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Response of Cucumber Plants to Foliar Application of Chitosan and Yeast under Greenhouse Conditions

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Abstract: The present study was carried out in two successive seasons of 2010 and 2011 to study the effect of foliar application of chitosan rates (1, 2, 3 and 4 mlL^{-1}) and yeast rates (1, 2, 3 and 4 gL^{-1}) on growth, yield and quality as well as chemical constituents of cucumber plants. Results of this work showed that foliar application with yeast and chitosan increased significantly the vegetative growth, yield and its quality of cucumber. Meanwhile, foliar spraying with active dry yeast at rates of 4 g L^{-1} recorded highest values of T.S.S., N (%), Fe, Zn, Cu and Mn (mg kg^{-1}) in cucumber fruits. However, foliar application of chitosan at rates of 4 mlL^{-1} gave highest contents of P and K % in the two seasons of study. It can be concluded that foliar application with chitosan at rates of 4 mlL^{-1} recorded the best treatment to obtain the highest vegetative growth, yield and quality of cucumber plants.

Key words: Cucumber (*Cucumis sativus* L), Chitosan, Yeast, Foliar application, Growth, Yield, Chemical contents.

INTRODUCTION

Cucumber (*Cucumis sativus* L) is an important vegetable and one of the most popular members of the cucurbitaceae family (Thoa, 1998). It is thought to be one of the oldest vegetables cultivated by man with historical records dating back 5,000 years (Wehner and Guner, 2004). Natural resources or ecologically friendly agriculture is increasingly being adopted around the world. Therefore, it is advisable to use a safe agriculture system for cucumber production.

Dry yeast is a natural bio-substance suggested to have stimulating, nutritional and protective functions when used on vegetables. Foliar application of yeast was found to increase growth, yield and quality of many vegetable crops (Abou El-Nasr *et al.*, 2001*;* Kabeel *et al.*, 2005 and Fawzy, 2007). In this connection, yeasts have been reported to be enriched source of phytohormones (especially cytokinins), vitamins, enzymes, amino acids and minerals (Barnett *et al.*, 1990*;* Fathy and Farid, 1996*;* Khedr and Farid, 2002 and Mahmoud, 2001). It was also reported about its stimulatory effects on cell division and enlargement, protein and nucleic acid synthesis and chlorophyll formation (Kraig and Haber, 1980*;* and Castelfranco and Beale, 1983). It participates in a beneficial role during stress due to its cytokinins content (Barnett *et al.* 1990). Improving growth and productivity of vegetable crops by application of active yeast extract were recorded by Amer (2004), and El-Tohamy and El-Greadly (2007) on beans; Hewedy *et al.* (1996) and El-Tohamy *et al.* (2008) on eggplant, El-Ghamriny *et al.* (1999) and Fathy *et al.* (2000) on tomatoes, Tartoura (2001) and El-Desuki and El-Greadly (2006) on pea, Taha and Omar (2010) and Ahmed *et al.* (2011) on potato plants.

Chitosan, a given name to a deacetylated form of chitin, is a natural biodegradable compound derived from crustaceous shells such as crabs and shrimps, whose main attributes corresponds to its polycationic nature (Bautista-Baños *et al.,* 2006). Chitosan also, a high molecular polymer, nontoxic, bioactive agent has become a useful appreciated compound due to its fungicidal effects and elicitation of defense mechanisms in plant tissues (Terry and Joyce, 2004). Chitosan is a low acetyl form of chitin mainly composed of glucosamine, 2-amino-2-deoxy-*β*-D-glucose (Freepons, 1991). The positive charge of chitosan confers to this polymer numerous and unique physiological and biological properties with great potential in a wide range of industries such as cosmetology (lotions, hair additives, facial and body creams) (Lang and Clausen, 1989), food (coating, preservative, antioxidant, antimicrobial) (Shahidi *et al.,* 2001), biotechnology (chelator, emulsifier, flocculent) (Sandford, 1989) pharmacology and medicine (fibers, fabrics, drugs, membranes, artificial organs) (Liu *et al.,* 2001) and agriculture (soil modifier, films, fungicide, elicitor) (Ren *et al.,* 2001 and Bautista-Baños *et al.,* 2006). An additional positive effect of chitosan coatings is related to its ability to extend the storage life of fruits and vegetables. Chitosan forms a semipermeable film that regulates the gas exchange and reduces transpiration loses and fruit ripening is slowed down. Because chitosan is applied as a coating, generally respiration rate and hence water loss is reduced. This effect has been reported for numerous horticultural commodities such as tomatoes, strawberries, apples, mangoes, bananas, bell peppers, etc. (Jiang and Li, 2001*;* Kittur *et al.*, 2001 and Bautista-Baños *et al.,* 2006). Moreover, the degraded chitin can be an efficient nitrogen source. However, direct

