Effect of Foliar Application with Sitofex and Salicylic Acid on Tomato Growth, Yield and Chemical Attributes

Faid, H. A[1]., A. A. Alkharpotly[2], A. A. Gabal[1], F. I. Radwan[1] and A. I. Abido[1]
[1]Pl. Prod. Dept., Fac. Agric. (Saba Bash), Alex. Univ., Egypt
[2]Hort. Dept., Fac. Desert & Environ. Agric., Matrouh Univ., Egypt

ABSTRACT: Two open field experiments were conducted during summer seasons of 2016 and 2017, in a private farm at Sedi Salem city, Kafr El-Sheikh Governorate, Egypt to investigate the effect of foliar application with sitofex CPPU, salicylic acid and their combinations on tomato growth, yield and chemical attributes. The 'Super Strain B F_1 hybrid' tomato cultivar, plants were treated with four concentrations of the synthetic cytokinin sitofex (0.00, 0.04, 0.08, and 0.12 mM) and four concentrations of SA (0.00, 1.00, 2.00 and 3.00 mM) were foliar applied separately and in combinations. Control plants were sprayed with tap water. Tomato plants were sprayed with the allocated or assigned treatments twice during the growing seasons, the first one at 10 days after transplanting and the second application was 35 days after the first one. The obtained results declare, in general, that foliar application treatments of cytokinin as sitofex and salicylic acid (SA) alone or in combination to tomato plants gave, significantly, the highest average values of vegetative growth, yield and chemical attributes compare to untreated plants. The combination between 0.12 mM CPPU plus 3.00 mM SA might be considered as an optimal treatment for the production of high yield and good quality of tomato fruits under the environmental conditions of Kafr El-Sheikh Governorate and other similar regions.

Keywords: CPPU, Sitofex, Salicylic acid (SA), Tomato growth and yield attributes, Tomato chemical attributes.

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is a member of the Solanaceae 'nightshade' family and one of the most important vegetables grown in Egypt which occupies, at 2017, the fifth grade worldwide in tomato production with 7297108 tons devoted to total area of 182444 hectares (FAOSTAT, 2019). It is, likewise, very important industrial raw material fruit crop for food processing and agricultural industry. In addition, it is used mostly as edible or eat enable fresh fruits and as salad's constituents. It is an important source for the pigment of lycopene, minerals, and vitamins that have been shown to have a profound effect on some cancer cells (Helyes *et al*., 2012).

Increasing the tomato yield and fruits, quality are crucial factors for this important crop, especially during summer seasons, where the predominant high temperature stress exerts an adverse effect on the growth of the whole plant, especially during flowering and fruit setting stages *via* restricting the supply of water and mineral nutrients, affecting the metabolism, growth and development (Boyer, 1982).

Cytokinins are plant hormones (upon biosynthesized endogenously), and plant growth regulators (upon synthesized exogenously), briefly, both promoting cell division , differentiation and hence plant growth and development. Since the

discovery of the first cytokinin, kinetin by Miller *et al*. (1955), numerous of chemicals as such have been synthesized to mimic the mode of action of natural cytokinins as adenine and phenylurea derivatives. The phenylureas represent a class of synthetic cytokinins, some of which are highly active, e.g. CPPU [N-(2-chloro-4-pyridyl) -N'- phenylurea] (Takahashi *et al.,* 1978) and thidiazuron (Mok *et al*., 1982).

The first cytokinin-active phenylurea as Diphenylurea (DPU) was identified by Shantz and Steward (1955). This synthesized cytokinin have the road to synthesize of a number of potent analogues such as forchlorfenuron (CPPU) and thidiazuron with cytokinin activity more than zeatin (Mok *et al*., 1987; and Shudo, 1994). Furthermore, these active phenylureas are highly stable than zeatin. Also, there is no sign that they are occur naturally within plant tissues.

Cytokinins (CKs) have long been suggested to play a prominent role in promote cell division and cell expansion in plant cell culture (Riou-Khamlichi *et al.,* 1999). In case of *in situ* situation, foliar application of cytokinin brought about regulation a variety of plant functions as proliferation of vegetative (foliage) growth, re-juvenility of senescence leaves, breaking apical dominance (even true).

Additionally, forchlorfenuron (CPPU) is a synthetic cytokinin which increases fruit set and growth of grape berry (Ogata *et al*., 1988), pear (Banno *et al*., 1986), kiwifruit (Iwahori *et al*., 1988), watermelon (Hayata *et al*., 1995), and muskmelon (Hayata *et al*., 2001). Sattelmacher and Marschner (2008) assumed that the shift in cytokinin mode of actions in shoot is the cause of connection with an increased photosynthetic activity.

