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Impact of Foliar Spray of Some Plant Stimulants on Growth, Yield, Fruit Quality and Viral Infection of Squash Grown under Low Plastic Tunnels

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Abstract: A field experiment was conducted in the two seasons of 2018 and 2019 in the Research Farm of the Faculty of Agriculture, Ain shams university to study the effect of spraying some plant stimulants on growth, yield and fruit quality of squash grown in winter season under low plastic tunnels. Eight treatments were applied i.e., (chitosan (2 cm / L), salicylic acid (4 mm/ L), garlic extract (10 cm/ L), etheryl (100 ppm/ L), ascorbic acids (200 ppm/ L), yeast extract (5gm/ L), seaweed extract (3 cm/ L) and folic acid (1.5cm/ L). The results indicated that chitosan at concentration of 2cm /l gave the highest values of the vegetative growth traits such as plant length, number of leaves, fresh and dry weight. Chitosan treatment recorded a significant increase in early flowering and sex ratio. The highest values of fruits length and diameter were recorded by spraying plants by chitosan and ascorbic acid. The highest values of TSS were obtained from chitosan, salicylic acid and yeast extract treatments. Moreover, salicylic acid and garlic extract reduced viral infection in squash plants.

Key words: Squash · Chitosan · Yeast extract · Garlic extract · Ascorbic acid · Folic acid · Salicylic acid · Seaweed extract · Etheryl

INTRODUCTION

Summer Squash (*Cucurbita pepo* L.) belongs to the Cucurbitaceae family, which is one of the most popular vegetable crops for human nutrition in Egypt and worldwide. Some plant stimulants increase the yield and quality of vegetables.

In this concern, spraying chitosan on summer squash has significantly increased plant growth characteristics, yield and its components [1]. ELsharkawy and Ghoneim [2] found that spraying chitosan on globe artichoke plants caused significant increases in vegetative growth characteristics such as plant height, the number of leaves and dry weight, yield distribution (early and total yields), fresh and dry weight as well as TSS and K contents. Using chitosan as a foliar spray increased vegetative growth, yield and quality of potato [3]. Doklega *et al.* [4] on squash found that foliar application of chitosan recorded the highest values of fruit length, diameter, total yield, total chlorophyll and K, content.

Youssef *et al*. [5] found that spraying with ascorbic acid led to an increase in fruit length and diameter in squash. Moreover, Hussein and Mustafa [6] noticed that ascorbic acid treatment gave increases of plant height and chlorophyll in squash leaves as well as N, P, K content.

There is a focus for using natural substances to improve the growth of plants where folic acid has a synergistic effect on vegetative development and components of yield in many plants where it was so effective in reducing free radicals [7]. Seaweed extract increases the yield and also increase the micro-nutrients in the soil. Elboukhari *et al*. [8] on okra showed that seaweed increased the yield and the micro nutrients in the soil. Using salicylic acid as foliar application increased the vegetative growth, yield and quality of some vegetable crops [9]. The squash plants grown under the high level of salicylic acid excelled in the characteristics of the number of fruits, fruit weight, early yield, total and TSS % compared with non sprayed [10-12]. Using garlic extracts improve the growth and productivity of squash plants

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and significant increases in leaves number, as well as fresh and dry weights [13]. Doklega [14] indicated that chlorophyll, potassium, total soluble solids, vitamin C, early and total yield were significantly increased by foliar spraying with yeast extract on summer squash. Spraying squash plants with ethrel, stimulated plant growth, increased female flowers ratio, fruit production and quality [15, 16].

Plant viruses are among the causes that affect cucurbits and these diseases lead to losses through reduced growth, yield and are responsible for the distortion of the fruit. It is group of viruses capable of infecting cucurbits. The most important virus can infect cucumbers are pumpkin mosaic virus (SqMv),cucumber mosaic virus (CMV),watermelon mosaic virus (WMV) pumpkin and papaya virus (SqMV) as well as (ZYMV) yellow zucchini virus.

Therefore, the objective of this study was to investigate the impact of foliar spray of some plant stimulants (chitosan, ascorbic acid, folic acid, seaweed extract, salicylic acid, garlic extract, yeast extract and etheryl) on growth, yield, fruit quality and viral disease of squash grown under low plastic tunnels.

