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INFLUENCE OF NITROGEN AND POTASSIUM FERTILIZERS RATE COMBINED WITH SALICYLIC ACID ON GROWTH, YIELD AND QUALITY OF HOT PEPPER CV. "CHAMPION"

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ABSTRACT

In order to investigate the influence of nitrogenous and potassium fertilizer's rates (0.0, 50, 75 and 100% of recommended rate), salicylic acid concentration (0.0, 50 and 100 ppm) and their interactions on hot pepper plants cv. Champion, a field experiment was assessed. The NK recommended rate (RR) as equivalency for planting area was 90 and 76 kg of N and K_2O/feddan, respectively. This experiment was set up in a split-plot design with three replicates and conducted in Agric. Res. Farm, Fac. Agric., Zagazig Univ., Egypt during the two consecutive summer seasons of 2019 and 2020. Results referred to the positive influence of nitrogen and potassium fertilization rate on hot pepper plants growth parameters *i.e*. plant height, number of branches per plant, stem diameter as well as fresh and dry weights of plant, which increased as the NK fertilization rate increased in comparison with control. Increasing nitrogen and potassium fertilization rate gradually increased fruit yield components and its quality as well as capsiacine content. In addition, salicylic acid at 100 ppm gave the maximum values in plant growth parameters and yield components of hot pepper plants compared to control. The best values regard early and total fruit yield as well as total soluble solids, total chlorophyll content and vitamin C were achieved by supplying 50 and 100 ppm salicylic acid compared to control (sprayed with normal water).

INTRODUCTION

Hot pepper (*Capsicum annuum*, L.) is a marketable crop among the people for its nutritional and medicinal values; in addition, the extract of hot pepper is used in a number of pharmaceutical products. It belongs to the family Solanaceae and has a major profitable value **(Malik, 1994)**. It is a substantial vegetable crop worldwide in terms of both trade amount and the turn it plays in the local economy (**Aktas *et al*., 2009; Gonzalez-Diaz *et al*., 2009**). Moreover, **Bose *et al*. (1993**) reported that, hot pepper supplies the human body with vitamins such as vitamin A and vitamin C, several of mineral nutrients and some protein compounds.

Nitrogen plays a major role in several physiological and biochemical processes in plants such as division and elongation of plant cells as well as carbohydrates and protein metabolism compounds (**Marschner, 1995**). In addition, **Wiedenhoeft (2006)** pointed out that, nitrogen (N) and potassium (K) elements are predominantly classified as main macronutrients, because its insufficiency is more common than the secondary macronutrients as calcium (Ca), magnesium (Mg) and sulphur (S). K affects the function and rates of enzymes involved in the carbohydrates biosynthesis (**Hafsi *et al*., 2015**). It was found that nitrogen and potassium fertilization enhanced sweet pepper growth, yield and fruit quality (**Aminifard *et al*., 2012**), *Gynura procumbens*

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growth pattern (**Bukhori *et al*., 2015)**, hot pepper growth, yield and chemical composition (**Ayodele *et al*., 2015**), canola yield and its quality (**Eledfawy, 2017)** and sweet pepper growth and yield **(Alkharpotly, 2018)**.

Salicylic acid (SA) was obtained from Latin word "Salix", meaning *Salix safsaf* tree. It is ubiquitously spread in the whole plant kingdom and is distributed under the collection of plant hormones (**Raskin *et al*., 1990)**. Salicylic acid functions an animated role in plant growth, ion transport and uptake. It can also play a considerable role in plant photosynthesis, water relations and plant growth (**Arfan *et al*., 2007**). **Abou El-Yazied (2011)** reported that, foliar application of SA improved growth and productivity of sweet pepper. Also, **Kazemi (2013)** pointed out that, SA treatment increased the growth, yield and fruit quality in strawberry plants.

Therefore, this study aimed to notice the profitable influences of foliar spraying of salicylic acid combined with nitrogenous and potassium fertilization in terms of enhanced growth, productivity and fruit quality of hot pepper (*Capsicum annuum*, L.) cv. "Champion" under Sharkia Governorate conditions, Egypt.

MATERIALS AND METHODS

This experiment was executed successfully during the two consecutive summer seasons of 2019 and 2020 at the Experimental Farm (Ghazala Farm), Faculty of Agriculture, Zagazig University, Egypt. This study was carried out to investigate the influence of different rates of NK fertilization [0.0, 50, 75 and 100% of recommended rate (RR)], different salicylic acid concentrations (tap water was sprayed as control, 50 and 100 ppm) as well as their combinations on plant growth and yield components as well as photosynthetic pigments, some chemical contents and capsiacine content of hot pepper plants (*Capsicum annuum*, L.) cv. Champion. The recommended rate (RR) equivalency for planting area was 90 and 76 kg/feddan of N and K_2O, respectively.

