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Impact of Foliar, Mineral Fertilization and some Plant Activators on Cucumber Growth and Productivity

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ABSTRACT

Two field experiments were conducted during 2016 and 2017 summer seasons in a private farm near El-Mahalla El-Kobra, El-Gharbia governrate to evaluate the effect of three NPK levels (100, 75 and 50 percentage of NPK recommended dose) and NPK foliar application (with or without foliar NPK spraying) with three foliar activators applications (chitosan, moringa leaf extract and lithovit) as well as tap water as a control and their interactions on vegetative growth characters, ion percentage, yield and its quality of cucumber plants cv. prince. Obtained data revealed that 100 % of recommended NPK (120 kg N, 50 kg P_2O_5, 100 kg K_2O/fed.) and foliar application with NPK at 3 g/l combined to foliar application with chitosan at 3 g/l gave the highest values of yield and its components *i.e.* (number of fruits, fruit yield/ plant, early and total yield/fed.), while 75% NPK of recommended dose (90 kg N, 37.5 kg P_2O_5, 75 kg K_2O/fed.) plus NPK foliar application with spraying moringa leaf extract at 10 ml/l gave the highest values of vegetative growth parameters *i.e.* (number of leaves/plant, shoot fresh and dry weight, plant height), also chitosan at 3 g/l combined with foliar NPK and 75% of NPK recommended dose as soil application gave superiority in N, P and K percentage in cucumber leaves, in addition, total sugar, TSS and total chlorophyll in cucumber fruits. Thus, it can be recommended that use 75% NPK from recommended dose plus foliar application NPK and foliar spray with moringa leaf extract applications to decrease mineral fertilization which reflected on reducing production costs and mitigate the environmental pollution and protect the human health.

Keywords: NPK levels, chitosan, cucumber, lithovit, moringa leaf extract, vegetative growth, yield and quality.

INTRODUCTION

Cucumber (*Cucumis sativas* L.) is the most important vegetables and economical popular member of family cucurbitacea. In Egypt the cultivated area of cucumber were 55620 fed. producing 495982 ton with an average yield 8.92 ton/feddan (FAO, 2017). Cucumber fruits are moisturizer for human body and decrease its need for water. Cucumber fruit contains edible portion carbohydrate (3%), total fat (0.5%), protein (1%) and dietary fiber (1%) (USDA, National Nutrient Data Base, 2014)

Mineral fertilizers were provide soil with nutrients in order to healthy growth of plant, crop production and yield quality, alternatively using huge amount of mineral fertilizers led to deteriorates in soil health and pollute environment then raise the production costs (Savci, 2012).

Therefore foliar application considered one of the strategies used to decrease the harmful effects (Jamal *et al.*, 2006), moreover it is the fastest to penetrate through plant tissues and remedy the nutrients deficiency especially under the Egyptian conditions because the soil solution pH is alkine which lose nitrogen in ammonium form, while phosphorus was fixed.

Chitosan is a natural compound derived from chitin, a polysaccharide found in exoskeleton of shell fish is known to possess biological activity (Gronik *et al.*, 2008). Islam *et al.* (2016) and Eladawy (2017) showed that foliar application with chitosan enhanced plant growth, yield and its component of tomato and artichoke, respectively.

Moringa leaves extract (MLE) contain natural antioxidants which used to avoid environmental stresses (Elzaawely *et al.*, 2017). It contains essential mineral, fibers, protein, sugars and vitamins (El Sohaimy *et al.*, 2015), also have phytohormones, cytokinin (zeatin), auxins and gibberellins (Howladar, 2014) that improve plant growth and yield. Abd-Elrhem (2017) mentioned that using MLE increasing vegetative growth, yield and quality of snap bean under early summer season.

Lithovit is a natural CO_2 nano-fertlizers. It contains magnesium carbonate (41%) a source to magnesium which plays a role to chlorophyll synthesis, also contains silica (5%) that plays important role in environmental stresses (Raven, 2003) and contains calcium carbonate (24%) that increases the intensity of photosynthesis. Abdel Nabi *et al.* (2017) showed that sprayed head lettuce with lithovit increased vegetative growth, yield and quality.

Thus, this work aimed to study the usage of different levels of NPK fertilization, NPK foliar fertilization and some plant activators on vegetative growth, ion percentage, yield and fruit quality of cucumber.

MATERIALS AND METHODS

This study was conducted during two successive summer seasons of 2016 and 2017 at a private farm near El-Mahalla El-Kobra district El-Gharbia governorate to evaluate the effect of NPK levels, foliar fertilization with NPK, foliar activators applications and their combinations on vegetative growth characters, ion percentage, yield and fruit quality of cucumber (*Cucumis sativas* L.) cv. prince. Factorial experiments in split split plot design with three replicates were conducted in both seasons. This experiment included 24 treatments which were the combinations among 3 NPK levels (100% – 75% – 50 % NPK of recommended dose), 2 foliar NPK fertilization (with or without foliar NPK) and 4 activators foliar application (control – chitosan - moringa leaf extract – lithovit). The main plots were allocated to soil mineral fertilization, while sub and sub sub plots were to foliar NPK and activators application, respectively.

Seeds of cucumber were sown at 30 cm between each and other on ridges at 25 and 28 June during the first and second seasons, respectively. The plot area was 10.5 m^2 (1.5 m width X 7 m length). Some physical and chemical properties of the experimental soil are presented in Table1 during the two seasons.