Likewise, salicylic acid (SA) acts as an endogenous hormone-like plant growth regulator, which has abroad, but also had different roles on stress adjustment and appears to be an effective agent for the plant to overcome different stresses (Vicente and Plasencia, 2011). It is well-known that SA is a member of the phenolic compounds that are urgent in lignin biosynthesis, which is one of the most important components of the cell wall as well as phenolic compounds, especially Phytoalexin which contribute strictly in chemical defence of the plant against germs, insects and herbivorous (AL-Khafaji, 2014). It, also, has a role in the secondary metabolism, which encourages root growth, conferring such resistance against pathogenesis infection to the plant, suppresses ethylene biosynthesis, and quality and quantity of contained proteins improvement (Canakci and Munzuroglu, 2007). Salicylic acid, further, helps protection of nucleic acids and prevents the protein degradation. It, also, has effects on certain genes that associated with the protein (s) that responsible for biotic and abiotic stresses (Amanullah *et al*., 2010). It plays a vital role in plant growth *via* ion uptake and transport photosynthetic assimilates membrane permeability and transpiration (Wang *et al*., 2006). Further, SA has numerous functions, particularly the inhibition of

germination and growth, interference with root absorption, reduced transpiration and leaf abscission (Ashraf *et al*., 2010).

Therefore, the main objective behind this study is to investigate the effectiveness of foliar application of both cytokinin as sitofex (CPPU or forchlorfenuron) and salicylic acid (SA) on tomato (*Solanum lycopersicum* L. Super Strain B cv.) as foliar application and to overcome or alleviate the heat stress or over heat of summer temperature (from June) during tomato plantation.

MATERIALS AND METHODS

Two field experiments were carried out during the summer seasons of 2016 and 2017 in a private farm, at Sedi Salem city, Kafr El-Sheikh Governorate, Egypt. The experimental field was polughed and pulverized. Tomato cultivar' seeds coined as 'Super Strain B F_1 hybrid' were used to conduct the experimentation. It was purchased from 'Nunhems for Seed Production Co.', Egypt. Seedlings of 31 days old were transplanted in the field at one side of the ridge on the first of April during the both seasons of the study.

Seedlings were transplanted at 0.50 m apart and 1.10 m width of ridge (*i. e*. the number of plants/feddan were 7636 plants). The experimental plot consisted of one ridge with 13.50 m long and 1.10 m width making an area of 14.85 m^2 using surface irrigation system. Both conducted experiments were factorial experiments laid out in a randomized complete block design (RCBD), with three replicates. Each replicate included 16 treatments. All determined treatments were distributed randomly within each block.

Treatments were consisted of two factors (independent variables) as foliar applicants, *i.e*.; four concentrations of cytokinin as Sitofex (CPPU or Forchlorfenuron) as control, 0.04, 0.08 and 0.12 mM in combination with four concentrations of salicylic acid (SA) as control, 1, 2 and 3 mM. Control plants were sprayed with tap water. Cytokinin and salicylic acid were purchased from 'Algomhoria Company for Chemicals', Alexandria, Egypt. All precautions and accuracy were followed during weighting, dissolving, spraying of both independent variables. Foliar application of both CPPU and SA was done afternoon during both seasons, to avoid deterioration caused by effect of higher temperatures and ambient atmosphere on the applied items, at time of application. Tomato plants were sprayed with the allocated or assigned treatments twice during the growing seasons, the first one at 10 days after transplanting and the second application was 35 days after the first one. The recommended agricultural practices for commercial tomato production under open field conditions were followed. Harvesting was accomplished after 73 days of transplanting during both seasons.Four plants from each treatment, in each replications, were randomly selected and tagged for recording growth attributes, early yield and total yield as well as fruit quality parameters.

Growth attributes' records,

After 73 days from transplanting, plant height (cm), number of leaves per plant, number of branches per plant, and plant fresh weight (g) characters were determined. Plant dry weight (g) was conducted in an electrical oven at 70˚ C till obtaining a constant weight, then determined (in gram).

Yield and its component measurements

Harvesting of fruits was done for early yield after 73 days of transplanting, then for the rest of harvesting, each 7 days (total 4 picking times). The harvested fruits were counted and weight using electronic scale.

The following criteria were determined, Number of fruits per plant, average fruit fresh weight (g), early yield (ton/feddan) and total yield per feddan (ton).

N, P and K contents of leaf and fruit were determined at 73 days after planting as follows: **Total N content** was determined colorimetrically according to Chapman and Pratt (1978), **total P content** was determined colorimetrically as described by Singh *et al*. (2005), **total K content** was determined photometrically using the flame photometer method (Jackson, 1973).