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application of chitosan is not approved as an organic growing method. In addition, chitosan treatment has been shown to stimulate plant growth (Kim, 2005) and to improve storability of postharvest fruits and vegetables (El Ghaouth *et al.,* 1991). Many investigators reported that using chitosan as foliar spray increased vegetative growth, yield and quality of vegetable crops (Abdel-Mawgoud *et al.,* 2010*;* Ghoname *et al.,* 2010 and Fawzy *et al.,* 2012).

Therefore, the present investigation was designed to disclose the influence of different levels from active dry yeast and chitosan on vegetative growth, yield and quality as well as chemical contents of cucumber plants.

MATERIALS AND METHODS

The present investigation was carried out during the two successive seasons of 2010 and 2011 in the Experimental Station of the Faculty of Agriculture, Abou-Atata, Giza, Egypt, to study the effect of foliar application of some bio-stimulants (active dry yeast and chitosan) compounds on growth, yield and quality as well as chemical composition of cucumber plants. Cucumber cv. Celebrity F1 was planted on the 6th and 9th May in the first and second seasons, respectively. Pest control and other agricultural practices, such as fertilization and irrigation, etc. were applied, wherever it was necessary and as commonly recommended in the commercial cucumber production in greenhouse condition. The experimental design included foliar application of active dry yeast and chitosan with the following levels:

Treatments	Levels
T1	Control (tap water)
T2	1 g L^{-1} yeast
T3	2 g L^{-1} yeast
T4	3 g L^{-1} yeast
T5	4 g L^{-1} yeast
T6	1 ml L^{-1} chitosan
T7	2 ml L^{-1} chitosan
T8	3 ml L^{-1} chitosan
T9	4 ml L^{-1} chitosan

With regarding to the chemical analysis of the dry yeast, N.R.P (1977) stated that, the analysis of dry yeast was protein (47.2%), arginine (2.6%), glycine (2.6%), histidine (1.4%), isolysine (2.9%), lauicine (3.5%), lysine (3.8%), methionine cystine (0.6%), phenyl-alanine (3%), tyrosine (2.1%), threonine (2.6%), tryptophan (0.5%) and vitamin B (2.9%). Khedr and Farid (2002) reported that, yeast preparation contained carbohydrates, sugars, proteins, fatty acids, amino acids, hormones, macro and micro elements in suitable balance.

Chitosan (2-Amino-2-deoxy-*β*-D-glucosasmine) solution was prepared by dissolving a proper amount of Chito – Care® (an Egyptian commercial product of chitosan) in fresh water. Spraying treatments were started after 25 days of transplanting and every 7 days for 3 times through the growing season. The experimental design was a complete randomized blocks with four replications for each treatment.

Data Recorded:

***- Plant Growth*:**

Random samples of three plants were taken after 80 days transplanting from each treatment to measure plant growth parameters i.e., plant height (cm), number of leaves/plant and fresh and dry weight of leaves and stem of plant (g).

- Fruit Yield and Quality:

Cucumber fruits at marketable stage were harvested twice weekly. At harvest, number of fruits/plant, mean weight of fruit, fruit length, fruit diameter and total yield (kg/plant) in each treatment were recorded.