Plant Material

The hot pepper seedlings were obtained from a privet nursery in Belbas District, Sharkia Governorate, Egypt. All hot pepper seedlings were comparable in growth and were about 10-12 cm in length. Hot pepper seedlings were transplanted in the experimental plots on 26th April and 4th May during the 1st and 2nd seasons, respectively.

Cultivation

The experimental unit area (4 × 3.5 m) was consisted of 5 ridges, with 70 cm among them. The hot pepper seedlings were transplanted at 50 cm distance between transplants, 8 transplants per ridge. The irrigation system was surface irrigation type. The physical and chemical analyses of soil site are tabulated in Table 1 as described by **Chapman and Pratt (1978)**.

Fertilization

The recommended rate (RR) of NK was 90 and 76 kg/feddan of N and K_2O, respectively. The source of nitrogen was 439 kg/feddan of ammonium sulphate (20.5% N) and potassium was 156.70 kg/ feddan of potassium sulphate (48.5% K_2O), also, phosphorus was 200 kg/feddan of calcium superphosphate (15.5% P_2O_5). All amount of P fertilizer was added during soil preparation. While N and K fertilizers were divided into 4 equal doses and were applied to the soil at 30, 50, 70 and 90 days after transplanting.

Salicylic Acid Source and Application

The source of salicylic acid (SA) acid ($C_7H_6O_3$) was Techno Gene Company, Dokky, Giza, Egypt. The different concentrations of SA as foliar application were applied at 30 , 45 and 60 days after

Table 1. Some physical and chemical properties of the experimental soil (average of two seasons)

Physical analysis				Soil texture
Clay (%)	Silt (%)	Fine sand (%)	Coarse sand (%)	Clayey
56.36	9.26	17.62	16.76	

Chemical analysis												
pH	E.C. m.mohs/cm	Organic matter (%)	Soluble cations (meq./L)			Soluble anions (meq./L)			Available (ppm)		
			Mg^{++}	Ca^{++}	Na^{+}	Cl^{-}	HCO_3^{-}	SO_4^{--}	N	P	K
7.86	0.98	0.58	3.7	1.9	4.1	4.5	1.7	3.5	18	20	71

transplanting date. Each experimental unit received five liters solution utilizing spreading agent (Super Film at a rate of 1 ml /l). The unsprayed control plants were sprayed with tap water with spreading agent. Also, all ordinary agricultural practices of growing hot pepper plants were done whenever necessitated.

Experimental Design

This experiment was set up in a split-plot design with three replicates. The main plots were occupied by four the NK rates. The sub plots were entitled to the three salicylic acid concentrations. The combination treatments between NK fertilization rates and salicylic acid concentrations were 12 treatments.

Sampling and Collecting Data

Plant growth parameters

After 100 days from hot pepper transplanting, 3 plants were randomly chosen from each plot to determine the following parameters: Plant height (cm), number of branches/plant, stem diameter (cm) at plant base as well as total fresh and dry weights / plant (g).

Yield and its components

Fruits of hot pepper were harvested every 2 days intervals, upon reaching 11-13 cm length. At harvesting stage, the yield components expressed as fruit set percentage (number of set flowers/total number of flowers marked × 100), fruit number per plant, fruit length (cm), fruit diameter (cm), fruit yield/plant (kg), [early fruit yield per feddan (ton) was recorded after135 days after transplanting date] and yield/feddan (ton) were recorded.

Chemical constituents

Total soluble solids (TSS) of hot pepper fruit juice (Brix°): It was determined by utilizing a hand refractometer as Brix degree at the harvest stage. In addition, leaf total chlorophyll content (SPAD unit) was determined in hot pepper fresh leaves after 100 days from transplanting date by utilizing SPAD- 502 meter (**Markwell *et al.*, 1995**). Vitamin C was determined as milligram l^{-} ascorbic acid per 100g of fresh fruits according to the method described by **AOAC (1990)**. Vitamin C was defined by titration in the presence of 2, 6 dichlorophenol-indophenol dyes as an indicator against 2% oxalic acid solution as substrate. Moreover, hot pepper fruit total capsiacine content (mg/100 g as dry weight) was determined under the second season only by the method of **Anan *et al.* (1996)**.

Statistical Analysis

The statistical layout of this experiment was split-plot experiment in completely randomized block design. Data were analyzed as stated by **Gomez and Gomez (1984)**. The means were compared utilizing computer program of Statistix version 9 (**Analytical Software, 2008**).