Statistical Analysis :

All obtained data of the present study were, statistically, analyzed according to the design used by the MSTAT-C computer software program (Bricker, 1991) and were tested by analysis of variance. Least significant difference test at 0.05 level of probability was used to compare the differences among the means of the various treatment combinations as illustrated by Duncan (1965) and Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The results, generally, revealed that sitofex cytokinin phenylurea derivative (CPPU), salicylic acid (SA) and their combinations affected, more or less, significantly ($p \leq 0.05$), the traits of the study as on overall during both seasons of the study.

1. Vegetative growth characters

The results illustrating the effects of sitofex (CPPU), salicylic acid (SA) and their combinations on vegetative growth characters of tomato plants (plant height, number of leaves/plant, number of branches/plant, plant fresh and dry weights) during both seasons of the study, *i. e*., 2016 and 2017, are presented in Table (1). Concerning the main effect of CPPU, the gained results reflect, generally more or less, that there is a direct proportionate relationship between the tested concentrations of this cytokinin and the traits under the study during both seasons of the study as compared to the control plants. For instance, foliar application of CPPU at the highest level (*i.e*. 0.12 mM) recorded the highest significant average values of all tested traits with insignificance effect ($p > 0.05$) between it and 0.08 mM for plant height character, during both seasons. The present results are in agreement with those obtained by El-Shraiy and Hegazi (2010). These results could be attributed to the multiple functions of cytokinins

and their derivates as CPPU. Whereas, cytokinins enhance cell division and enlargement (Te-Chato and Lim, 2000). Also, Zhang and Chang (2010) reported that CPPU has the functions to promote cell division, cell enlargement and delay senescence. Increasing plant fresh and dry weights could be given rise due to increasing number of branches, number of leaves and plant height due to using CPPU treatments.

In terms of the main effect of foliar application with salicylic acid on the given characteristics, results presented in Table (1) reflect similar performance as CPPU, where there is a direct proportionate relationship was obvious between both independent and dependent variables, and the obtained calculated averages were affected significantly ($p \leq 0.05$) by applied levels of salicylic acid, during both seasons of the study. For example, spraying SA at 3 mM; brought about the highest average values of the studied traits, compare to average values of control plant measurements.

The present results are in agreement with those obtained by Flores-Lopez *et al*. (2016) who reported that potato foliar application with SA at 10^{-8} and 10^{-10} M**;** led to significant increases in plant height and plant fresh weight.

Table (1). Averages values of some vegetative growth-related characters of tomato plants as affected by foliar application with sitofex (CPPU or Forchlorfenuron), salicylic acid (SA) and their combinations during the summer seasons of 2016 and 2017