MARTIALS AND METHODS

This experiment was carried out under low plastic tunnels in 2018 and 2019 seasons. Experiment was executed in the Research Farm of Faculty of Agriculture in Ain Shams University. The seedlings took place on 13th and 18th on February in the first and second seasons respectively. Zucchini hybrid azyad was used to study the effect of some plant stimulants on growth, yield and fruit quality of squash. Soil analysis and temperatures were shown in the Tables (A and B) as follows:

Eight treatments were used i.e., chitosan at 3cm / L, ascorbic acid at 100 ppm /L, folic acid at 1.5cm /L, seaweed extract at 3cm/ L, salicylic acid at 4Mm /L, garlic extract at 10 cm /L, yeast extract at 5gm /L and etheryl at 200 ppm /L. Treatments were sprayed during the vegetative growth stage, after the appearance of four true leaves from planting the seed for three times 10 days intervals. The fertilization, irrigation and pest control was carried out according to the recommendations of the Egyptian ministry of agriculture. Randomized complete blocks design with three replications was used. Each replicate consisted of 3 rows with a 70 cm width and 3m long.

Data recorded were plant length, number of leaves, days to flowering, six ratio, early and total yield, fruit length, fruit diameter, fresh and dry weight, chlorophyll content in fruit, TSS, K and Ca content.

Estimation of Viral Diseases: Viral disease severity was determined using the following formula as reported by Abdel-Wahed [17].

$$\text{Disease severity \%} = \frac{\text{Sum of (nxv)}}{5N} \text{x} 100$$

where:

n = number of leaves or plants in infection category.

V = numerical values of infection category.

N = Total number of leaves or plants in the sample.

Statistic of Analysis: All obtained data were, statistically, analyzed according to Waller and Duncan [18].

Table A: Chemical analysis of the soil used in the experiment

m.mohs		Total (available) mg/100 g soil			ppm				%	
E.C	pH	N	P	K	Fe.	Mn.	Zn.	Cu.	$Caco_3$	O.M
0.35	8.06	76.9	2.4	53.08	16.39	2.87	2.78	3.06	4.17	1.31

Table B: Weather data of Egypt, Shubra-El-Khema, Qalyubiya, Monthly (January to May) during 2018-2019 seasons

	2018		2019	
Months	Minimum (EC)	Maximum (EC)	Minimum (EC)	Maximum (EC)
January	6.96	18.50	5.83	18.39
February	9.85	22.39	7.30	20.62
March	11.40	28.03	8.70	23.30
April	14.07	30.11	12.22	27.84
May	18.98	34.93	17.96	36.44
Average	12.25	26.79	10.40	25.32

RESULTS AND DISCUSSION

Vegetative Growth Characters: As for plant length, data in Table (1) show clearly that, the highest plant length was obtained from the foliar application with chitosan compared with the other treatments in the first seasons. On other hand, no significant effect among the treatments in the second season was found.

As for leaves number, results cleared that using chitosan gave the highest value of leaves number in both seasons but without significant differences between it and using salicylic acid and yeast extract in the first season. These results agree with those of Ibraheim and Mohsen [1]; ELsharkawy and Ghoneim [2]; Morovvat *et al*. [3] and Doklega *et al*. [4].

Results in Table (2) showed the superiority of chitosan and salicylic acid (SA) in fresh and dry weight of squash plants in both seasons. These results might be explained by the chitosan role as key of enzyme activities of nitrogen metabolism (nitrate reductase, glutamine synthetase and protease) and its effect on photosynthesis which enhance the plant growth [19, 20]. The positive effects of SA on vegetative growth-related characters in the present study could be attributed to SA mode of action in regulating and modulating the physiological processes on growth and development of squash. These results agree with those of Ibraheim and Mohsen [1]; Umar [21]; Abd B Elaziz *et al*. [10]; EL-sharkawy and Ghoneim [2]; Morovvat *et al*. [3]; Al-Ahmad and Al-Jubouri [12] and Doklega *et al*. [4].

Flowering and Sex Ratio: Data in Table (3) showed that chitosan decreased the number of days to flowering and male flowers in both seasons, while chitosan, folic acid and etheryl were superior in the number of female flowers in both seasons. These results are in agreement with the findings of Galala *et al*. [15]; Ibrahim and Mohsen [1]; Abokhdeer *et al*. [16]; Elsharkawy and Ghoneim [2]; Morovvat *et al*. [3] and Doklega *et al*. [4].