RESULTS AND DISCUSSION

Influence of Nitrogen and Potassium Fertilizers Rate, Salicylic Acid Concentrations and Their Combinations on Plant Growth Parameters

Results presented in Tables 2 and 3 indicate that, hot pepper plants fertilized with N, K up to 100% of recommended rate (RR) were produced high value for each of plant height, number of branches per plant, stem diameter furthermore total fresh and dry weights of plant than control in both seasons. In addition, different N and K fertilization rates showed significant influence in this connection. Also, the tallest, more branches and the heaviest plant weights of *Capsicum annuum* was obtained by 100 % RR of nitrogen and potassium fertilization in both seasons. The increases in hot pepper dry weight were about 65.10 and 54.40 % for 100% RR of NK treatment compared to control in the 1st and 2nd seasons, respectively. These results are in accordance with those reported by **Ortas (2013)** on pepper and tomato, **Alkharpotly (2018)** on sweet pepper and **Souza *et al*. (2018)** on eggplant plants.

Salicylic acid treatments significantly increased hot pepper vegetative growth compared to untreated plants in the two seasons. SA at 100 ppm significantly increased plant height, branch number per plant, stem diameter and total fresh and dry weights compared to control and the other ones under study (Tables 2 and 3). Moreover, the increases in total plant dry weight were about 13.56 and 20.70 % for 100 ppm salicylic acid over control treatment in the 1st and 2nd seasons, respectively. These results hold true in the 2019 and 2020 seasons. In addition, **Kowalska and Smoleñ (2013)** on tomato, **Bakundi and Yahaya (2017)** on sweet pepper plants had found similar results.

The combination treatment between nitrogen and potassium fertilization at 100% RR and salicylic acid at 100 ppm significantly increased hot pepper growth parameters compared to control and the other combinations under study in both seasons (Tables 2 and 3). The increases in number of branches per plant were about 82.34 and 80.29 % for the combination between 100% RR of NK fertilization rate and 100 ppm salicylic acid over control treatment in the 1st and 2nd seasons, respectively. Furthermore, increasing SA concentration under each N and K fertilization rate gradually increased plant height (cm), number of branches per plant and stem diameter (cm) as well as total plant fresh and dry weights (g). Moreover, as mentioned above, both NK fertilization and salicylic acid (each alone) increased growth parameters of hot pepper plants, in turn; they together might maximize their influences leading to taller, more branches and heaviest plant weight.

Influence of Nitrogen and Potassium Fertilizers Rate, Salicylic Acid Concentrations and Their Combinations on Yield and its Components

Results of both seasons in Table 4 show that, fruit set percentage, fruit number per plant, fruit length and diameter of hot pepper significantly increased due to NK fertilization rates application compared to control. In the same trend, each of fruit yield per plant, early fruit yield per feddan and total fruit yield per feddan gave the highest value when hot pepper plants were fertilized by 100% RR of nitrogen and potassium fertilizers (Table 5). However, fruit yield components was significantly increased as NK rates increased in both seasons. In other words, the increases in total fruit yield per feddan were about 44.97 and 42.79 % for the 100% RR of NK rate compared to control (unfertilized plants) in the first and second seasons, respectively, with significant difference between this treatment and the other rates under study in 2019 and 2020 seasons. In addition, nitrogen application significantly increased ripe fruit yield (number and weight) of hot pepper up till 75 kg $N.ha^{-1}$ in both years (**Ayodele *et al*., 2015**).

Table 2. Influence of nitrogen and potassium fertilizers rate (F), salicylic acid concentrations (S) and their combinations (F×S) on plant height (cm), number of branches per plant and stem diameter (mm) of hot pepper plants during 2019 and 2020 seasons