Treatments		Plant height (cm)		No. of leaves/plant		No. of branches/plant		Plant fresh weight (g)		Plant dry weight (g)	
		2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
CPPU (main effect)											
Control		61.99 c	64.95 c	69.67 d	71.75 d	3.83 c	5.25 d	511.49 d	522.93 d	67.61 d	70.24 d
0.04 mM		67.16 b	69.84 b	78.75 c	80.58 c	5.08 b	6.58 c	529.16 c	542.34 c	71.09 c	73.10 c
0.08 mM		70.45 a	73.57 a	84.33 b	85.92 b	6.00 b	7.33 b	539.93 b	555.01 b	73.23 b	74.90 b
0.12 mM		71.51 a	74.50 a	86.25 a	88.08 a	6.33 a	7.83 a	544.05 a	559.56 a	74.09 a	75.61 a
SA (main effect)											
Control		61.81 d	64.50 d	70.00 d	71.83 d	3.67 c	5.17 d	511.03 d	522.64 d	67.58 d	70.20 d
1 mM		67.36 c	70.29 c	79.00 c	81.58 c	5.33 b	6.42 c	529.27 c	542.50 c	71.11 c	73.13 c
2 mM		69.38 b	72.34 b	82.25 b	83.33 b	5.75 a	7.25 b	536.68 b	551.45 b	72.60 b	74.35 b
3 mM		72.56 a	75.74 a	87.75 a	89.58 a	6.50 a	8.17 a	547.66 a	563.23 a	74.73 a	76.16 a
Combinations effects											
CPPU (mM)	**SA (mM)**										
Control	**Control**	57.51 l	60.35 k	62.67 n	65.67 l	2.33 l	4.33 k	497.18 p	507.03 p	64.88 p	68.03 p
	1	67.54 g	70.36 f	79.00 hi	82.33 g	5.33 e-h	6.33 f-h	529.59 i	542.56 i	71.07 i	73.13 i
	2	60.53 k	63.72 j	67.67 lm	68.33 jk	3.67 jk	5.00 i-k	507.35 n	518.64 n	66.83 n	69.55 n
	3	62.39 j	65.37 ij	69.33 l	70.67 j	4.00 ij	5.33 h-k	511.84 m	523.47 m	67.66 m	70.23 m
0.04	**Control**	59.51 k	61.53 k	65.33 mn	66.00 ki	2.67 kl	4.67 jk	502.05 o	512.16 o	65.89 o	68.76 o
	1	63.58 ij	66.48 hi	73.00 k	75.67 i	4.33 h-j	5.33 h-k	516.62 l	528.43 l	68.56 l	70.99 l
	2	70.73 e	73.73 d	84.67 ef	86.33 de	6.33 b-e	7.67 c-e	542.53 f	557.32 f	73.66 f	75.24 f
	3	74.83 bc	77.62 b	92.00 bc	94.33 b	7.00 a-c	8.67 a-c	555.45 c	571.44 c	76.23 c	77.42 c
0.08	**Control**	64.81 hi	67.52 gh	75.00 jk	76.33 i	4.67 g-j	5.67 g-j	520.42 k	533.50 k	69.34 k	71.64 k
	1	68.63 fg	71.66 ef	80.67 gh	83.33 fg	5.67 d-g	6.67 e-g	533.31 h	547.62 h	71.97 h	73.85 h
	2	72.62 d	75.51 c	87.67 de	88.00 d	6.33 b-e	8.00 b-d	546.37 e	562.42 e	74.55 e	75.97 e
	3	75.73 ab	79.60 a	94.00 ab	96.00 ab	7.33 ab	9.00 ab	559.63 b	576.49 b	77.08 b	78.12 b
0.12	**Control**	65.42 h	68.60 g	77.00 ij	79.33 h	5.00 f-i	6.00 g-i	524.46 j	537.88 j	70.22 j	72.36 j
	1	69.69 ef	72.67 de	83.33 fg	85.00 ef	6.00 c-f	7.33 d-f	537.54 g	551.40 g	72.84 g	74.54 g
	2	73.64 cd	76.39 bc	89.00 cd	90.67 c	6.67 a-d	8.33 b-d	550.48 d	567.43 d	75.35 d	76.65 d
	3	77.30 a	80.36 a	95.67 a	97.33 a	7.67 a	9.67 a	563.70 a	581.52 a	77.96 a	78.87 a

- CPPU, synthetic cytokinin N-(2-chloro-4-pyridyl)-N'-phenyl urea; SA, salicylic acid
- Values having the same alphabetical letter (s) in common, within each column, do not significantly differ, using L.S.D. test at 0.05 level of probability.

In the same context, AL-Jeboori *et al*. (2017) ascertained the previous results, where spraying potato plants with salicylic acid at 100 mg/l; resulted in highest significant values of plant height, number of leaves per plant, foliage dry weight and leaf area. 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 plants under the study *via* ion uptake and transport, photosynthetic rate, membrane permeability and transpiration (Wang *et al*., 2006). Increasing plant fresh and dry weights could be given rise due to increasing number of stems, number of leaves and plant height owing to SA treatments.

Pertaining the interaction between both independent variable levels, average values in Table (1) disclosed significant differences ($p \leq 0.05$) among the averages of their interactions. In general, combination between CPPU at 0.12 mM and SA at 3 mM achieved, more or less, the highest average values of all the studied characters.

2. Yield characters

Results presented in Table (2) epressed that foliar application of tomato plant with synthetic cytokinin as CPPU, salicylic acid (SA) and their combinations; affected significantly ($p \leq 0.05$) all tested characteristics during both seasons. Concerning the main effect of CPPU, results presented in Table (2) reflected, generally, that there is such a proportionate relationship between the tested concentrations of the cytokinin and the traits of the study during both seasons of the study as compared to the control plants. For instance, foliar application of CPPU at the highest level (*i.e*. 0.12 m M) recorded the highest average values of the all examined items compared to control plant measurements. The present results are in agreement with those obtained by several authors (Romanov *et al*., 2000; Roumeliotis *et al*., 2012; Kolachevskaya *et al.,* 2015, 2017).