Table 1. Some physical and chemical properties of experimental soil during 2016 and 2017 seasons:

Seasons	Mechanical analysis (%)				Texture class	OM (%)	SP %	T. $CaCO_3$ g/kg	EC dS.m^{1} 1:5	pH (1:2.5)	Available (mg/kg soil)		
	Coarse Sand	Fine Sand	Silt	Clay							N	P	K
1st	3.86	20.77	47.62	27.75	Clay loamy	1.49	60.7	3.65	0.96	8.18	59.5	6.19	191.5
2nd	3.59	25.16	46.38	25.31	Clay loamy	1.69	62.5	3.25	1.18	8.05	53.6	5.91	171.6

SP: Saturation percentage OM: Organic matter EC: Electrical conductivity

The recommended dose of nitrogen fertilizer was added at 120 kg N/fed. (ammonium nitrate 33.5 N%). Calcium super phosphate (15.5% P_2O_5) was added at 50 P_2O_5/fed. and potassium sulphate (48% K_2O) was added at 100 K_2O/feddan. Nitrogen and potassium doses were divided into two equal parts; the first added at 21 days from sowing and the second after two weeks later, while phosphorus fertilizer was added before sowing.

NPK (20:20:20) was used as foliar fertilization five times every 10 days started after sowing at the rate of 3 g/l.

Chitosan was used at 3 g/l and prepared by dissolving in acetic acid solution. Moringa leaf extract (MLE) at 10 ml/l was prepared according to Culver *et al.* (2012) and lithovit was used at 1 g/l. The plants were sprayed with activators applications three times 15, 30 and 45 days from sowing using spreading agent to improve adherence of the spry to the plant foliage.

Data recorded:

After 60 days from sowing five plants were randomly taken from each plot to perform the following measurements:

Vegetative growth characters: represented as plant height (cm); number of leaves/ plant and shoot fresh weight (g/plant). Shoot fresh weight was oven dried at 70°C till constant weight, then shoot dry weight was recorded (g/plant).

Ion (N, P and K) percentage:

- Nitrogen, phosphorus and potassium content were determined in dry leaves by the method according to AOAC (2012).

Yield and its components:

Cucumber fruits of each plot were harvested at proper stage counted, weighted and the following data were calculated:

- No. of fruits/plant.
- Yield/ plant (kg)
- Early yield (ton/fed.): It was calculated from the first four pickings.
- Total yield (ton/fed.).

Fruit quality:

- Total Soluble Solids (TSS) percentage: were determined by using Refract meter according to AOAC (1990).
- Total sugar percentage: was determined according to Malik and Srivastava (1979).
- Vitamin C (mg/100 g Fw): It was determined according to the method reported in AOAC (2012).
- Total chlorophyll (mg/g Fw) was determined as described by Goodwine (1965).

Economic feasibility:

(1) Cucumber marketable yield as average of two seasons.

(2) Gross return as marketable yield (Ton fed^{-1}) x 3000 LE /Ton.

(3) Treatments cost were calculated according to the prices of all treatments: chitosan, moringa leaf extract, lithovit, ammonium nitrate, potassium sulphate, calcium super phosphate and NPK (20:20:20).

(4) Total variable and fixed cost (LE fed^{-1}) including: Treatment cost plus land leasehold, seeds, microelements, pesticides, labors and other agricultural practices, which equal nearly 11250 LE fed^{-1}.

(5) Net return (LE/fed.) and benefit cost ratio were determined according to Boardman *et al.* (2001) as:

Net return = gross return (LE fed^{-1}) - total variable and fixed cost (LE fed^{-1})

$$\textbf{Benefit cost ratio} = \frac{\textbf{gross return (LE fed}^{-1}\textbf{)}}{\textbf{total variable and fixed cost (LE fed}^{-1}\textbf{)}}$$

Statistical analysis:

Data were statistically analyzed according to the technique of ANOVA for factorial experiment in split split plot design according to Gomez and Gomez (1984). The treatment means were compared using Duncan Multiple Rang Test (Duncan, 1955).

RESULTS

Effect of soil mineral fertilization:

Concerning the effect of soil mineral NPK fertilization, data in Table 2 indicate that 100% recommended dose of NPK as soil application gave the highest values of the most plant growth parameters (leaves number, shoot fresh and dry weight), except plant highest in the second season, that 75% NPK gave the highest value.

Regarding ion percentage in the plant leaves, the data in Table 3 show that there were insignificant effect between 100 and 75 % recommended dose of soil NPK in N, P and K percentage.

Data illustrated in Table 4 reveal that 100% of recommended dose of NPK (120 kg N, 50 kg P_2O_5, 100 kg K_2O/fed.) gave the high yield of cucumber, while 50% of recommended dose of NPK gave the lowest yield.

The data presented in Table 5 clear that 100% of recommended dose of NPK gave the highest values of vitamin C and TSS, but there were insignificant effect between 100 and 75 % recommended dose of soil NPK at total sugar, and total chlorophyll of fruits in the two seasons

Effect of foliar NPK application:

Regarding to the effect of foliar application with NPK, data presented in Tables 2, 3, 4 and 5 proved that using foliar fertilization with NPK at 3 g/l enhanced significantly vegetative growth characters, ion percentage, yield and fruits quality of cucumber.

