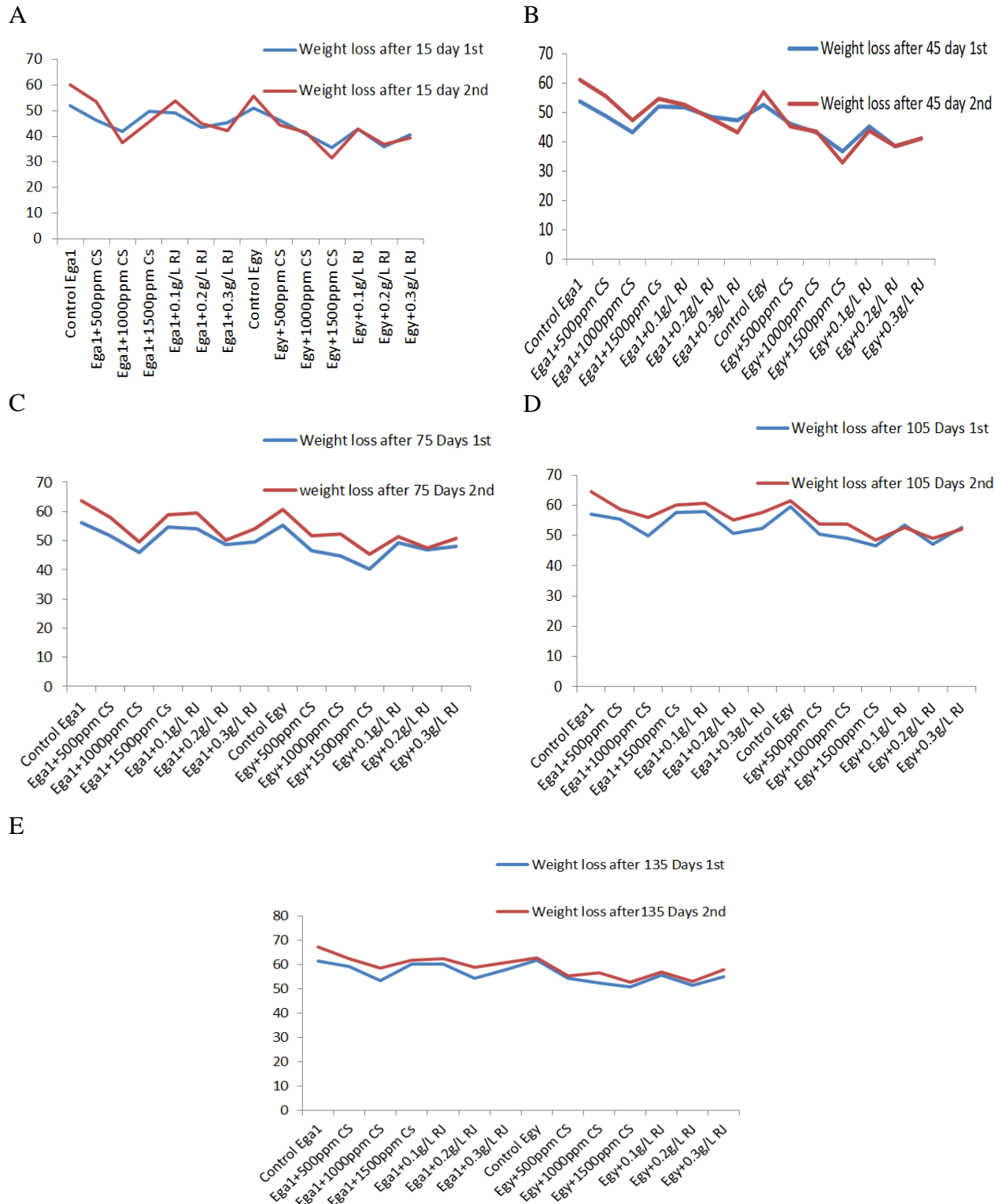
harvesting the highest value was 53.94% for 1<sup>st</sup> and 61.31% for 2<sup>nd</sup> season. After 75 days from harvesting the highest values were 56.23% for the 1<sup>st</sup> season and 63.65% for 2<sup>nd</sup> season. After 105 and 135 day from harvesting the highest values found with control plants of both cultivars. The lowest values were found in Egy cultivar sprayed with 1500ppm chitosan after 15, 45, 75, 105 and 135 days from harvesting.

Because chitosan produces a semipermeable film that regulates gas exchange and minimizes transpiration and respiration, it increases the storability of post-harvest fruits and vegetables. As a result, water loss is minimized and fruit

ripening is slowed. Tomatoes and strawberries (Jiang and Li, 2001; Kittur *et al.*, 2001; Bautista-Baos *et al.*, 2006), on (Raghuram and Srividya, 2013), and garlic (Raghuram and Srividya, 2013) have all been documented to have this impact (Khreba, *et al.*, 2014; El-Sagan and El Dsouky, 2015).

#### 4. Conclusion

From the previous results it could be concluded that the foliar application of chitosan (1000 and 1500 ppm) and Royal Jelly (0.2 and 0.3 g.L-1) can be used to enhance yield, quality and storability of garlic plants grown in loamy clay soil.



**Figure 1.** Effects of three of chitosan (500, 1000 and 1500ppm) and royal jelly (0.1, 0.2 and 0.3g/L) concentrations on weight loss % of two garlic cultivars after 15, 45, 75, 105 and 135 days from harvesting in two successive seasons.

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