Pertaining of the main effect of foliar application of salicylic acid on the given characteristics, results presented in Table (2) reflected similar performance as CPPU too, during both seasons of the study upon foliar spray SA at 3 mM; gave the highest average values, compare to control plants' measurements. The present results are in agreement with those obtained by Awad and Mansour (2007) and Sánchez-Rojo *et al*. (2011). Similar findings were recorded by Hadi *et al*. (2014), Flores-Lopez *et al*. (2016) and AL-Jeboori *et al*. (2017). The obtained results could be attributed to the role of salicylic acid (SA) in enhancing the plant defense in tomato against phytoplasma attack, reduces infection symptoms, favors photosynthates translocation and improves the yield and quality of fruits (Lopez-Delgado *et al*., 2018).

Regarding the interaction between both variables of the present study, the results presented in Table (2), in general, illustrated that various tested combinations affected significantly ($p \leq 0.05$) the characters under the investigation, in such way, arranged ascendingly with increasing or raising the tested concentrations of both variables and especially the combination of 0.12 mM CPPU plus 3 mM SA, which, brought about; the highest significant average values of all studied traits during both seasons compare to control plant treatments. In the present study, increasing of tomato yield could be taken place due to foliar application of CPPU, SA, and their combinations might be attributed to the increase of vegetative growth parameters (*i.e.* no. of branches/plant, no. of leaves/plant, plant height, plant fresh and dry weights).

Table (2). Averages values of some yield characters of tomato plants as affected by foliar application with sitofex (CPPU or Forchlorfenuron), salicylic acid (SA) and their combinations during the summer seasons of 2016 and 2017

Treatments		No. of fruits/plant		Fruit fresh weight (g)		Early yield (ton/fed)		Total yield (ton/fed)	
		2016	2017	2016	2017	2016	2017	2016	2017
CPPU (main effect)									
Control		22.75 d	24.33 d	114.11 d	121.09 d	8.89 d	10.16 d	19.82 d	22.49 d
0.04 mM		24.50 c	25.92 c	128.07 c	135.37 c	10.85 c	12.18 c	23.95 c	26.79 c
0.08 mM		25.42 b	27.00 b	136.30 b	144.73 b	11.95 b	13.48 b	26.45 b	29.83 b
0.12 mM		25.83 a	27.50 a	139.63 a	147.97 a	12.44 a	14.04 a	27.54 a	31.07 a
SA (main effect)									
Control		22.67 d	24.17 d	114.84 d	120.68 d	8.91 d	10.06 d	19.87 d	22.37 d
1 mM		24.67 c	26.08 c	127.31 c	135.29 c	10.80 c	12.14 c	23.98 c	26.94 c
2 mM		25.08 b	26.75 b	133.59 b	142.25b	11.57 b	13.15 b	25.58 b	29.23 b
3 mM		26.08 a	27.75 a	142.37 a	150.94 a	12.85 a	14.50 a	28.35 a	31.98 a
Combinations effects									
CPPU (mM)	**SA (mM)**								
Control	**Control**	20.00 l	22.67 l	104.49 o	108.88 p	6.92 m	8.48 n	15.95 m	18.84 n
	1	24.67 e-h	26.00 f-h	124.75 i	135.70 i	10.57 g	12.12 hi	23.50 g	26.94 hi
	2	23.00 jk	24.00 jk	111.77 m	118.61 n	8.83 k	9.78 m	19.62 k	21.73 m
	3	23.33 i-k	24.67 ij	115.43 l	121.15 m	9.25 jk	10.27 lm	20.56 jk	22.82 1m
0.04	**Control**	22.33 k	23.00 ki	108.59 n	113.89 o	8.27 l	9.00 n	18.51 1	20.00 n
	1	23.67 h-j	25.00 h-j	118.38 k	123.55 l	9.63 ij	10.61 kl	21.39 i	23.58 kl
	2	25.67 c-e	27.33 c-e	137.68 f	146.64 f	12.14 de	13.77 ef	26.98 j	30.60 ef
	3	26.33 bc	28.33 a-c	147.64 c	157.41 c	13.36 c	15.33 bc	29.68 c	34.05 bc
0.08	**Control**	24.00 g-j	25.33 g-i	121.79 j	128.46 k	10.04 hi	11.18 jk	22.31 hi	24.84 jk
	1	25.00 d-g	26.33 e-g	131.42 h	139.55 h	11.29 f	12.63 gh	25.08 f	28.05 gh
	2	25.67 c-e	27.67 b-d	140.38 e	150.38 e	12.38 d	14.30 de	27.51 d	31.77 de
	3	27.00 ab	28.67 ab	151.63 b	160.52 b	14.07 b	15.81 b	31.26 b	35.14 b
0.12	**Control**	24.33 f-i	25.67 g-i	124.49 i	131.48 j	10.41 gh	11.60 ij	23.12 gh	25.77 ij
	1	25.33 c-f	27.00 d-f	134.71 g	142.37 g	11.73 ef	13.21 fg	26.05 ef	29.35 fg
	2	26.00 b-d	28.00 b-d	144.52 d	153.35 d	12.91 c	14.75 cd	28.69 c	32.78 cd
	3	27.67 a	29.33 a	154.78 a	164.66 a	14.71 a	16.60 a	32.70 a	36.87 a

- CPPU, synthetic cytokinin N-(2-chloro-4-pyridyl)-N'-phenyl urea; SA, salicylic acid
- Values having the same alphabetical letter (s) in common, within each column, do not significantly differ, using L.S.D. test at 0.05 level of probability.