Yield: Results in Table (4) indicated that, the heaviest total and early fruit yield are associated with plants sprayed with chitosan and salicylic acid in the two tested seasons without significant differences between them and the other used treatments. These increments may be explained as a result of the favorable stimulatory effects of all treatments on vegetative growth characters and enhanced photosynthetic apparatus. The stimulating effects of vegetative growth might be due to the chitosan application enhanced the increase of water and essential minerals availability uptake through adjusting cell osmotic pressure and the reduction of the accumulation of harmful free radicals by increasing antioxidants and enzyme activities [22]. Also, the obtained results could be attributed to the role of salicylic acid (SA) in enhancing the plant defense in plant against phytoplasma attack, reduces and infection symptoms, favors photosynthetic translocation and improves the yield and quality of fruits [23]. These findings were completely similar of Ibraheim and Mohsen [1]; Omar [9]; Abd B Elaziz *et al*. [10]; ELsharkawy and Ghoneim [2]; Morovvat *et al*. [3]; Al-Ahmad and Al-Jubouri [12] and Doklega *et al*. [4]. All treatments showed an increase in the early yield during the first season compared to the control.

Physical Fruit Properties: The results in Table (5) shows a significant effect of chitosan on fruit length without significant difference between it and ascorbic acid in the both of seasons. As for fruit diameter, data recorded that chitosan and ascorbic acid gave the highest values in the both of seasons. These results are in harmony with Youssef *et al*. [5] and Doklega *et al.* [4]. All treatments showed an increase in the fruit diameter during the first season compared to the control.

Chemical Fruit Properties: The results illustrated in Table (6) show that the highest values of TSS were obtained from chitosan, salicylic acid and yeast extract treatments compared with the other treatments in the both of seasons. These results are in harmony with Doklega [14]; El-Shoura [11] and Morovvat *et al*. [3]. Data showed also that spraying squash plants with chitosan significantly increased the chlorophyll content of fruit in the two tested seasons. All treatments showed an increase in the chlorophyll content of fruit in both seasons compared to the folic acid and control.

The data in Table (7) showed the superiority of chitosan on calcium fruits contact of squash plants. As for potassium, there were no significant differences among the treatments in the both seasons. These results did not agree with those of ELsharkawy and Ghoneim [2] and Doklega *et al.* [4]. The stimulating effect of chitosan on the studied characters may be attributed to it enhanced the photosynthetic rate and improving the chemical composition of squash fruits [22]. Chitosan reduces the accumulation of harmful free radicals and increases

Table 1: Effect of spraying some plant growth stimulants on plant length and leaves number of squash plants in 2018 and 2019 seasons

	Plant length (cm)		No. of leaves / plant	
Treatments	2018	2019	2018	2019
Control	87.66 f	113.0 a	39.83 cd	41.00 d
Chitosan	122.50 a	126.0 a	46.00 a	51.33 a
Ascorbic	93.50 g	124.0 a	37.33 de	45.33 bc
Folic acid	94.84 fg	113.0 a	36.00 e	44.33 bc
Seaweed Extract	115.50 d	116.0 a	42.33 bc	45.00 bc
Salicylic acid	110.00 c	115.0 a	45.00 ab	45.33 bc
Garlic extract	115.50 c	110.0 a	37.66 de	42.33cd
Yeast extract	102.66 e	116.0 a	44.66 ab	46.00 b
Etheryl	101.66 e	110.0 a	41.66 c	46.66 b

Values in the same column followed by the same letter do not significantly differ from each other according to Duncan's multiple range tests at 5% level

Table 2: Effect of spraying some plant growth stimulants on fresh weight and dry weight of squash plants in 2018 and 2019 seasons