Effect of activators foliar application

Data in the same Tables show that activators foliar applications (chitosan, moringa and lithovit) increased significantly vegetative growth parameters, chemical composition, yield and its components and fruit quality compared to control treatment.

Concerning the effect of activators on vegetative growth parameters data in Table 2 show that moringa leaf extract at 10 ml/l gave the highest values of fresh weight, plant height and number of leaves without significant differences between chitosan and moringa on shoot fresh weight in two seasons and plant height in the first season, while chitosan gave the highest values of dry weight.

Regarding the effect of activators on ion percentage, and fruit quality data in Tables 3 and 5 clear that chitosan gave superiority on these parameters.

The data presented in Table 4 show that chitosan increased cucumber total yield (13.4% and 14.82%) in the first and second seasons, respectively followed by moringa leaf extract.

Table 2. Number of leaves, shoot fresh, dry weights and plant height of cucumber as affected by application methods of NPK and activators foliar application during 2016 and 2017 seasons.

Characters / Treatments	Number of leaves/plant		Shoot fresh weight (g/plant)		Shoot dry weight (g/plant)		Plant height (cm)	
	2016	2017	2016	2017	2016	2017	2016	2017
A- NPK levels:								
100 %	37.38 a	39.17 a	270.8 a	281.8 a	60.71 a	64.6 a	137.92 a	149.13 b
75 %	34.5 b	36.79 b	254.9 b	265.7 b	54.50 b	57.6 b	140.75 a	151.13 a
50 %	28.08 c	29.38 c	226.1 c	236.3 c	45.62 c	49.1 c	128.08 b	137.71 c
B- Foliar NPK (20:20:20) at 3g/l:								
without	26.22 b	27.81 b	213.8 b	224.7 b	40.64 b	44.9 b	121.86 b	132.36 b
with	40.42 a	42.42 a	287.4 a	297.8 a	66.58 a	69.3 a	149.31 a	159.61 a
C- Activators foliar application:								
Control	29.83 d	31.67 d	233.0 c	242.4 c	49.50 d	52.3 d	124.61 c	135.39 d
Chitosan at 3g/l	34.55 b	36.56 b	261.6 a	272.9 a	57.72 a	61.5 a	142.17 a	152.06 b
MLE at 10 ml/l	36.61 a	38.00 a	263.7 a	275.7 a	54.67 b	59.1 b	142.39 a	154.56 a
Lithovit at 1g/l	32.27 c	34.22 c	244.0 b	253.9 b	52.56 c	55.6 c	133.17 b	141.94 c

Table 3. Nitrogen, phosphorus and potassium percentages in cucumber leaves as affected by application methods of NPK and activators foliar application during 2016 and 2017 seasons.

Characters / Treatments	N (%)		P (%)		K (%)	
	2016	2017	2016	2017	2016	2017
A- NPK levels:						
100 %	1.32 a	1.38 a	0.124 a	0.130 a	2.34 a	2.41 a
75 %	1.33 a	1.38 a	0.122 a	0.129 a	2.34 a	2.40 a
50 %	1.18 b	1.24 b	0.111 b	0.117 b	2.26 b	2.30 b
B- Foliar NPK (20:20:20) at 3g/l:						
without	1.17 b	1.22 b	0.108 b	0.113 b	2.20 b	2.26 b
with	1.39 a	1.45 a	0.130 a	0.138 a	2.43 a	2.48 a
C- Activators foliar application:						
Control	1.18 d	1.22 d	0.107 d	0.114 d	2.18 d	2.26 d
Chitosan at 3g/l	1.38 a	1.45 a	0.130 a	0.137 a	2.44 a	2.49 a
MLE at 10 ml/l	1.31 b	1.38 b	0.123 b	0.130 b	2.35 b	2.40 b
Lithovit at 1g/l	1.23 c	1.29 c	0.116 c	0.120 c	2.28 c	2.33 c

Table 4. Number of fruits, yield/plant, early and total yield/fed. of cucumber as affected by application methods of NPK and activators foliar application during 2016 and 2017 seasons.

Characters / Treatments	Number of fruits/plant		Yield/ plant (kg)		Early yield (ton/fed.)		Total yield (ton/fed.)	
	2016	2017	2016	2017	2016	2017	2016	2017
A- NPK levels:								
100 %	14.42 a	14.92 a	0.86 a	0.93 a	2.25 a	2.70 a	7.93 a	8.52 a
75 %	10.71 b	12.83 b	0.80 b	0.86 b	2.03 b	2.44 b	7.38 b	7.88 b
50 %	9.17 c	11.04 c	0.74 c	0.77 c	1.69 c	2.10 c	6.79 c	7.04 c
B- Foliar NPK (20:20:20) at 3g/l:								
without	10.42 b	11.88 b	0.74 b	0.78 b	1.80 b	2.20 b	6.80 b	7.16 b
with	12.44 a	13.97 a	0.86 a	0.92 a	2.18 a	2.62 a	7.93 a	8.46 a
C- Activators foliar application:								
Control	8.67 d	10.38 d	0.75 d	0.79 d	1.81 d	2.28 d	6.86 d	7.22 d
Chitosan at 3g/l	14.06 a	15.11 a	0.84 a	0.90 a	2.15 a	2.52 a	7.78 a	8.29 a
MLE at 10 ml/l	12.28 b	13.77 b	0.82 b	0.88 b	2.06 b	2.45 b	7.55 b	8.07 b
Lithovit at 1g/l	10.72 c	12.44 c	0.79 c	0.84 c	1.94 c	2.39 c	7.26 c	7.68 c

Table 5. Total sugar percentage, vitamin C (Vit. C), total chlorophyll and TSS in cucumber fruits as affected by application methods of NPK and activators foliar application during 2016 and 2017 seasons.