***- Fruit Analysis*:**

In order to determine the mineral contents of plant fruit, the samples were oven-dried at 65^{o}C for 48 h and then ground. Total nitrogen and phosphorus concentrations were determined using Kjeldahl method and colorimetric method using spectrophotometer (SPECTRONIC 20 D, Milton Roy Co. Ltd., USA), respectively, according to the procedure described by Cottenie (1980). Potassium concentration was measured using flame photometer method (JENWAY, PFP-7, ELE Instrument Co. Ltd., UK) as described by Chapman and Pratt (1982). Some micro-nutrients, i.e. Fe, Cu, Zn and Mn were determined using Atomic Absorption Spectroscopy (AAS) according to Chapman and Pratt (1961).

The results were analyzed statistically by a General Linear Model procedure and 2 way analysis of variance (ANOVA) using Cohort computer program according to the method of Gomez and Gomez (1984). Mean separation procedure was performed using Duncan's test at a 0.05 level of significance.

RESULTS AND DISSCUSION

Growth Characteristics:

The results presented in the Table (1) clearly revealed that, foliar spraying of bio-stimulants "yeast and chitosan" significantly had influence on all growth characters (plant height, number of leaves, fresh and dry weight of leaves and stems) in the two seasons with exception for leaves number in the second season only. The highest plant height (250 cm for season 2010) was recorded by foliar application of chitosan at a rate of 4 ml L^{-1}. Meanwhile, the lowest plant height (102 cm for season 2011) was found by control treatment (foliar spraying with tap water). These similar results were obtained in both of the two seasons of study. With regarding of leaves number, the highest number of leaves (30.5 for season 2010) was recorded by foliar spraying of yeast at rates of 4 gL^{-1}. However, lowest number (16.5 for season 2011) was recorded by foliar application of water (control). However, data in Table 1 found that, the highest fresh and dry weight of leaves (169.6 and 22.9 g, respectively in case of season 2010) were recorded by foliar spraying of yeast at rates of 2 gL^{-1} in both of the two seasons of study. Meanwhile, the lowest fresh and dry weight of leaves of cucumber plants (5.7g) were recorded by control treatment except for fresh weight of leaves (88.3g) in the second season only, which was found by foliar spraying of chitosan at rates of 4 mlL^{-1}.

The positive effects of dry yeast application were reflected its significance as a natural source of cytokinins, vitamins, enzymes, amino acids and minerals (Khedr and Farid, 2002*;* Mahmoud, 2001). It was reported that, dry yeast has stimulatory effects on cell division and enlargement, protein and nucleic acid synthesis and chlorophyll formation (Kraig and Haber, 1980*;* Castelfranco and Beale, 1983). It participates in a beneficial role during stress due to its content of cytokinins (Barnett *et al.,* 1990). Improving growth and productivity of vegetable crops by application of active yeast extract were recorded by several studies such as on beans (Fathy and Farid, 1996; Amer, 2004 and El-Tohamy and El-Greadly, 2007) on eggplant (Hewedy *et al.,* 1996 and El-Tohamy *et al.,* 2008), on tomatoes (El-Ghamriny *et al.,* 1999 and Fathy *et al.,* 2000), on pea (Tartoura, 2001 and El-Desuki and El-Greadly, 2006) on Snap bean (Fawzy *et al.,* 2010), on sweet pepper (Ghoname *et al.,* 2010) and on potatoes (Taha and Omar, 2010 and Ahmed *et al.,* 2011). Data in Table 1 show clearly that, the highest fresh and dry weight of cucumber stems were recorded by foliar spraying of chitosan at rate of 1 ml L^{-1}. Meanwhile, the lowest amount was recorded by control treatment (foliar spraying with tap water). These results were similar in the two seasons of study.