NK fertilizers rate (from100% recommended rate*)	Salicylic acid concentration (ppm)							
	0.0	50	100	Mean (F)	0.0	50	100	Mean (F)
	First season				Second season			
	Plant height (cm)							
0.0	56.89g	59.89f	60.56de	**59.11D**	60.78i	61.22i	61.78hi	**61.26D**
50	58.89f	61.45d	63.22c	**61.19C**	62.44gh	63.56fg	66.78d	**64.26C**
75	60.55de	64.11c	67.89b	**64.18B**	64.00f	66.89d	71.22b	**67.37B**
100	63.55c	66.67b	70.89a	**67.04A**	65.33e	68.89c	72.89a	**69.04A**
Mean (S)	**59.97C**	**63.03B**	**65.64A**		**63.14C**	**65.14B**	**68.17A**	
	Number of branches / plant							
0.0	14.44g	15.78f	17.22e	**15.81D**	15.22g	16.89f	17.44f	**16.52D**
50	15.44f	19.11d	22.78c	**19.11C**	14.89g	18.67e	20.78d	**18.11C**
75	19.89d	22.34c	24.78b	**22.33B**	16.89f	21.89d	26.11b	**21.63B**
100	22.78c	24.55b	26.33a	**24.55A**	18.67e	23.11c	27.44a	**23.07A**
Mean (S)	**18.14C**	**20.45B**	**22.78A**		**16.42C**	**20.14B**	**22.94A**	
	Stem diameter (mm)							
0.0	51.67i	55.00f	53.00gh	**53.22D**	52.33h	53.33gh	55.67ef	**53.78D**
50	52.33hi	55.33f	56.67e	**54.78C**	53.00gh	56.33e	57.33e	**55.56C**
75	53.67g	59.00d	58.67d	**57.11B**	54.33fg	60.33d	62.33c	**59.00B**
100	60.33c	66.33b	70.33a	**65.67A**	64.67b	69.33a	70.00a	**68.00A**
Mean (S)	**54.50C**	**58.92B**	**59.67A**		**56.08C**	**59.83B**	**61.33A**	

*****Recommended rate (RR): 90 and 76 kg/feddan of N and K_2O, respectively.

Table 3. Influence of nitrogen and potassium fertilizers rate (F), salicylic acid concentrations (S) and their combinations (F×S) on total plant fresh and dry weights (g) of hot pepper plants during 2019 and 2020 seasons

NK fertilizers rate (from100% recommended rate*)	Salicylic acid concentration (ppm)							
	0.0	50	100	Mean (F)	0.0	50	100	Mean (F)
	First season				Second season			
	Total plant fresh weight (g)							
0.0	381.73j	404.87i	417.93h	**401.51D**	413.03j	428.77hi	436.17gh	**425.99D**
50	404.57i	420.37h	433.90g	**419.61C**	418.90ij	437.37gh	455.63f	**437.30C**
75	445.23f	488.23e	503.07d	**478.84B**	439.07g	471.77e	529.43c	**480.09B**
100	532.30c	573.80b	613.33a	**573.14A**	507.23d	591.40b	657.73a	**585.46A**
Mean (S)	**440.96C**	**471.82B**	**492.06A**		**444.56C**	**482.32B**	**519.74A**	
	Total plant dry weight (g)							
0.0	80.47k	81.77j	87.67hi	**83.30 D**	85.77k	90.87i	93.80h	**90.14D**
50	86.03i	89.20h	93.30g	**89.51 C**	88.33j	97.23g	99.87f	**95.14C**
75	96.57f	119.47e	122.87d	**112.97B**	95.07h	108.07e	129.50c	**110.88B**
100	130.47c	139.10b	143.03a	**137.53A**	124.47d	141.10b	151.97a	**139.18A**
Mean (S)	**98.38C**	**107.38B**	**111.72A**		**98.41C**	**109.32B**	**118.78A**	

*****Recommended rate (RR): 90 and 76 kg/feddan of N and K_2O, respectively.

Table 4. Influence of nitrogen and potassium fertilizers rate (F), salicylic acid concentrations (S) and their combinations (F×S) on fruit set percentage, fruit number per plant, fruit length (cm) and fruit diameter (cm) of hot pepper plants during 2019 and 2020 seasons

NK fertilizers rate (from100% recommended rate*)	Salicylic acid concentration (ppm)							
	0.0	50	100	Mean (F)	0.0	50	100	Mean (F)
	First season				Second season			
	Fruit set percentage							
0.0	34.67g	36.07ef	36.60e	**35.78D**	35.17f	36.57e	37.60d	**36.44D**
50	35.57f	37.70d	39.20c	**37.49C**	36.17e	37.40d	38.97c	**37.51C**
75	37.50d	38.83c	40.77ab	**39.03B**	36.67e	39.20c	40.03b	**38.63B**
100	38.70c	40.53b	41.30a	**40.18A**	39.03c	40.37b	42.10a	**40.50A**
Mean (S)	**36.61C**	**38.28B**	**39.47A**		**36.76C**	**38.38B**	**39.68A**	
	Number of fruits per plant							
0.0	15.44g	17.00ef	17.22e	**16.56D**	16.22h	17.44fgh	18.00fg	**17.22D**
50	16.22fg	17.44e	17.89e	**17.18C**	16.89gh	18.11efg	19.33de	**18.11C**
75	17.44e	20.78d	22.00c	**20.07B**	18.22ef	23.00c	24.78b	**22.00B**
100	21.66cd	23.44b	25.89a	**23.66A**	20.44d	24.33b	26.22a	**23.67A**
Mean (S)	**17.69C**	**19.67B**	**20.75A**		**17.95C**	**20.72B**	**22.09A**	
	Fruit length (cm)							
0.0	9.23f	9.47ef	10.00de	**9.57D**	8.83f	10.00e	10.87cd	**9.90D**
50	10.13d	10.50d	11.57c	**10.73C**	10.30de	11.00c	11.73b	**11.01C**
75	10.50d	11.73c	12.50b	**11.58B**	10.73cd	12.00b	13.07a	**11.93B**
100	11.43c	12.80ab	13.27a	**12.50A**	11.78b	12.20b	13.03a	**12.33A**
Mean (S)	**10.33C**	**11.13B**	**11.83A**		**10.41C**	**11.30B**	**12.18A**	
	Fruit diameter (cm)							
0.0	1.147g	1.177f	1.200e	**1.174D**	1.150d	1.157d	1.193c	**1.167D**
50	1.170f	1.210de	1.253c	**1.211C**	1.163d	1.187c	1.240b	**1.197C**
75	1.213d	1.257c	1.287b	**1.252B**	1.190c	1.227b	1.280a	**1.232B**
100	1.220d	1.260c	1.307a	**1.262A**	1.197c	1.233b	1.297a	**1.242A**
Mean (S)	**1.188C**	**1.226B**	**1.262A**		**1.175C**	**1.201B**	**1.253A**	