Characters / Treatments	Total sugar (%)		Vitamin C (mg/100 g)		Total chlorophyll (mg/g F.W)		TSS	
	2016	2017	2016	2017	2016	2017	2016	2017
A- NPK levels:								
100 %	4.28 a	4.33 a	3.68 a	3.69 a	1.029 a	1.047 a	4.85 a	4.89 a
75 %	4.31 a	4.36 a	3.59 b	3.61 b	1.028 a	1.047 a	4.80 b	4.81 b
50 %	4.07 b	4.15 b	3.37 c	3.39 c	1.000 b	1.023 b	4.68 c	4.70 c
B- Foliar NPK (20:20:20) at 3g/l:								
without	4.01 b	4.06 b	3.32 b	3.35 b	0.996 b	1.014 b	4.59 b	4.62 b
with	4.43 a	4.49 a	3.76 a	3.78 a	1.043 a	1.065 a	4.96 a	4.98 a
C- Activators foliar application:								
Control	3.95 d	4.02 d	3.29 d	3.33 d	0.995 d	1.016 d	4.61 d	4.65 d
Chitosan at 3g/l	4.49 a	4.55 a	3.79 a	3.80 a	1.045 a	1.063 a	4.93 a	4.96 a
MLE at 10 ml/l	4.32 b	4.37 b	3.63 b	3.64 b	1.026 b	1.048 b	4.83 b	4.85 b
Lithovit at 1g/l	4.12 c	4.17 c	3.46 c	3.49 c	1.012 c	1.031 c	4.72 c	4.74 c

Effect of interactions:

Concerning the effect of interactions among treatments on number of leaves, fresh weight, plant height data in Tables 6 show that used 75 % of recommended NPK (90 kg N, 37.5 kg P_2O_5, 75 kg K_2O/fed.) and foliar application with NPK at 3 g/l plus moringa leaf extract at 10 ml/l gave superiority in all vegetative growth parameters. The highest values of ion percentage and fruits quality came from foliar application with chitosan combined with 75% of recommended NPK and foliar application with NPK followed by moringa leaf extract as shown in Tables 7 and 8.

Regarding the interaction effects on number of fruits, yield/plant, early and total yield, data in Tables 9 and 10 show that fertilizing with 100% of recommended NPK (120 kg N, 50 kg P_2O_5, 100 kg K_2O/fed.) and foliar application with NPK at 3 g/l combined with foliar amendment of chitosan increased yield and its components and resulted in the highest values followed by moringa leaf extract.

Table 6. Number of leaves, fresh weight and plant height of cucumber as affected by the interaction among NPK levels, foliar NPK and activators foliar application treatments during 2016 and 2017 seasons.

Characters / Treatments			Number of leaves/plant		Shoot fresh weight (g/plant)		Plant height (cm)	
			2016	2017	2016	2017	2016	2017
100% NPK	Without foliar NPK	Control	29.0 j	31.0 jk	239.67 g	248.67 gh	117.67 hij	129.00 jk
		Chitosan	34.0 h	35.0ghi	259.00 e	270.33 ef	138.33 cde	145.67 fgh
		Moringa	35.3 gh	36. 7 fg	259.33 e	272.00 ef	135.00 def	148.67 efg
		Lithovit	32.0 i	33.0 ij	242.67 f	253.33 g	124.33fghi	134.33 ij
	With foliar NPK	Control	39.0 e	40.7 de	265.33 de	277.67de	138.00 cde	149.00 ef
		Chitosan	43.0 c	46.0 b	305.67 a	316.00b	151.33 b	164.67 bc
		Moringa	45.3 b	48.0 ab	309.00 a	318.00ab	153.33 b	167.00 b
		Lithovit	41.3 cd	43.0 cd	285.67 bc	298.00 c	145.33 bcd	154.67 de
75% NPK	Without foliar NPK	Control	21.0 mn	24.0 n	194.00 ij	201.67 k	115.00 ij	125.00 kl
		Chitosan	26.0 k	28.7klm	226.33 h	237.00 i	128.67 efg	139.67 hi
		Moringa	29.0 j	29. 3 kl	227.67gh	240.33 hi	129.00 efg	140.33 ghi
		Lithovit	23.0 l	27.0 lm	205.67 i	215.33 j	121.33 ghi	132.00 ijk
	With foliar NPK	Control	41.0 d	43.0 cd	274.00 cd	283.67 d	146.33 bcd	156.00 de
		Chitosan	45.7 ab	47.7 ab	309.67 a	323.33 ab	166.33 a	176.33 a
		Moringa	47.3 a	49.3 a	312.00 a	325.00 a	166.00 a	177.67 a
		Lithovit	43.0 c	45.3 bc	289.67 b	299.00 c	153.33 b	162.00 bcd
50% NPK	Without foliar NPK	Control	17.0 o	18.0 p	165.67 k	177.67 l	100.67 k	113.00 m
		Chitosan	22.7 lm	24.0 n	185.33 j	197.00 k	121.33 ghi	129.67 jk
		Moringa	25.3 k	26.0mn	187.33 j	200.00 k	123.00 fghi	133.33 ijk
		Lithovit	20.3 n	21.0 o	172.33 k	182.67 l	108.00 jk	117.67 lm
	With foliar NPK	Control	32.0 i	33.3hij	259.33 e	265.33 f	130.00 efg	140.33 ghi
		Chitosan	36.0 fg	38.0 ef	283.67 bc	293.67 c	147.00 bcd	156.33 cde
		Moringa	37.3 ef	38.7 ef	287.00 b	298.67 c	148.00 bc	160.33 bcd
		Lithovit	34.0 h	36.0fgh	268.00 de	275.33 de	146.67 bcd	151.00 ef