	Fresh weight / plant (kg)		Dry weight / plant (kg)	
Treatments	2018	2019	2018	2019
Control	1.265 d	1.674 bc	0.220 f	0.227 bc
Chitosan	3.178 a	2.876 a	0.483 a	0.602 a
Ascorbic	2.456 c	1.520 bc	0.240 ef	0.255 bc
Folic acid	2.442 b	0.842 d	0.260 ef	0.282 bc
Seaweed Extract	2.357 c	1.617 bc	0.374 b	0.180 c
Salicylic acid	3.127 a	2.528 a	0.463 a	0.516 ab
Garlic extract	2.442 b	1.576 bc	0.328 bed	0.222 bc
Yeast extract	2.447 c	1.810 b	0.315 cd	0.237 bc
Etheryl	2.502 c	1.093 cd	0.285 de	0.241 bc

Values in the same column followed by the same letter do not significantly differ from each other according to Duncan's multiple range tests at 5% level

Table 3: Effect of spraying some plant growth stimulants on sex ratio and flowering days of squash plants in the 2018 and 2019 seasons

	Sex ratio (female/male flowers)		Days to flowering	
Treatments	2018	2019	2018	2019
Control	0.86 e	0.78 e	67.66 a	72.00 a
Chitosan	1.23 a	1.22 a	63.33b	65.66 c
Ascorbic	1.05 bcd	0.93 cd	63.33b	67.33 bc
Folic acid	1.14 abc	0.94 cd	66.33ab	68.66 abc
Seaweed Extract	1.04 cd	1.01 bc	65.00b	66.66 bc
Salicylic acid	1.02 cd	1.03 bc	65.33b	67.66 abc
Garlic extract	0.96 de	0.96 c	66.00b	68.66 abc
Yeast extract	1.04 cd	0.82 de	66.67ab	67.33abc
Etheryl	1.19 ab	1.11 ab	66.00b	71.00 ab

Values in the same column followed by the same letter do not significantly differ from each other according to Duncan's multiple range tests at 5% level

Table 4: Effect of spraying some plant growth stimulants on the early and total yield of squash plants in 2018 and 2019 seasons

	Early yield (g/plant)		Total yield (kg/plant)	
Treatments	2018	2019	2018	2019
Control	550.40 b	687.33 d	2.750 d	2.851 bc
Chitosan	827.00 a	910.00 a	3.750 a	3.602 a
Ascorbic	807.00 ab	810.67 b	3.293c	3.254 ab
Folic acid	572.00 ab	707.33 d	3.323 c	2.851 bc
Seaweed Extract	646.67 ab	617.67 e	2.548 e	2.534 c
Salicylic acid	826.67 a	982.33 a	3.800 a	3.664 a
Garlic extract	703.00 ab	770.00 c	3.650 b	3.084 abc
Yeast extract	742.67 ab	748.33 c	2.836 d	3.000 bc
Etheryl	646.67 ab	632.67 e	2.533 e	2.534 bc

Values in the same column followed by the same letter do not significantly differ from each other according to Duncan's multiple range tests at 5% level

Table 5: Effect of spraying some plant growth stimulants on fruit length and fruit diameter of squash plants in 2018 and 2019 seasons

	Fruit length (cm)		Fruit diameter (cm)	
Treatments	2018	2019	2018	2019
Control	11.33 bc	13.66 c	.53 b	2.500 c
Chitosan	12.33 a	16.00 a	3.33 a	3.33a
Ascorbic	12.00 ab	15.66 ab	3.16 a	3.00 a
Folic acid	10.66 c	14.00 bc	2.66 ab	2.66 bc
Seaweed Extract	11.50 bc	14.33abc	2.66 ab	3.00 ab
Salicylic acid	11.33 bc	14.00 bc	2.66 ab	2.66 bc
Garlic extract	11.00 c	13.66 c	3.00 ab	2.66 bc
Yeast extract	12.00 b	14.66 abc	3.00 ab	2.50 c
Etheryl	12.00 b	14.33abc	2.66 ab	2.50 c

Values in the same column followed by the same letter do not significantly differ from each other according to Duncan's multiple range tests at 5% level.