Chitosan also promoted growth of various crops such as cabbage (Hirano, 1988), soybean sprouts (Lee *et al.,* 2005), sweet basil (Kim, 2005), strawberry (Abd El Mawgoud *et al.,* 2010) and sweet pepper plants (Ghoname *et al.,* 2010). Several experiments on the effects of concentration and frequency of chitosan application were conducted using various crops such as chilli, Chinese cabbage, celery and bitter cucumber (Chandrkrachang *et al.,* 2003 and Boonlertnirun *et al.,* 2005). It is reported that, chitosan concentration and frequency of application significantly increased growth rates of chilli and the harvest yield of Chinese cabbage (Chandrkrachang *et al.,* 2003). Lee *et al.* (2005) found that chitosan treatment increases the yield and marketability of soybean sprouts. However, the mechanism of action of chitosan on plant growth remains unclear.

Total Yield and its Quality of Cucumber Fruits:

The results presented in the Table (2) clearly revealed that, foliar spray of bio- stimulants (yeast and chitosan) had significantly effect on all quality characteristics (fruit length, fruit diameter, fruit weight and T.S.S) and total yield of cucumber fruits in the two seasons of study except for T.S.S in the first season only. Meanwhile, the highest fruit length and T.S.S content of cucumber (21 and 15.3 cm and 3.6 %, for season 2010 and 2011, respectively) were recorded by foliar spraying of yeast at a rate of 4 g L^{-1}. Whereas, the lowest fruit length and T.S.S content of cucumber (17 and 14.3 cm and 3.1 and 2.4 %, in the two seasons respectively) was recorded by control (spraying with tap water). The positive effects of applying active dry yeast was attributed to increase contents of different nutrients, high percent of protein, high amounts of vitamin B and natural plant growth regulators such as cytokinins (Glick, 1995 and Fathy and Farid, 1996); physiological roles of vitamins and amino acids in the yeast extract which increased the metabolic processes role and levels of endogenous hormones i.e., IAA and GA3 (Chaliakhyan, 1957 and Sarhan and Abdullah, 2010). Similar trend of results, as previously, were reported by several scientists for several crops (e.g., tomato, cucumber, eggplant, sweet pepper, and Snap bean).

Data in Table (2) demonstrated that, using chitosan as a foliar application at rates of 4 ml L^{-1} gave the best properties of fruit quality (i.e., fruit diameter and fruit weight) and highest values of total yield of cucumber fruits. Generally, it could be concluded that, the highest total yield and quality (5.01 and 2.99 kg/plant in case of 2010 and 2011, respectively) were recorded by foliar spraying of chitosan at rates of 4 ml L^{-1}. Meanwhile, the lowest values of total yield and quality of cucumber fruits (3.06 and 2.23 kg/plant in case of 2010 and 2011, respectively) were found by foliar spraying of water (control treatment). These results were in agreement with those obtained from Abdel-Mawgoud *et al.* (2010) on strawberry and Ghoname *et al.* (2010) on sweet pepper

plants. Lee *et al.* (2005) found that chitosan treatment increases the yield and marketability of soybean sprouts. Trials conducted on tomatoes showed that foliar applications of chitosan increased yield nearly 20 % and a significant improvement in powdery mildew disease control (Walker *et al.,* 2004). Chitosan treatments have promoting effects on plant growth, resulting in improved yield and plant resistance to diseases in several vegetable and fruit crops.

Table 1: Effect of foliar spraying of active dry yeast and chitosan on vegetative growth of cucumber plants during 2010 and 2011 seasons.