Table 7. Interaction effect of NPK levels, foliar NPK and activators foliar application treatments on N, P and K contents of cucumber leaves during 2016 and 2017 seasons.

Characters / Treatments			N (%)		P (%)		K (%)	
			2016	2017	2016	2017	2016	2017
100% NPK	Without foliar NPK	Control	1.17 jk	1.19 l	0.106hij	0.110k	2.11 m	2.21 j
		Chitosan	1.33 defg	1.43 f	0.129cd	0.134g	2.41de	2.46 d
		Moringa	1.27 fghi	1.33 hij	0.121def	0.125h	2.31 g	2.37 f
		Lithovit	1.21 ij	1.27 jk	0.114fgh	0.117ij	2.24ijk	2.30 i
	With foliar NPK	Control	1.30 efgh	1.35 ghi	0.118efg	0.126h	2.26hij	2.37 f
		Chitosan	1.50 ab	1.58 ab	0.140b	0.148bc	2.54 b	2.60 b
		Moringa	1.45 bc	1.50cde	0.135bc	0.142cde	2.45cd	2.50 c
		Lithovit	1.35 def	1.41fg	0.128cd	0.133g	2.37f	2.44 de
75% NPK	Without foliar NPK	Control	1.08 lm	1.11 mn	0.096kl	0.102lm	2.05 n	2.14 k
		Chitosan	1.30 efgh	1.35 ghi	0.118efg	0.127h	2.28gh	2.35 fg
		Moringa	1.25 ghij	1.31 ij	0.111ghi	0.116ij	2.22jk	2.29 i
		Lithovit	1.11 kl	1.16 lm	0.103ijk	0.108kl	2.16 l	2.21 j
	With foliar NPK	Control	1.36 de	1.44 ef	0.124de	0.135fg	2.38ef	2.46 d
		Chitosan	1.56 a	1.65 a	0.151a	0.157a	2.62 a	2.66 a
		Moringa	1.50 ab	1.56 bc	0.140b	0.149b	2.56 b	2.58 b
		Lithovit	1.46 bc	1.51 bcd	0.135bc	0.141def	2.48 c	2.51 c
50% NPK	Without foliar NPK	Control	0.97 n	0.9 o9	0.088l	0.092n	2.05 n	2.08 l
		Chitosan	1.18 jk	1.2 kl2	0.105hij	0.113jk	2.30gh	2.33 gh
		Moringa	1.10 klm	1.18 l	0.103ijk	0.109k	2.20kl	2.23 j
		Lithovit	1.03 mn	1.08 n	0.098jk	0.100m	2.10 m	2.14 k
	With foliar NPK	Control	1.20 ij	1.27 jk	0.112fghi	0.120hi	2.28gh	2.31 hi
		Chitosan	1.41 cd	1.45 def	0.137bc	0.143bcd	2.47 c	2.52 c
		Moringa	1.31 efgh	1.39fgh	0.129cd	0.136efg	2.39ef	2.43 e
		Lithovit	1.24 hij	1.32 ij	0.116efg	0.121hi	2.32 g	2.38 f

Table 8. Total sugar, TSS and total chlorophyll of cucumber fruits as affected by the interaction among NPK levels, foliar NPK and activators foliar application treatments during 2016 and 2017 seasons.