*****Recommended rate (RR): 90 and 76 kg/feddan of N and K_2O, respectively.

Table 5. Influence of nitrogen and potassium fertilizers rate (F), salicylic acid concentrations (S) and their combinations (F×S) on fruit yield per plant (g), early fruit yield per feddan (ton) and total fruit yield per feddan (ton) of hot pepper plant during 2019 and 2020 seasons

NK fertilizers rate (from100% recommended rate*)	Salicylic acid concentration (ppm)							
	0.0	50	100	Mean (F)	0.0	50	100	Mean (F)
	First season				Second season			
	Fruit yield per plant (g)							
0.0	307.56h	342.36g	360.72f	**336.88D**	281.16j	330.96h	347.04g	**319.72D**
50	360.24f	397.32e	421.56d	**393.04C**	314.64t	354.72f	409.44e	**359.60C**
75	405.36e	454.80c	482.40b	**447.52B**	358.32f	427.20d	438.24c	**407.92B**
100	466.20c	483.84b	515.28a	**488.44A**	443.04c	454.44b	472.20a	**456.56A**
Mean (S)	**384.84C**	**419.58B**	**444.99A**		**349.29C**	**391.83B**	**416.73A**	
	Early fruit yield per feddan (ton)							
0.0	0.337g	0.357h	0.373i	**0.356D**	0.347h	0.367g	0.377g	**0.363D**
50	0.377g	0.443f	0.497d	**0.439C**	0.370g	0.420f	0.457e	**0.416C**
75	0.467e	0.517c	0.527bc	**0.503B**	0.487d	0.507c	0.537b	**0.510B**
100	0.487d	0.533b	0.570a	**0.530A**	0.513c	0.547ab	0.557a	**0.539A**
Mean (S)	**0.417C**	**0.463B**	**0.492A**		**0.429C**	**0.460B**	**0.482A**	
	Total fruit yield per feddan (ton)							
0.0	3.691h	4.108g	4.329f	**4.043D**	3.374j	3.972h	4.165g	**3.837D**
50	4.323f	4.768e	5.059d	**4.717C**	3.776i	4.257f	4.913e	**4.315C**
75	4.864e	5.458c	5.789b	**5.370B**	4.300f	5.126d	5.259c	**4.895B**
100	5.594c	5.806b	6.183a	**5.861A**	5.317c	5.453b	5.666a	**5.479A**
Mean (S)	**4.618C**	**5.035B**	**5.340A**		**4.192C**	**4.702B**	**5.001A**	

*****Recommended rate (RR): 90 and 76 kg/feddan of N and K_2O, respectively.

As shown in Tables 4 and 5 that, fruit set (%), number of fruits per plant, both fruit length and diameter (cm) as well as fruit yield per plant (g) and per feddan (ton) of *Capsicum annuum* plants significantly increased with salicylic acid application at any concentration compared to control (plants sprayed with tap water) in both seasons. However, increasing SA concentration gradually increased fruit yield components in 2019 and 2020 seasons. The best treatment in this connection was that 100 ppm of SA with significant differences with the other SA concentrations under study. However, application of either silicon or salicylic acid gave higher mean values for tomato yield and its components (**Elkhatib *et al*., 2017**).