Treatments		Plant height (cm)	No. of leaves	Fresh weight of leaves (g)	Dry weight of leaves (g)	Fresh weight of stem (g)	Dry weight of stem (g)
Season 2010							
Control	Water	175.0 e	25.5 c	116.3 d	7.9 d	46.9 d	3.8 d
Yeast	1 g L^{-1}	213.0 d	30.0 a	131.2 c	14.9 bc	60.5 c	6.0 c
	2 g L^{-1}	227.5 c	28.5 b	169.6 a	22.9 a	76.9 b	7.7 b
	3 g L^{-1}	224.0 c	28.5 b	146.6 b	19.9 b	71.4 c	6.6 bc
	4 g L^{-1}	243.5 b	30.5 a	166.0 a	20.7 a	71.5 c	7.5 b
Chitosan	1 ml L^{-1}	243.5 b	28.5 b	158.5 a	14.6 c	91.2 a	8.3 a
	2 ml L^{-1}	244.5 b	28.0 b	110.5 e	13.4 c	64.9 bc	5.5 d
	3 ml L^{-1}	222.5 c	27.0 c	131.8 c	15.1 c	59.1 c	5.0 d
	4 ml L^{-1}	250.0 a	25.5 c	111.8 e	13.0 c	85.6 a	6.8 c
Season 2011							
Control	Water	102.0 e	16.5 c	90.4 d	5.7 d	22.3 e	2.4 d
Yeast	1 g L^{-1}	124.0 bc	20.5 a	103.6 b	7.8 c	27.7 b	4.3 b
	2 g L^{-1}	136.0 b	18.0 a	114.8 a	12.6 a	30.4 a	4.2 b
	3 g L^{-1}	130.0 c	17.5 b	105.7 b	13.4 a	28.9 b	3.5 bc
	4 g L^{-1}	136.0 b	18.5 a	113.4 a	12.3 a	27.3 b	3.1 c
Chitosan	1 ml L^{-1}	132.0 c	17.5 b	105.8 b	9.4 b	33.4 a	6.8 a
	2 ml L^{-1}	138.0 b	17.0 b	89.00 bc	8.9 bc	25.6 bc	5.7 a
	3 ml L^{-1}	120.0 d	17.0 b	94.7 bc	10.4 b	24.8 c	2.6 d
	4 ml L^{-1}	144.0 a	18.0 a	88.3 c	9.3 b	27.4 b	3.1 c

Values followed by the same letters are not significantly different by Duncan's test at 0.05 level

Table 2: Effect of foliar spraying of active dry yeast and chitosan on total yield and quality of cucumber fruits during 2010 and 2011 seasons.

Treatments		Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	T.S.S (%)	Total yield (kg/Plant)
Season 2010						
Control	Water	17.0 c	2.9 c	102.2 d	3.1 b	3.06 d
Yeast	1 g L^{-1}	19.7 a	3.1 b	134.3 c	3.4 a	4.02 bc
	2 g L^{-1}	19.0 b	3.0 b	130.3 bc	3.4 a	3.90 bc
	3 g L^{-1}	18.9 b	3.2 b	136.1 c	3.5 a	4.08 bc
	4 g L^{-1}	21.0 a	3.2 b	162.8 a	3.6 a	4.86 b
Chitosan	1 ml L^{-1}	18.5 ab	3.5 a	135.5 c	3.2 a	4.02 c
	2 ml L^{-1}	17.7 b	3.3 ab	135.5 c	3.3 a	4.05 c
	3 ml L^{-1}	18.0 ab	3.5 a	144.0 b	3.2 b	4.32 bc
	4 ml L^{-1}	19.9 a	3.6 a	167.7 a	3.4 a	5.01 a
Season 2011						
Control	Water	14.3 c	2.3 c	80.3 d	2.4 d	2.23 d
Yeast	1 g L^{-1}	14.8 b	2.5 ab	85.4 c	3.5 a	2.44 c
	2 g L^{-1}	14.2 c	2.5 ab	81.0 d	2.8 ab	2.45 c
	3 g L^{-1}	14.4 bc	2.6 b	87.3 c	3.3 b	2.57 c
	4 g L^{-1}	15.3 a	2.5 ab	90.5 bc	3.6 a	2.84 a
Chitosan	1 ml L^{-1}	14.7 b	2.7 a	87.9 c	3.4 b	2.54 c
	2 ml L^{-1}	14.6 b	2.6 b	83.8 c	3.5 a	2.57 bc
	3 ml L^{-1}	15.1 a	2.6 b	90.4 b	3.5 a	2.64 b
	4 ml L^{-1}	15.3 a	2.9 a	112.6 a	3.5 a	2.99 a

Values followed by the same letters are not significantly different by Duncan's test at 0.05 level

Cucumber Fruit Content of Protein and Macro-Nutrients:

At harvest, cucumber fruits were prepared in order to measure the concentration of selected some essential macro (N, P and K) and micro-nutrients (Fe, Zn, Cu and Mn) to calculate the uptake of these nutrients in plant tissues.