Characters / Treatments			Total sugar (%)		TSS (%)		Total chlorophyll (mg/g F.W)	
			2016	2017	2016	2017	2016	2017
100% NPK	Without foliar NPK	Control	3.92 hi	3.96 lm	4.59 klm	4.63 ij	0.988lmno	1.003 kl
		Chitosan	4.40 cde	4.43 ef	4.92 defg	4.97 cde	1.036efgh	1.052def
		Moringa	4.19 f	4.23 hij	4.83 fgh	4.87 ef	1.013ijk	1.037 gh
		Lithovit	3.97 hi	4.04 kl	4.68 jk	4.73 ghi	1.004klm	1.020 ij
	With foliar NPK	Control	4.16 fg	4.22 hij	4.79 hij	4.83 fg	1.017hijk	1.043 efg
		Chitosan	4.72 ab	4.79 ab	5.08 bc	5.12 b	1.077ab	1.092 ab
		Moringa	4.51 c	4.58 cd	4.99 cde	5.00 cd	1.052cde	1.075 c
		Lithovit	4.38 cde	4.41 ef	4.89 efgh	4.91 def	1.040defg	1.057 d
75% NPK	Without foliar NPK	Control	3.75 jk	3.82 n	4.42 o	4.43 lm	0.973 no	0.991 lm
		Chitosan	4.30 def	4.36 fg	4.66 kl	4.68 hi	1.023 ghij	1.040 fg
		Moringa	4.16 fg	4.18 ij	4.55 lmn	4.57 jk	1.014 ijk	1.025 hi
		Lithovit	3.96 hi	3.99klm	4.46 no	4.49 kl	0.984 mno	1.001 klm
	With foliar NPK	Control	4.28 ef	4.34 fgh	4.88 efgh	4.90 def	1.032fghi	1.061 d
		Chitosan	4.88 a	4.92 a	5.23 a	5.25 a	1.086 a	1.100 a
		Moringa	4.69 b	4.72 bc	5.14 ab	5.12 b	1.062 bc	1.083 bc
		Lithovit	4.45 cd	4.53 de	5.03 bcd	5.02 c	1.056 cd	1.077 c
50% NPK	Without foliar NPK	Control	3.58 k	3.66 o	4.30 p	4.33 m	0.952 p	0.973 n
		Chitosan	4.18 fg	4.24 ghi	4.68 jk	4.70 hi	1.002 klm	1.020 ij
		Moringa	3.95 hi	4.01 kl	4.51 mno	4.57 jk	0.992 lmn	1.011 jk
		Lithovit	3.81 ij	3.86 mn	4.45 no	4.46 l	0.970 op	0.989 m
	With foliar NPK	Control	4.01 gh	4.10 jk	4.70 ijk	4.74 gh	1.005 jkl	1.024 hij
		Chitosan	4.49 c	4.58 cd	5.02 bcd	5.04 bc	1.045 cdef	1.076 c
		Moringa	4.40 cde	4.50 de	4.94 def	4.94 cde	1.024ghij	1.055 de
		Lithovit	4.17 fg	4.22 hij	4.81 ghi	4.83 fg	1.016ijk	1.039 fg

Table 9. Number of fruits and yield/plant of cucumber fruits as affected by the interaction among NPK levels, foliar NPK and activators foliar application treatments during 2016 and 2017 seasons.

Characters			Number of fruits/plant		Yield / plant (kg)	
Treatments			2016	2017	2016	2017
100% NPK	Without foliar NPK	Control	10.67 ghij	11.33 j	0.80 defgh	0.83 ef
		Chitosan	15.33 bc	16.00 c	0.86 abcd	0.91 cd
		Moringa	14.00 cde	14.67 d	0.84 bcde	0.89 de
		Lithovit	13.00 def	13.33 fg	0.81 defg	0.86 ef
	With foliar NPK	Control	12.00 efgh	13.33 fg	0.85 bcde	0.94 c
		Chitosan	18.67 a	18.00 a	0.93 a	1.01 a
		Moringa	16.67 ab	17.00 b	0.90 ab	1.00 ab
		Lithovit	15.00 bcd	15.67 c	0.89 abc	0.97 b
75% NPK	Without foliar NPK	Control	7.00 lm	9.33 k	0.66 k	0.69 lm
		Chitosan	13.00 def	14.00 def	0.76 fghi	0.81 gh
		Moringa	10.33 hij	12.33 hi	0.75 ghi	079 hi
		Lithovit	8.67 jkl	11.00 j	0.69 ijk	0.74 jk
	With foliar NPK	Control	9.00 ijkl	11.67 ij	0.84 bcde	0.91 cd
		Chitosan	14.00 cde	16.00 c	0.93 a	1.00 ab
		Moringa	12.67 efg	14.67 d	0.90 ab	0.97 b
		Lithovit	11.00 fghi	13.67 ef	0.86 abcd	0.94 c
50% NPK	Without foliar NPK	Control	5.67 m	7.67 l	0.55 l	0.61 n
		Chitosan	10.33 hij	12.33 hi	0.73 hij	079 hi
		Moringa	9.33 ijk	11.33 j	0.71 ijk	0.76 ij
		Lithovit	7.67 klm	9.33 k	0.67 jk	0.67 m
	With foliar NPK	Control	7.67 klm	9.00 k	0.76 fghi	0.73 kl
		Chitosan	13.00 def	14.33 de	0.84 bcde	0.89 de
		Moringa	10.67 ghij	12.67 gh	0.82 cdef	0.86 ef
		Lithovit	9.00 ijkl	11.67 ij	0.79 efgh	0.82 g

Table 10. Early yield and total yield of cucumber fruits as affected by the interaction among NPK levels, foliar NPK and activators foliar application treatments during 2016 and 2017 seasons.