3. Chemical analyses of leaves and fruits characters

3.1 Leaf N, P and K contents

Results outline in Table (3) exhibited that both variables of study (*i.e.* CPPU and SA concentrations) either individually or their combination showed significant ($p \leq 0.05$) effects on leaf nutrient content (N, P, and K) of tomato plants during both seasons. In relation to the main effect of CPPU levels, the presented averages declare that the given independent variable exerted significant ($p \leq 0.05$) effect on leaf nutrient contents (N, P, and K) of tomato plants and the relationship between the tested concentrations of CPPU and the given traits was clear (progressive relationship), and *vice versa*. It is obvious that the tomato plants treated with the highest CPPU concentration (0.12 mM) exhibited significant ($p \leq 0.05$) effect and resulted in the highest average values compare to other treatments during both seasons of the study, while control plants; recorded the lowest significant average values compare to other treatments during both seasons of the experiments. Pertaining main effect of SA concentration, there is a direct proportionate relationship between the tested levels and their corresponding traits. The highest concentration (3 mM SA) provided the highest significant leaf nutrient content of tomato plants, and *vice versa* compare to other treatments during both seasons of the experimentation. On the other side, control plants recorded the lowest significant average values for the traits under the study.

These results could be taken place due to the enhancing effect of SA on the availability and movement of nutrients could result in stimulating formation of different nutrients in the leaves (Raskin, 1992). In this concern, Grown (2012) reported such stimulatory effect of salicylic acid on concentrations of nutrition elements and yield components of sunflower plants and attributed these findings to the effect of salicylic acid on many biochemical and physiological processes that were reflected on improving vegetative growth and active translocation of photosynthesis products from source to sink.

Table (3). Averages values of leaf nutrient content of tomato plants as affected by foliar application with sitofex (CPPU or Forchlorfenuron), salicylic acid (SA) and their combinations during the summer seasons of 2016 and 2017

Treatments		Nutrient contents of leaf (% dw)					
		N		P		K	
		2016	2017	2016	2017	2016	2017
CPPU (main effect)							
Control		2.18 d	2.38 d	0.291 d	0.308 d	2.25 d	2.38 d
0.04 mM		2.44 c	2.66 c	0.325 c	0.344 c	2.59 c	2.74 c
0.08 mM		2.65 b	2.89 b	0.349 b	0.370 b	2.86 b	2.98 b
0.12 mM		2.73 a	2.98 a	0.358 a	0.379 a	2.94 a	3.08 a
SA (main effect)							
Control		2.15 d	2.35 d	0.289 d	0.305 d	2.20 d	2.35 d
1 mM		2.47 c	2.69 c	0.327 c	0.346 c	2.64 c	2.76 c
2 mM		2.59 b	2.82 b	0.343 b	0.363 b	2.79 b	2.92 b
3 mM		2.79 a	3.05 a	0.364 a	0.386 a	3.01 a	3.15 a
Combinations effects							
CPPU (mM)	**SA (mM)**						
Control	**Control**	1.88 o	2.06 n	0.257 o	0.273 n	1.84 p	2.02 o
	1	2.51 h	2.73 h	0.327 h	0.346 i	2.65 i	2.77 i
	2	2.11 m	2.32 l	0.285 m	0.302 l	2.22 n	2.32 m
	3	2.20 l	2.41 k	0.293 l	0.309 l	2.29 m	2.43 l
0.04	**Control**	1.94 n	2.12 m	0.267 n	0.281 m	1.94 o	2.12 n
	1	2.26 k	2.45 k	0.301 k	0.319 k	2.37 l	2.51 k
	2	2.66 f	2.89 f	0.353 f	0.374 f	2.90 f	3.04 f
	3	2.91 c	3.16 c	0.379 c	0.402 c	3.15 c	3.29 c
0.08	**Control**	2.35 j	2.56 j	0.312 j	0.330 j	2.46 k	2.56 k
	1	2.51 h	2.73 h	0.336 g	0.356 h	2.73 h	2.84 h
	2	2.75 e	2.99 e	0.361 e	0.382 e	3.00 e	3.12 e
	3	3.00 b	3.27 b	0.388 b	0.410 b	3.24 b	3.38 b
0.12	**Control**	2.43 i	2.66 i	0.319 i	0.337 j	2.54 j	2.68 j
	1	2.59 g	2.83 g	0.343 g	0.364 i	2.81 g	2.94 g
	2	2.83 d	3.08 d	0.371 d	0.393 d	3.06 d	3.20 d
	3	3.07 a	3.34 a	0.397 a	0.423 a	3.34 a	3.48 a