Data in Table (3) show clearly that, foliar spray of some bio-stimulants (yeast and chitosan) significantly increased N, P and K concentration (%) in tissue of cucumber plants, but it was failed only to reach to significant in K content in the second season of study. Generally, it could be concluded that, the highest concentration of nitrogen in tissues of cucumber (2.89 and 2.58 % in case of 2010 and 2011, respectively) was found by foliar spraying of active dry yeast at a rate of 4 g L^{-1}. On the contrary, the lowest concentration of nitrogen (1.87 and 1.45 % in case of 2010 and 2011, respectively) was recorded by control treatment (foliar spraying of tap water). With regarding to P (%) and K (%), data in Table 3 show clearly that, the highest

concentration of P and K (0.877 and 0.504 % for P and 4.27 and 3.94 % for K in case of 2010 and 2011, respectively) was recorded by foliar spraying of chitosan at rates of 4 ml L^{-1} (Figure 1). However, the lowest concentration of P and K (0.465 and 0.342 % for P and 2.76 and 2.43 % for K in case of 2010 and 2011, respectively) was obtained by control treatment. The similar trend of results was obtained in both of the two seasons of study. These results are in agreement with results, which obtained with Abdel-Mawgoud *et al.* (2010).

Cucumber Fruit Content of Micro-Nutrients:

Data presented in Table (3) illustrated that, all applied bio-stimulants as a foliar spray have positive effects on some micro-nutrients (Fe, Zn, Cu and Mn) content of fruits tissues of cucumber. Furthermore, the highest values of Fe, Zn, Cu and Mn (131.2, 70.32, 18.74, and 31.04 mg kg^{-1}, respectively for season 2010) were recorded by foliar spraying of yeast at a rate of $4gL^{1}$. On the other hand, the lowest values of Fe, Zn, Cu and Mn (85.3, 39.45, 16.25, and 27.56 mg/kg, respectively for season 2011) were obtained by foliar spraying with tap water (control). It was found that accumulation of the previous micro-nutrients in cucumber fruits decreased in the following order: Fe > Zn > Mn > Cu for each bio-stimulant (yeast and chitosan) for both of the two seasons. These results are similar in both of the two seasons of study (Figure 2).