Characters			Early yield (ton/fed.)		Total yield (ton/fed.)	
Treatments			2016	2017	2016	2017
100% NPK	Without foliar NPK	Control	1.92 ghi	2.35 ij	7.35 defgh	7.67 gh
		Chitosan	2.26 cd	2.51 fg	7.96 abcd	8.34 de
		Moringa	2.16 def	2.46 gh	7.72 bcde	8.18 ef
		Lithovit	2.08 efg	2.43 ghi	7.49 defg	7.93 fg
	With foliar NPK	Control	2.22 cde	2.80 c	7.82 bcde	8.59 cd
		Chitosan	2.57 a	3.09 a	8.55 a	9.31 a
		Moringa	2.48 ab	2.98 b	8.32 ab	9.19 ab
		Lithovit	2.34 bc	2.93 b	8. 21 abc	8.98 b
75% NPK	Without foliar NPK	Control	1.63 kl	2.11 no	6.08 k	6.41 m
		Chitosan	2.03 fg	2.32 jk	7.00 fghi	7.44 hi
		Moringa	1.95 gh	2.28 jkl	6.89 ghi	7.23 ij
		Lithovit	1.79 ijk	2.20 lmn	6.42 ijk	6.76 kl
	With foliar NPK	Control	2.07 efg	2.50 g	7.76 bcde	8.35 de
		Chitosan	2.33 bc	2.77 cd	8.59 a	9.22 ab
		Moringa	2.26 cd	2.69 de	8.29 ab	8.97 b
		Lithovit	2.16 def	2.60 ef	7.98 abcd	8.64 c
50% NPK	Without foliar NPK	Control	1.30 n	1.77 r	5.13 l	5.59 n
		Chitosan	1.57 lm	2.05 op	6.80 hij	7.24 i
		Moringa	1.51 lm	1.97 pq	6.54 ijk	6.97 jk
		Lithovit	1.44 mn	1.92 q	6.18 jk	6.21 m
	With foliar NPK	Control	1.74 jk	2.16 mn	7.04 fghi	6.68 l
		Chitosan	2.14 def	2.37 hij	7.78 bcde	8.17 ef
		Moringa	2.00 fgh	2.29 jkl	7.56 cdef	7.90 g
		Lithovit	1.86 hij	2.24 klm	7.27 efgh	7.57 h

DISCUSSION

The results of this study revealed significant increase in vegetative growth, ion percentage, yield and quality of cucumber with increasing soil fertilizers this may be attributed to the increasing of mineral fertilization dose in addition to the present quantities of the three element N, P

and K in soil (as shown in Table 1) increased utilization of carbon and subsequent synthesis of assimilation (Lawal, 2000). Increasing all evaluated parameters (number of leaves, shoot fresh, dry weight, plant height, yield/plant, early and total yield) in response to soil NPK fertilizer may be attributed to take nutrients up by plant and utilize in cell division, amino acid synthesis (Eifediyi and Remison, 2010) and several metabolic process which reflected positively on formation of photoassiilates that translocated to various sinks (fruits and growing bud) and therefore increased vegetative growth this led to enhance yield and ion percentage in plant tissues. These results are in accordance with those obtained by Feleafel *et al.* (2014) on cucumber and Doklega and Abd El-Hady (2017) on broccoli.

Foliar fertilization with NPK enhancing significantly vegetative growth characters, yield and its components these results may be due to the positive effects of NPK where rapid penetration was occurred through stomata and cuticle layer, also continuous supply of nutrients lead to balance of macro elements and increase percentage of N, P and K (as shown in Table 5) which improved vegetative growth and yield. These results are in harmony with those reported by Chaurasia *et al.* (2005) on tomato and Seadh *et al.* (2017) on wheat.

Using plant activators increased all measured parameters comparing to control treatment. In this regard enhancement effect of chitosan may be due to its content of polysaccharides which are important to increase plant metabolism phytoprotection and maintain plant health and consequently improve photosynthetic products and vegetative growth hence increased yield and quality. These results in the same trend with those obtained by Shehata *et al.* (2012) on cucumber, Islam *et al.* (2016) on tomato and Eladawy (2017) on artichoke.

The improvement of aforementioned measurements allied with moringa leaf extract may be due to its high source of vitamins, amino acids, cytokinin and plant growth regulators (Mahmood *et al.*, 2010 and Emongor, 2015), enhancing growth compounds (phenolcs, ascorbate and minerals) which consequently enhanced vegetative growth and facilitates the mobilization of nutrients to fruits which lead to improve fruit yield and quality. These results are going with those obtained by Farouk (2015) on potato, Abd El-Mageed *et al.* (2017) on squash and Eladawy (2017) on artichoke.

The favorable effect of lithovit may be due to its contain of magnesium that rapidly penetrate the leaves and plays an important role in the formation of chlorophyll, which is reflected positively on the process of photosynthesis. Additionally it increases CO_2 concentration that enhance photosynthetic efficiency by increasing carbon assimilation, biomass and plants leaf area, consequently improve vegetative growth and yield. These results are agree with those reported by Farouk (2015) on potato, Abo El-Hamd and Abd Elwahed (2017) on okra and Doklega (2017) on potato.

Economic feasibility:

The economic feasibility of cultivation cucumber plants as affected by recommended NPK rates, foliar NPK application and activators (chitosan – moringa leaf extract – lithovit) are shown in Table 11. The results showed that the highest net return (9022 LE/fed.) was obtained under 75% recommended NPK plus foliar NPK application combined with foliar moringa leaf extract, also this treatment returns the highest benefit cost ratio (1.53) in compared to other treatments. Therefore this treatment considered to be economical for cucumber production under the condition of the present study.

Table 11. Economic performance of cucumber production as affected by soil mineral fertilization, foliar NPK and activators foliar application treatments during 2016 and 2017 seasons.