- CPPU, synthetic cytokinin N-(2-chloro-4-pyridyl)-N'-phenyl urea; SA, salicylic acid.
-Values having the same alphabetical letter (s) in common, within each column, do not significantly differ, using L.S.D. test at 0.05 level of probability.

Concerning the combinations effects CPPU and SA concentrations, the obtained results tabulated in Table (3) reflected that as CPPU concentration increased, and SA at 3 mM, the average values increased significantly, especially when the combination was 0.12 mM CPPU combined with 3 mM of SA; which caused the highest significant average values for N, K and P leaves content compare to other treatments during both seasons of the experiments. On the contrary, the control plants showed the lowest average values for traits under the study. This finding could be attributed to the synergistic mode of action of both variables under the study in accumulation of absorbed nutrients within leaf tissues.

3.2 fruits N, P and K contents

Results outline in Table (4) showed that both CPPU and SA concentrations that sprayed as foliar application, either individually or their combination showed clearly significant ($p \leq 0.05$) effects on fruits' nutrient content (N, P, and K) of tomato plants during both growing seasons of 2016 and 2017.

Concerning the main effect of CPPU levels, the obtained results declare that, in general, there is a significant ($p \leq 0.05$) effect and direct proportionate relationship between CPPU concentration and the nutrient contents of fruits (N, P, K). It is obvious clearly that the tomato plants treated with the highest CPPU level (0.12 mM); recorded significantly ($p \leq 0.05$) the highest average values on dry weight basis compare to the other treatments during both seasons of the study. Whereas, control plants recorded the lowest significant average values.
In terms of main SA effect, the given results established similar performance as CPPU, where a direct proportionate was obvious and the obtained calculated averages were affected significantly ($p \leq 0.05$) by applied levels of salicylic acid, during both seasons of the study. For example, spraying SA at 3 mM; resulted in the highest average values for N, P and K fruit contents compare to other treatments during both seasons of the experiments. On the other hand, control plants achieved the lowest significant average values for traits under the study. In the same context, Awad and Mansour (2007) reported that foliar spraying of SA at 100 ppm increased, significantly, N, P and K contents in potato tubers.

Table (4). Averages values of some chemical determination of tomato fruit characteristics as affected by foliar application with sitofex (CPPU or Forchlorfenuron), salicylic acid (SA) and their combinations during the summer seasons of 2016 and 2017

Treatments		Nutrient contents of fruit (% d.w.)					
		N		P		K	
		2016	2017	2016	2017	2016	2017
CPPU (main effect)							
Control		1.40 d	1.69 d	0.164 d	0.189 d	1.67 d	2.00 d
0.04 mM		1.72 c	2.02 c	0.202 c	0.222 c	2.04 c	2.32 c
0.08 mM		1.90 b	2.24 b	0.226 b	0.247 b	2.22 b	2.56 b
0.12 mM		1.98 a	2.32 a	0.234 a	0.256 a	2.31 a	2.65 a
SA (main effect)							
Control		1.38 d	1.66 d	0.167 d	0.191 d	1.70 d	1.96 d
1 mM		1.71 c	2.04 c	0.203 c	0.224 c	2.01 c	2.35 c
2 mM		1.86 b	2.18 b	0.217 b	0.240 b	2.18 b	2.50 b
3 mM		2.05 a	2.39 a	0.239 a	0.260 a	2.37 a	2.70 a
Combinations effects							
CPPU (mM)	**SA (mM)**						
Control	**Control**	1.15 p	1.41 o	0.133 n	0.162 m	1.43 n	1.68 n
	1	1.71 i	2.04 i	0.199 h	0.223 g	1.94 i	2.33 h
	2	1.33 n	1.62 m	0.158 l	0.182 k	1.63 l	1.95 l
	3	1.40 m	1.71 l	0.166 k	0.190 j	1.70 k	2.02 k
0.04	**Control**	1.23 o	1.48 n	0.150 m	0.173 l	1.55 m	1.76 m
	1	1.48 l	1.80 k	0.178 j	0.198 i	1.80 j	2.10 j
	2	1.96 f	2.29 f	0.228 f	0.247 e	2.28 f	2.58 f
	3	2.19 c	2.53 c	0.254 c	0.271 c	2.51 c	2.83 c
0.08	**Control**	1.54 k	1.84 k	0.188 i	0.210 h	1.84 j	2.15 j
	1	1.78 h	2.12 h	0.212 g	0.231 f	2.11 h	2.44 g
	2	2.02 e	2.36 e	0.238 e	0.260 d	2.36 e	2.70 e
	3	2.26 b	2.62 b	0.264 b	0.285 b	2.58 b	2.94 b
0.12	**Control**	1.60 j	1.92 j	0.198 h	0.218 g	1.97 i	2.25 i
	1	1.87 g	2.20 g	0.221 f	0.242 e	2.17 g	2.53 f
	2	2.11 d	2.45 d	0.246 d	0.270 c	2.43 d	2.78 d
	3	2.33 a	2.71 a	0.271 a	0.293 a	2.68 a	3.02 a