Utilizing salicylic acid at 100 ppm under all NK levels which tested significantly increased hot pepper yield components as compared to use NK treatments alone during both seasons. In the same time, the combination treatment between 100% RR of NK and SA at 100 ppm was more effective in respect to fruit set percentage, number of fruits per plant, both fruit length and diameter, fruit yield per plant, early fruit yield per feddan and total fruit yield per feddan values than the other interaction treatments of NK fertilization and SA which studied during the two seasons (Tables 4 and 5). In addition, **Ahmed and Abdelkader (2020)** on chilli plants showed that, fruit yield per plant (kg) were gradually increased by increasing NPK fertilizer levels. Furthermore, exogenous application of SA to hot pepper plants can influence their yield maximize through participating in the regulation of several plant physiological processes such as cell membranes permeability, ion uptake and photosynthetic content and rate (**Gunes *et al*., 2005; Stevens *et al*., 2006; Mimouni *et al*., 2016**).

Influence of Nitrogen and Potassium Fertilizers Rate, Salicylic Acid Concentrations and Their Combinations on some Chemical Constituents

It is quite clear from the results in Tables 6 and 7 that, using NK fertilization rates at 100% RR significantly increased total chlorophyll content, total soluble solids, both vitamin C and capsiacine content (second season) of hot pepper plants compared with control and the other ones under study in both seasons, in most cases. Generally, increasing NK fertilization rates gradually increased hot pepper chemical constituents which studied. However, the lowest values of total chlorophyll content (44.68 and 45.40 SPAD) obtained without NK application treatment (control) in the 1st and 2nd seasons, respectively. Likewise, the increase in this connection was also found by **Koshale *et al*. (2018)** on chilli plants.

Different salicylic acid concentrations (100 ppm) significantly increased studied chemical constituents' content of hot pepper plants compared to control in both seasons (Tables 6 and 7). Moreover, the increases in capsiacine content were about 1.45% and 2.45 % for the SA at 50 and 100 ppm compared to control, respectively during the second season only. In contrast the lowest value in this regard (133.63 mg/ 100g as dry weight) was produced without foliar spray with salicylic acid (control). **Ibrahim *et al*. (2019)** pointed out that, salicylic acid showed the greatest fruit quality traits of sweet pepper plants, such as vitamin C content, total soluble solid content and total sugar content than control.

In general, total chlorophyll content, total soluble solids, vitamin C content and capsiacine content of hot pepper were increased by using all salicylic acid concentrations which studied under NK fertilization treatments up to 100% RR level if compared with control during 2019 and 2020 seasons (Tables 6 and 7). However, salicylic acid treatment at 100 ppm

Table 6. Influence of nitrogen and potassium fertilizers rate (F), salicylic acid concentrations (S) and their combinations (F×S) on total chlorophyll content (SPAD), total soluble solids (Brixº) and vitamin C content of hot pepper plants during 2019 and 2020 seasons

NK fertilizers rate (from100% recommended rate*)	Salicylic acid concentration (ppm)							
	0.0	50	100	Mean (F)	0.0	50	100	Mean (F)
	First season				Second season			
	Total chlorophyll content (SPAD)							
0.0	44.60f	44.57f	44.87f	**44.68D**	45.33b	45.10b	45.77b	**45.40D**
50	45.97e	46.50e	48.00bc	**46.82C**	46.10b	46.50b	48.37b	**46.99C**
75	46.17e	47.63cd	48.47b	**47.42B**	47.60b	48.57b	49.97ab	**48.71B**
100	47.17d	50.23a	50.47a	**49.29A**	58.23a	49.17b	49.97ab	**52.46A**
Mean (S)	**45.98C**	**47.23B**	**47.95A**		**49.32C**	**47.33B**	**48.52A**	
	Total soluble solids (Brixº)							
0.0	6.040i	6.173g	6.187ef	**6.133D**	6.103j	6.130i	6.153gh	**6.129D**
50	6.107h	6.203e	6.240d	**6.183C**	6.133hi	6.183f	6.223e	**6.180B**
75	6.183fg	6.233d	6.273c	**6.230B**	6.157g	6.267d	6.310c	**6.244C**
100	6.357b	6.430a	6.440a	**6.408A**	6.320c	6.367b	6.420a	**6.369A**
Mean (S)	**6.172C**	**6.260B**	**6.285A**		**6.178C**	**6.237B**	**6.277A**	
	Vitamin C content (mg/100g fruit as fresh weight)							
0.0	173.60i	183.67de	184.00de	**180.42D**	177.03cd	173.23d	185.00a-c	**178.42D**
50	178.07g	181.67f	182.90e	**180.88C**	180.73b-d	181.70b-d	185.97a-c	**182.80C**
75	175.90h	189.17b	193.10a	**186.06B**	182.37a-d	185.87a-c	188.27ab	**185.50B**
100	184.40d	186.93c	189.27b	**186.87A**	185.47a-c	188.43ab	191.37a	**188.42A**
Mean (S)	**177.99C**	**185.36B**	**187.32A**		**181.40C**	**182.31B**	**187.65A**	