Treatments			Marketable yield (Ton/ fed)	Gross return (LE/fed)	Treatments cost (LE/fed)	Total variable and fixed cost (LE/fed)	Net return (LE/fed)	Benefit cost ratio	Order
100% NPK	Without foliar NPK	Control	7.51	22530	4330	15580	6950	1.45	13
		Chitosan	8.15	24450	7030	18280	6170	1.34	16
		Moringa	7.95	23850	4580	15830	8020	1.51	9
		Lithovit	7.71	23130	4630	15880	7250	1.46	12
	With foliar NPK	Control	8.21	24630	4450	15700	8930	1.57	6
		Chitosan	8.93	26790	7150	18400	8390	1.46	12
		Moringa	8.76	26280	4700	15950	10330	1.65	4
		Lithovit	8.60	25800	4750	16000	9800	1.61	5
75% NPK	Without foliar NPK	Control	6.25	18750	3248	14498	4252	1.29	18
		Chitosan	7.22	21660	5948	17198	4462	1.26	19
		Moringa	7.06	21180	4398	15648	5532	1.35	15
		Lithovit	6.59	19770	4448	15698	4072	1.26	19
	With foliar NPK	Control	8.06	24180	3368	14618	9562	1.65	4
		Chitosan	8.91	26730	6068	17318	9412	1.54	7
		Moringa	8.63	25890	3618	14868	11022	1.74	1
		Lithovit	8.31	24930	3668	14918	10012	1.67	3
50% NPK	Without foliar NPK	Control	5.36	16080	2165	13415	2665	1.20	20
		Chitosan	7.02	21060	4865	16115	4945	1.31	17
		Moringa	6.76	20280	2415	13665	6615	1.48	10
		Lithovit	6.20	18600	2465	13715	4885	1.36	14
	With foliar NPK	Control	6.86	20580	2285	13535	7045	1.52	8
		Chitosan	7.98	23940	4985	16235	7705	1.47	11
		Moringa	7.73	23190	2535	13785	9405	1.68	2
		Lithovit	7.42	22260	2585	13835	8425	1.61	5

CONCLUSION

In spite of using 100 % of recommended NPK (120 kg N, 50 kg P_2O_5, 100 kg K_2O/fed.) and foliar treatment with NPK at 3 g/l combined to foliar application with chitosan at 3 g/l gave the highest values of yield and its components. Economically, using 75% NPK from recommended dose (90 kg N, 37.5 kg P_2O_5, 75 kg K_2O/fed.) plus NPK foliar application at 3 g/l with foliar moringa leaf extract at 10 ml/l gave the highest net return and high quality and mitigate the environmental from pollution and protect the human health due to decrease mineral fertilization by 25% under the similar circumstances at the experiment condition.

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تأثير التسميد الورقى والمعدنى وبعض المنشطات النباتية على نمو وإنتاجية الخيار

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أجريت تجربتان حقليتان خلال الموسمين الصيفيين لعامى ٢٠١٦ - ٢٠١٧ فى مزرعة خاصة بمنطقة قريبة من المحلة الكبرى بمحافظة الغربية لدراسة تأثير ثلاث معدلات من التسميد المعدنى الأرضى (١٠٠%، ٧٥% و ٥٠% من الكمية الموصى بها) ومعاملتان للرش الورقى بالسماد المركب NPK (الرش الورقى بـ NPK - بدون رش) مع ثلاث معاملات بالمنشطات الورقية (شيتوزان – مستخلص اوراق المورينجا - الليثوفيت) بالإضافة الى الماء العادى (الكنترول) وكذلك التفاعل بينهم على صفات النمو الخضرى، المحتوى الكيماوى ،المحصول وصفات الجودة لنبات الخيار صنف برنس.وقد اظهرت النتائج أن التسميد الأرضى بمعدل ١٠٠ % من الكمية الموصى بها من NPK(١٢٠كجم أزوت ، ٥٠ كجم فوسفور ، ١٠٠ كجم بوتاسيوم للفدان) و الرش الورقى بالسماد المركب NPK بمعدل ٣ جم/لتر مع الرش بالشيتوزان بمعدل ٣ جم/لتر أعطى أفضل محصول (عدد الثمار/نبات ومحصول النبات والمحصول المبكر والكلى) بينما التسميد الأرضى بمعدل ٧٥% من الكمية الموصى بها من NPK (٩٠كجم أزوت ، ٣٧.٥ كجم فوسفور ، ٧٥ كجم بوتاسيوم للفدان) مع الرش الورقى بالسماد المركب NPK بمعدل ٣ جم/لتر ومستخلص اوراق المورينجا بمعدل ١٠ مل/لتر أعطت أعلى القيم لصفات النمو الخضرى (عدد الأوراق/نبات،الوزن الطازج و الجاف للنمو الخضرى و طول النبات) كما أن التفاعل بين الرش بالشيتوزان بمعدل ٣ جم/لتر والسماد الورقى NPK مع التسميد الأرضى بمعدل ٧٥ % من الكمية الموصى حققت تفوقا معنويا عن باقى المعاملات فى محتوى أوراق الخيار من العناصر النيتروجين، الفوسفور والبوتاسيوم وكذلك محتوى ثمار الخيار من السكريات الكلية والمواد الصلبة الذائبة والكلوروفيل الكلى. لذا يمكن التوصية بإستخدام ٧٥ % من الكمية الموصى بها للتسميد المعدنى NPK مع الرش الورقى بالسماد المركب NPK وإستخدام المنشطات النباتية رشا مثل مستخلص أوراق المورينجا لتقليل التسميد المعدنى مما يؤدى لتقليل تكاليف الإنتاج وتقليل الأثار الضارة على البيئة والحفاظ عل صحة الإنسان والحصول على محصول جيد ذات صفات جودة مقبولة.