- CPPU, synthetic cytokinin N-(2-chloro-4-pyridyl)-N'-phenyl urea; SA, salicylic acid.
-Values having the same alphabetical letter (s) in common, within each column, do not significantly differ, using the revised L.S.D. test at 0.05 level of probability.

Pertaining the combinations between CPPU and SA concentrations, the obtained results reflected that tomato plants treated with 0.12 mM of CPPU combined with 3 mM of SA, led to the highest significant average values for N, P and K fruits content during both seasons compare to other treatments.

On the contrary, control plants showed the lowest mean values for traits under the study compare to other treatments during both seasons of the experiments. This study recommends that foliar spraying of a combination of both CPPU and SA at 0.12 mM and 3.00 mM respectively could enhance the productivity and quality of tomato plants.

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الملخص العربي

تأثير الرش الورقي بالسيتوفكس وحمض السالسيلك على المحصول والتركيب الكيمائي للطماطم

حسام الدين السعيد فايد [١] عبد الباسط عبد السميع الخربوطلي [٢] علي عدنان عوض جبل [١]
فتحي إبراهيم رضوان [١] علي إبراهيم علي عبيدو [١]

[١] قسم الإنتاج النباتي– كلية الزراعة (سابا باشا) – جامعة الإسكندرية– مصر

[٢] قسم البساتين– كلية الزراعة الصحراوية والبيئية– جامعة مطروح– مصر

أجريت تجربتان حقليتان في الحقل المفتوح خلال فصلي الصيف لعامي ٢٠١٦ و٢٠١٧، في مزرعة خاصة ، في مدينة سيدي سالم، محافظة كفر الشيخ، مصر لدراسة تأثير الرش الورقي بالسيتوفكس (CPPU) وحمض الساليسيليك (SA) والخليط بينهما على النمو والمحصول والتركيب الكيماوي لمحصول الطماطم. تم الرش الورقي لصنف الطماطم سوبر سترين بي بأربعة تركيزات من السيتوكينين المخلق صناعياً السيتوفيكس (CPPU) بتركيزات (٠,٠٠، ٠,٠٤، ٠,٠٨، و٠,١٢ ملليمول) واربعة تركيزات من حمض السالسيلك (٠,٠٠، ١,٠٠، ٢,٠٠، ٣,٠٠ ملليمول) تم رشها منفردة أو في خليط مرتين الأولى بعد ١٠ أيام من الشتل والثانية بعد ٣٥ يوم من الرشة الأولى. تم رش نباتات المشاهدة (الكنترول) بماء الصنبور. تم دراسة تأثير كل من المتغيرين المستقلين وتركيزاتهما على صفات النمو الخضري والمحصول والتركيب الكيميائي للأوراق والثمار. وأوضحت النتائج المتحصل عليها، بشكل عام، أن معاملات الرش الورقي بالسيتوكينين (CPPU) بتركيز ٠,١٢ ملليمول وحمض الساليسيليك (SA) بتركيز ٣ ملليمول منفردين أو معاً في مزيج على نباتات الطماطم صنف 'سوبر سترين بي' قد أدت إلى الحصول، بشكل معنوي، على أعلى إنتاجية وجودة مقارنة بالنباتات غير المعاملة. ويمكن اعتبار التوليفة بين ٠,١٢ ملليمول سيتوكينين (CPPU) بالإضافة إلى ٣ ملليمول حمض سالسيلك (SA) المعاملة المثلى لإنتاج أعلى محصول وجودة لنباتات الطماطم تحت الظروف البيئية لمحافظة كفر الشيخ والمناطق الأخرى المماثلة لها.