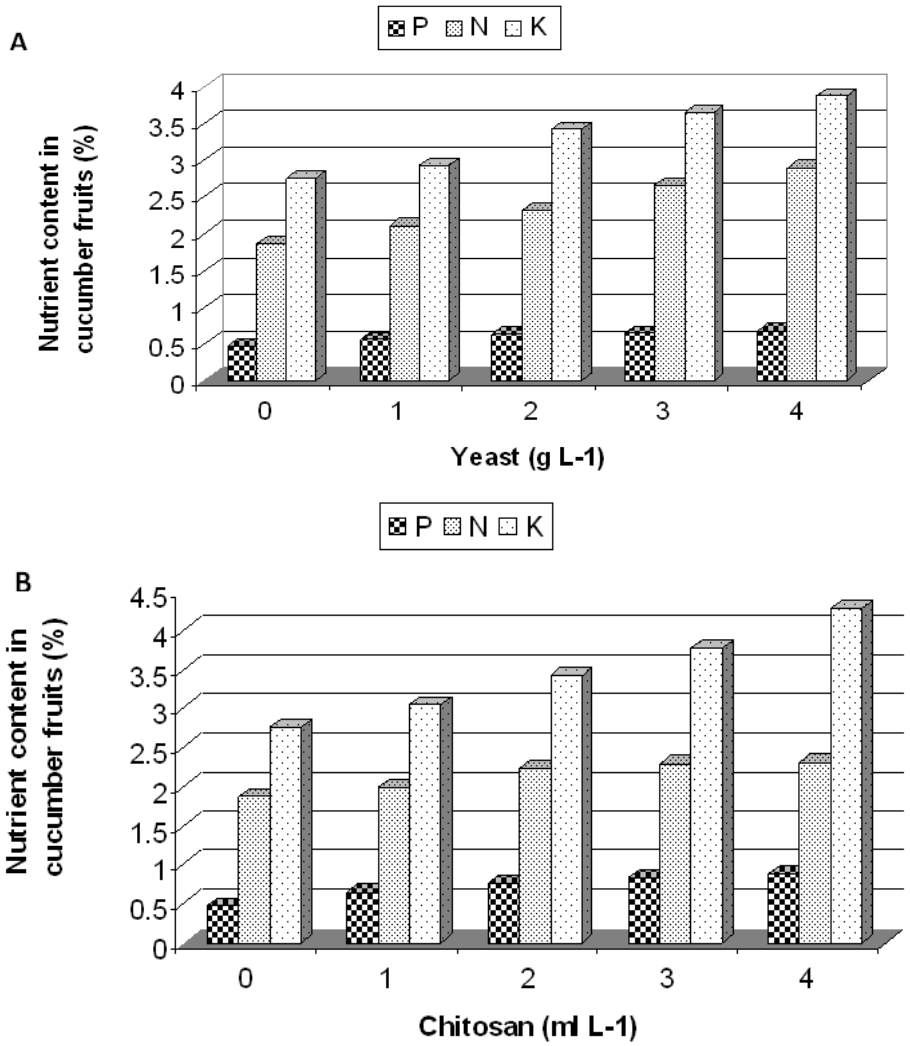

Fig. 1: Influence of foliar spraying of active dry yeast (A) and chitosan (B) on concentration of macronutrients (N, P and K in %) of cucumber fruits during 2010 season.

