Impact of Irrigation and Foliar Application with Salicylic Acid on the flowers patterns and yield of summer Squash

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Abstract:

The experiment was conducted in open field condition during summer season of 2015 to investigate the effect of salicylic acid on flowers patterns and yield of Squash grown under open field conditions. Squash seedlings were treated with salicylic acid as irrigation or foliar application at different concentrations (0.25 – 0.50 – 0.75 – 1 mM). The experiment was completely randomized experimental design with 10 plants for each treatment and 3 replications.

Results indicated that both application methods of salicylic acid have a positive effect on squash plants compared with control. The (1 mM) concentration of salicylic acid in both application methods (R1, F1) significantly increased the number of female flowers and total flowers/plant, as well as fruits number, fruit weight, mean plant yield and total yield, and decreased the number of male flowers. Also, foliar application treatments showed more positive results than irrigated treatments, especially within low salicylic acid concentration treatments (R0.25 and R0.50) which had not significant effect on the studied characters compared with control plants.

Application of salicylic acid improved the yield contributing factors that resulted in significant increase in squash fruit yield.

Key words: *Squash, salicylic acid, flowering, yield.*

I. INTRODUCTION

Squash (*Cucurbita pepo* L.) is one of the most important vegetable crops belongs to the genus Cucurbita and the family cucurbitaceae, the genus contain four cultivated spices: *Cucurbita mixta*, *Cucurbita maxima*, *Cucurbita moschata*, and *Cucurbita pepo* [1]. Squash have originated in southwest America and Mexico [2], and has a wide range of distribution in temperate and sub-tropical regions ([3]; [4]). Today, various cultivars of squash are grown all over the world and called: zucchini, summer squash and spaghetti squash [5], which are eaten as a vegetable, or used for ornament [6].

Salicylic acid (SA) is classified as a phenolic growth regulator, known as an antioxidant compound that can control plant growth ([7]; [4]; [8]). SA has numerous functions on plants, especially the inhibition of germination and growth, reduced transpiration and leaf abscission [9], a flower inducing factor [10], photosynthetic rate and transpiration could also be affected by SA application [11]. Later studies found that SA improve plant tolerance to various environmental stresses ([12]; [13]; [14]), and disease resistance ([15]; [16]; [17]).

The effect of SA on plants varies according to species, developmental stage, as well as SA concentration [18]. For example, [19] studied the effect of foliar SA applications on fruit-quality characteristics and yield of strawberry in different stages of plant growth under greenhouse conditions, the results indicate the positive affect of SA on strawberry fruits quality especially when they used three to four applications from SA during different stages of plant growth. [20] treated Tomato plants with foliar SA applications at different concentrations (0.00, 0.25, 0.50, 1.00 mM), they found that foliar applications of SA showed positive effect on plant growth, fruit characteristics, chlorophyll content in leaves and yield in all the treatments, but the highest yield occurred in 0.50 mM SA treatment.

Cucumber was one of the plants treated with salicylic acid, the treated plants had higher yield in the species, cultivated either in greenhouse or in open conditions or species grown under different stress conditions ([20]; [4]). Water irrigation of *Cucumis sativus*. L plants with different concentration of SA increase the number of female and total flowers, fruits number and weight, as well as plant yield [21].
Cucumber seedlings were treated with foliar SA applications at different concentrations (0.00, 0.25, 0.50, 1.00 mM) two times as before and after transplanting under salt stress [20], treated plants showed more positive values of growth, chlorophyll, and mineral Content than non-

A. Effect of SA on flowering:

Data in Table 1 show that the number of female flowers, total flowers per plant and the percentage of female /total flowers were positively affected in all the treatments comparing with the control plants, while the number of male flowers were negatively affected.

The number of female and total flowers were significantly increased gradually with the gradual increase of SA concentration in both application methods. Namely, the treatment (FI) significantly increased the number of female flowers (39), total flowers (46) and the persentag female/total (82%) comparing with the other treatments, followed by (R1) and (F0.75), respectively. Additionally, the effect of low SA concentration on the number of female and total flowers in Irrigate treatments (R0.25, R0.5) showed slightly decreased compared to the high concentration of SA in irrigation water (R1, R0.75), as well as in all foliar application treatments.

The maximum male flower number was recorded with control squash plants (15 flowers) followed be (F0.25) and (R0.5) treatments.

The number of female flowers and total flowers dominantly existed in (R1) (foliar application treatment) comparing with all other treatments (table 1). Also, (F1, R0.75, R0.50) treatments show significant difference in female and total flowers number compared to (F0.25, R0.5, R0.25, C0) treatments. High concentrations of SA significant decreased male flowers in both application methods.

It was clear that the most positive effect of SA on squash plant flowers was observed on the foliar application treatments comparing with water irrigation treatments, and both methods of SA application gave more positive effect comparing with control. Except for (R1) treatment, all foliar application treatments (F0.25, F0.5, F0.75, F1) significantly increased the number of female flowers, total flowers and the percentage of female/total compared with irrigate treatments (R0.25, R0.5, R0.75) and control plants(C0).

In agreement to our results, the positive effect of SA on flowering process has been conducted in several studies ([23]; [24]; [25]). But the specific flower inducing mechanism that involves salicylic acid is still not explainable.

treated ones, the greatest values were obtained from 1.00 mM SA application.

Objective of the current study was to assess the efficacy of irrigation and foliar-applied with different concentrations of SA on flowering, fruits and yield of summer squash plants grown under open field conditions.