Table 6: Effect of spraying some plant growth stimulants on TSS % and Chlorophyll content of squash plants in 2018 and 2019 seasons

	TSS %		Chlorophyll content (SPAD)	
Treatments	2018	2019	2018	2019
Control	7.42 de	9.35 d	3.75 bc	4.06 c
Chitosan	11.67 a	12.17 a	4.43 a	4.93 a
Ascorbic	10.73 b	6.71 f	4.31 ab	4.66 ab
Folic acid	8.72 c	9.08 d	3.50 c	3.10 c
Seaweed Extract	8.05 cd	10.09 c	4.25 ab	4.46 ab
Salicylic acid	11.22 ab	11.87 ab	4.10 abc	4.50 ab
Garlic extract	6.70 c	8.65 e	4.03 abc	4.46 ab
Yeast extract	11.54 ab	12.11 a	4.11 abc	4.33 ab
Etheryl	8.67 c	6.18 g	4.20 ab	4.66 ab

Values in the same column followed by the same letter do not significantly differ from each other according to Duncan's multiple range tests at 5% level.

Table 7: Effect of spraying some growth stimulants on calcium and potassium fruits content of squash plants in 2018 and 2019 seasons

	Calcium %		Potassium %	
Treatments	2018	2019	2018	2019
Control	0.153 d	0.143 cd	3.133 a	2.883 a
Chitosan	0.310 a	0.206 a	2.446 a	2.720 a
Ascorbic	0.200 bc	0.173 b	2.886 a	2.860 a
Folic acid	0.190 c	0.160 bc	2.870 a	2.970 a
Seaweed Extract	0.193 bc	0.130 d	3.003 a	2.946 a
Salicylic acid	0.190 c	0.163 bc	3.050 a	2.970 a
Garlic extract	0.216 b	0.166 bc	3.100 a	2.866 a
Yeast extract	0.153 d	0.160 bc	3.106 a	2.883 a
Etheryl	0.176 cd	0.146 cd	3.126 a	2.950 a

Values in the same column followed by the same letter do not significantly differ from each other according to Duncan's multiple range tests at 5% level

antioxidants and enzyme activities improves essential nutrients and uptake and the availability of water by adjusting cell osmotic pressure [24]. Chitosan is consider a new plant growth promoter such as GA3 which has a great role in the growth and yield of plant El-Bassiony *et al.* [25]. These results are agreed with Ibraheim and Mohsen [1] on summer squash and Geries *et al.* [26] on onion.

Viral Diseases Severity: The results illustrated in Table (8) showed significant reduction of viral severity on squash plants sprayed with salicylic acid and garlic extract treatments compared with the other treatments during 2018 and 2019 seasons. These results revealed that in the first season viral disease severity was more aggressive compared with the second season, it was mild in most treatments. In addition, in both seasons the treated plants in most treatments did not show any symptoms in the first week subsequently the viral infection started showing clear symptoms which expressed in disease severity from the second week then the peak of severity increased in the third week in all treatments. The reason that the virus multiplication increased with time and started showing symptoms after

Table 8: Effect of foliar spraying of plant some growth stimulants on reducing viral severity on squash plants in the 2018 and 2019 seasons

Seasons	Treatments	First week	Second week	Third week
First Season 2018				
	Control	0	16.6	25
	Chitosan	21.92	33.3	50
	Ascorbic	0	0	12.5
	Folic acid	0	0	25
	Seaweed extract	0	11.11	41.6
	Salicylic acid	0	0	0
	Garlic extract	0	0	12.5
	Yeast extract	0	11.1	12.5
	Etheryl	21.42	33.3	50
Second Season 2019	Control	0	0	12.5
	Chitosan	0	0	0
	Ascorbic	0	33.3	50
	Folic acid	0	0	0
	Seaweed extract	0	0	0
	Salicylic acid	0	0	0
	Garlic extract	0	0	0
	Yeast extract	0	21.42	33.3
	Etheryl	0	21.42	33.3

two weeks of infection then the severity of infection increased with symptoms expression which is related to the sensitivity of plants and defense substances formed in treated plants due to sprayed treatments. These results are in harmony with El Bshazly, *et al*. [27] who found that spraying SA at the pre-and after viral infection reduces the ratio of infection by 90,80 and 60% respectively, compared to infected plants. Moreover, Umar *et al*. [21] showed that exogenous applied SA could offer a good source for the management of ZYMV by inducing resistance in cucumber.

This study recommends, generally, that the foliar spray application of chitosan at 3cm / L and salicylic acid at 4Mm /L gave the highest values of yield, quality as well as chemical properties of fruits. Also, using salicylic acid and garlic extract at10 cm /L gave significant reduction of viral severity on squash plants.

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