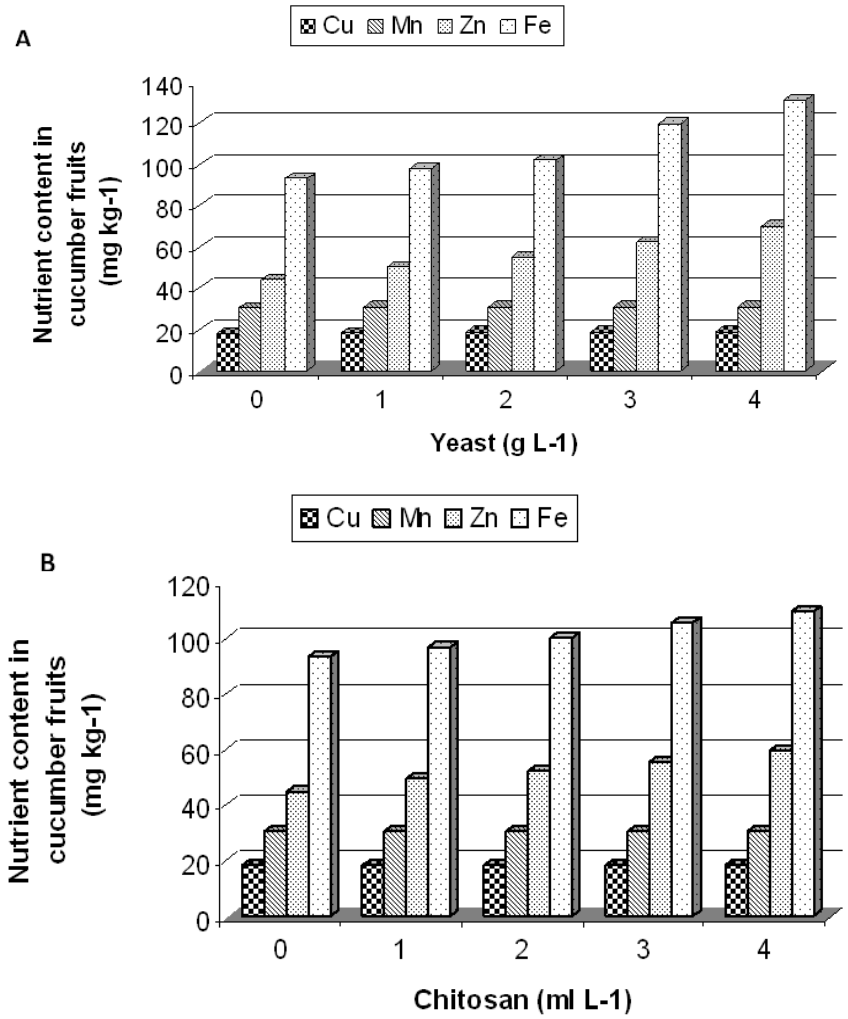

Fig. 2: Influence of foliar spraying of active dry yeast (A) and chitosan (B) on concentration of micronutrients (Fe, Zn, Cu and Mn in mg kg^{-1}) of cucumber fruits during 2010 season.

These results may be due to the physiological roles of vitamins and amino acids in the yeast extract which increased the metabolic processes role and levels of endogenous hormones, i.e. IAA and GA_3 (Chailakhyan, 1957). Khedr and Farid (2002) reported that, yeast preparation contained carbohydrates, sugars, proteins, fatty acids, amino acids, hormones, macro and micro elements in suitable balance. The obtained results are in harmony with those of Ghoname *et al.* (2010), Fawzy *et al.* (2010) and Ahmed *et al.* (2011) who studied the effects of application of yeast on sweet pepper, Snap bean and potato plants, respectively.

Table 3: Influence of foliar spraying of active dry yeast and chitosan on concentration of macronutrients (N, P, and K in %) and micronutrients (Fe, Zn, Cu and Mn in mg kg^{-1}) of cucumber fruits during 2011 season

Treatments		Concentration in cucumber fruits (%)			Concentration in cucumber fruits (mg kg^{-1})			
		N	P	K	Fe	Zn	Cu	Mn
Control	Water	1.45 d	0.342 d	2.43 b	85.3 d	39.45 d	16.25 b	27.56 b
Yeast	1 g L^{-1}	1.84 bc	0.387 d	2.68 b	92.5bc	42.53 c	16.43 a	27.87 b
	2 g L^{-1}	2.14 b	0.412 c	2.98 b	98.3ab	48.53 b	16.63 a	28.35 a
	3 g L^{-1}	2.32 a	0.436 bc	3.37 a	110.8ab	52.69 b	16.69 a	28.45 a
	4 g L^{-1}	2.58 a	0.476 b	3.58 a	120.3 a	60.64 a	17.23 a	28.87 a
Chitosan	1 ml L^{-1}	1.56 c	0.410 bc	2.87 b	90.3 c	42.56 c	16.54 a	27.76 b
	2 ml L^{-1}	1.78 bc	0.454 b	3.46 a	96.3bc	48.97 b	16.63 a	27.83 b
	3 ml L^{-1}	1.98 b	0.473 b	3.75 a	102.6 b	50.35 ab	16.87 a	27.94 b
	4 ml L^{-1}	2.24 a	0.504 a	3.94 a	112.6 b	53.64 b	16.98 a	28.12 a

Values followed by the same letters are not significantly different by Duncan's test at 0.05 level

Conclusion:

It can be recommended that all applied bio-stimulants have positive and promoting effects on cucumber plants growth by providing supplemental doses of bio-stimulants "yeast and chitosan". The results of the present investigation indicated that, foliar application of active dry yeast as stimulated dose was superior effect of vegetative growth characters of cucumber plants and some chemical compounds of fruits of cucumber plants .Whilst, foliar application of chitosan led to producing higher total yield and quality of cucumber plants. It could be concluded that, chitosan more effective than yeast as a bio-stimulant for yield and quality of cucumber under the experimental conditions.

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