*****Recommended rate (RR): 90 and 76 kg/feddan of N and K_2O, respectively.

Table 7. Influence of nitrogen and potassium fertilizers rate (F), salicylic acid concentrations (S) and their combinations (F×S) on capsiacine content of hot pepper plants during 2020 season

NK fertilizers rate (from100% recommended rate*)	Salicylic acid concentration (ppm)			
	0.0	50	100	Mean (F)
	Capsiacine content (mg/100g as dry weight)			
0.0	130.73h	132.40fg	131.30gh	**131.47D**
50	135.73de	137.43bc	138.30b	**134.16C**
75	132.83fg	133.70ef	135.93cd	**136.99B**
100	135.73d	138.77b	142.10a	**138.87A**
Mean (S)	**133.63C**	**135.57B**	**136.91A**	

*****Recommended rate (RR): 90 and 76 kg/feddan of N and K_2O, respectively.

might succeed in increasing fruit chemical quality under high NK fertilization levels (100% RR) compared to control in both seasons, in most cases. Generally, total chlorophyll content, total soluble solids, vitamin C content of hot pepper gradually increased as NK fertilization levels increased under any SA concentration during 2019 and 2020 summer seasons as well as capsiacine content at the second one. The positive effect of NK fertilization may be due to increase nutrients in the soil solution. This increase can encourage the plant growth, which increased the photosynthetic rates leading to an increase in the assimilation rates and hence the total soluble solids and capsiacine content were increased. These results are in harmony with those found by **Aljalaly *et al*. (2018)** on the pepper plant.

Conclusion

It can be concluded that, utilizing 100 ppm salicylic acid as foliar application three times/season combined with 100% NK at recommended rate (90 and 76 kg/feddan of N and K_2O, respectively) enhancing plant growth, yield components and fruit quality of hot pepper plants (*Capsicum annuum*, L.) cv. Champion under Sharkia Governorate conditions.

REFERENCES

Abou El-Yazied, A. (2011). Effect of foliar application of salicylic acid and chelated zinc on growth and productivity of sweet pepper (*Capsicum annuum* L.) under autumn planting. Res. J. Agric. and Biol. Sci., 7(6): 423-433.

Ahmed, M.A. and Abdelkader, M.A.I. (2020). Enhancing growth, yield components and chemical constituents of chilli (*Capsicum annuum* L.) plants by using different NPK fertilization levels and nano-micronutrients rates. Asian J. Soil Sci. and Plant Nutr., 6(2): 17-29.

Aktas, H.; Abak, K. and Sensoy, S. (2009). Genetic diversity in some Turkish pepper (*Capsicum annuum* L.) genotypes revealed by AFLP analyses. Afr. J. Biotechnol., 8 (18): 4378–86.

Aljalaly, S.S.; Al-Mentafji, H.N.H. and Al-Arzawazi, A.L.A. (2018). The effect of salicylic acid, fertilizer NPKZn and water stress on the pepper plant, *Capsicum annuum* L. Int. J. Agric. Stat. Sci., 14 (2): 705-712.

Alkharpotly, A.A. (2018). Growth and yield responses of sweet pepper (*Capsicum annuum* L.) to organic and NPK mineral fertilization under plastic houses conditions at arid regions. J. Plant Prod., Mansoura Univ., 9 (3): 299-305.

Aminifard, M.H.; Aroiee, H.; Ameri, A. and Fatemi, H. (2012). Effect of plant density and nitrogen fertilizer on growth, yield and fruit quality of sweet pepper (*Capsicum annuum* L.). Afr. J. Agric. Res., 7 (6): 859-866.

Analytical Software (2008). Statistix Version 9, Analytical Software, Tallahassee, Florida, USA.

Anan, T.; Ito, H.; Mtsunga, H. and Monma, S. (1996). A simple method for determining the degree of pungency of peppers. *Capsicum* and Eggplant Nesletter, 15: 51-54.

AOAC (1990). Official Methods of Analysis 15th Ed. Association of Official Analyt. Chem., Inc., Virginia, USA.

Arfan, M.; Athar, H.R. and Ashraf, M. (2007). Does exogenous application of salicylic acid through the rooting medium modulate growth and photosynthetic capacity in two differently adapted spring wheat cultivars under salt stress. J. Plant. Physiol., 164: 685-694.