II. MATERIALS AND METHODS

The experiment was conducted in summer 2015 at field located in Bouka- Latakia (Syria). Seeds of Squash plant variety "Nancy F1" (Syngena - Holland) were planted at 1 May in small plastic pots (500 ml). After sowing (1-2 leaves) seedlings were transplanted into the field, two weeks after transplanting (5-6 leaves), SA solutions were supplied once to seedlings as irrigation (first experiment) and foliar applications (second experiment). Irrigation or foliar solutions containing one of four levels of SA (0.25, 0.50, 0.75, 1 mM) .

The experiment consisted of 4 irrigation treatments (R0.25, R0.5, R0.75, R1), 4 foliar application treatments (F0.25, F0.5, F0.75, F1) and one control (C0), the treatments were arranged in a completely randomized design with 10 plants for each treatment, the 9 tested treatments were replicated three times for each, making a total of 270 Plants. The experimental plot area was 162 m^2 ; 18 m length × 1 m width (9 rows), and 0.6 m spacing between.

A. *Flowering characteristics:*

Number of male and female flowers on the plant; number of total flowers; Percentage of female/total flowers.

B. Fruit characteristic and yield:

Total fruits number (Fruit/plant) and Fruit yield (kg/plant) was calculated as number and fresh weight of fruits in all pickings. Also the total yield per dunum was calculated.

C. Statistical analysis:

The collected data were analyzed statistically using analysis of variance according to [22] with the aid of COSTAT computer program. Treatment means were compared using least significant differences (LSD) at 5% level ($p \leq 0.05$).

III. RESULTS AND DISCUSSION

Table 1. Show the number of male, female and total flowers per plant and the percentage female/total.

Treatments	Male flowers/plant	Female flowers/plant	Total flowers/plant	Female/total %
R0.25	12	27	39	69.23
R0.5	13	27	40	67.50
R0.75	10	31	41	75.60
R1	9	35	44	79.54
F0.25	13	30	43	69.67
F0.5	11	34	45	75.55
F0.75	10	34	44	77.27
F1	9	39	48	81.25
C0	15	26	41	63.41
LSD 5%	2	2.5	2.2	2.8

yield (Table 2). There were significant correlations between fruit number and yield. In general, Plants treated with foliar SA had higher values of fruit number and weight as well as plant yield than irrigated plants with the same concentration, and both treatments show more values comparing with control plants. The present findings are in agreement with the results obtained by ([26]; [27]) who found that the fruit yield in tomato, enhanced significantly when the plants were sprayed with different concentrations of salicylic acid, and [28] results who indicated that spraying by different concentration of SA gave significant increased on yield of the corn silk.

The highest total yield was obtained from the (F1) and (R1) treatments which were dialed with (1 mM) SA concentration and had a significant effects on squash fruit yield comparing with the other concentration and the control plants. This increasing of yield closely linked to increase the number of female flowers/plant (Table 1). These results are supported by those of [25] who found that foliar application of salicylic acid to soybean enhanced the flowering, pod formation and consequently yield of soybean, and [21] who found that high concentrations of SA in irrigation water increased female flowers and fruits number and consequently fruit yield of cucumber plant grown under greenhouse conditions.

B. Effect of SA on fruit and yield:

Fruit data of treatments are presented in Table 2. There was an increase in fruit number (fruits/plant) as SA concentration increased in irrigation as well as foliar application treatments, except for the (R0.5) treatment. Similarly, treatments with high SA concentration produced more fruit weight than others.

The results indicated that (1 mM) SA in both application methods caused a manful increase in fruit number and weight compared to other levels of SA (Table 2). Highest fruit number (31 and 30) was found in squash treated with (1 mM) SA (F1 and R1), followed by the treatments (F0.75, F0.5, R0.75). While the highest fruit weight was found in (1 mM) SA treatments (R1: 122g) and (F1: 120g).

Mean plant yield and total fruit yield were positively correlated with both irrigation and foliar application treatments comparing with control plants, especially with increasing level of SA. Highest means of plant yield (3.720 g) and fruit yield (6175 kg/dunum) were found in foliar treated squash with (1 mM) SA concentration (F1), followed by mean plant yield (3.660 g) and fruit yield (6075 kg/dunum) in irrigate treated squash with (1 mM) SA concentration (R1).

Analysis of variance showed that water irrigation and foliar application of different concentration of salicylic acid significantly affected squash

Table 2. show the number of fruits per plant, fruit weight, plant yield and yield per dunum.

Treatments	Fruit number	Mean fruit weight (g)	Mean plant yield (Kg)	Yield Kg/dunum
R0.25	22	116	2.552	4236
R0.5	**I. 21**	**II. 118**	**III. 2.478**	**IV. 4113**
R0.75	**V. 26**	**VI. 119**	**VII. 3.094**	**VIII. 5136**
R1	**IX. 30**	**X. 122**	**XI. 3.660**	**XII. 6075**
F0.25	**XIII. 24**	**XIV. 115**	**XV. 2.760**	**XVI. 4581**
F0.5	**XVII. 27**	**XVIII. 119**	**XIX. 3.213**	**XX. 5333**
F0.75	**XXI. 29**	**XXII. 120**	**XXIII. 3.480**	**XXIV. 5776**
F1	**XXV. 31**	**XXVI. 120**	**XXVII. 3.720**	**XXVIII. 6175**
C0	**XXIX. 20**	**XXX. 115**	**XXXI. 2.300**	**XXXII. 3818**

LSD 5%	XIII. 1.8	XIV. 2.2	XXV. 216.5	XVI. 398

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IV. CONCLUSIONS

In this study, our results demonstrate that the effects of irrigation and foliar application of different concentration of SA are significantly important in order to get more yield in summer squash grown in field conditions. High concentration of SA significantly affected the female flowers number as well as fruits number and weight and in total fruit yield of summer squah. However, further investigations are required to elucidate the possible role of SA on plant vegetative growth, flowers, fruits and yield activity.

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