Ayodele, O.J.; Alabi, E.O. and Aluko, M. (2015). Nitrogen fertilizer effects on growth, yield and chemical composition of hot pepper (Rodo). Int. J. Agric. and Crop Sci., 8 (5): 666-673.

Bakundi, Y.M. and Yahaya, S.U. (2017). Mitigation of moisture stress in sweet pepper (*Capsicum annuum* L.) by foliar application of salicylic acid in Sudan Savanna Agro-Ecology, Nigeria. J. Dry Land Agric., 3(1): 10-18.

Bose, T.K.; Som, M.G. and Kabir, J. (1993). Vegetable Crops, Naya Prokash Pub Co. Calcutta. Pp, 234.

Bukhori, M.F.M.; Jaafar, H.Z.E. and Ghasemzadeh, A. (2015). Watering and nitrogen and potassium fertilization: The significance of abiotic control on *Gynura procumbens* (Lour.) Merr herbs in Malaysia for better growth and secondary metabolite enrichment. J. Mol. Biol. Biotechnol., 23 (2): 303-313.

Chapman, H. and Pratt, P. (1978). Methods of Analysis for Soils, Plants and Waters. Div. Agric., Sci. Univ. Calif. USA, 16-38.

Eledfawy, Y.M. (2017). Effect of NPK – fertilizers and humic acid applications on yield and quality of canola plant (*Brassica napus* L.) grown in sandy soil. Nature and Sci., 15(12): 205-2011.

Elkhatib, H.A.; Gabr, S.M.; Roshdy, A.H. and Abd Al-Haleem, M.M. (2017). The impacts of silicon and salicylic acid amendments on yield and fruit quality of salinity stressed tomato plants. Alex. Sci. Exch. J., 38 (4): 933-939.

Gomez, N.K. and Gomez, A.A. (1984). Statical Procedures for Agricultural Research. 2nd Ed., John wiley and sons, New York. USA, 680.

Gonzalez-Diaz, L.; Martinez-Jimenez, P.; Bastida, F. and Gonzalez-Andujar, J.L. (2009). Expert systems for integrated plant protection in pepper (*Capsicum annuum* L.). Expert Systems with Application, 36:8975–79.

Gunes, A.; Inal, A.; Alpaslan, M.; Cicek, N.; Guneri, E.; Eraslan, F. and Guzelordu, T. (2005). Effects of exogenously applied salicylic acid on the induction of multiple stress tolerance and mineral nutrition in maize (*Zea mays* L.). Arch. Agron. Soil Sci., 51:687-95.

Hafsi, C.; Debez, A. and Abdelly, C. (2015). Potassium deficiency in plants: effects and signaling cascades. Acta Physiol. Plant, 36: 1055-1070.

Ibrahim, A.; Abdel-Razzak, H.; Wahb-Allah, M.; Alenazi, M.; Alsadon, A. and Dewir, Y.H. (2019). Improvement in growth, yield, and fruit quality of three red sweet pepper cultivars by foliar application of humic and salicylic acids. Hort. Technol., 18 (93): 1-9.

Kazemi, M. (2013). Foliar application of salicylic acid and calcium on yield, yield component and chemical properties of strawberry. Bull. Env. Pharmacol. Life Sci., 2 (11):19-23.

Koshale, C.; Kurrey, D.K. and Banjare, L.D. (2018). Effect of organic manure and inorganic fertilizer on growth, yield and physiological parameter of chilli (*Capsicum annuum* L.). Int. J. Chem. Stud., 6(4): 118-122.

Kowalska, I. and Smoleñ, S. (2013). Effect of foliar application of salicylic acid on the response of tomato plants to oxidative stress and salinity. J. Elementol., 18 (2): 39–254.

Malik, M.N. (1994). Horticulture. In: Baloch AF (ed.) Vegetable crops. National Book Foundation Islamabad, 510-511.

Markwell, J.; Osterman, J.C. and Mitchell, J.L. (1995). Calibration of the Minolta SPAD-502 leaf chlorophyll meter. Photosynthesis Res., 46: 467-472.

Marschner, H. (1995). Mineral of Higher Plants. 2nd Ed., New York, Academic Press.

Mimouni, H.; Wasti, S.; Manaa, A.; Gharbi, E.; Chalh, A.; Vandoorne, B.; Lutts, S. and Ahmed, H.B. (2016). Does salicylic acid (SA) improve tolerance to salt stress in plants? a study of SA effects on tomato plant growth, water dynamics, photosynthesis, and biochemical parameters. Omics: A J. Integrative Biol., 20 (3): 180-190.

Ortas, I. (2013). Influences of nitrogen and potassium fertilizer rates on pepper and tomato yield and nutrient uptake under field conditions. Scien. Res. and Essays, 8 (23): 1048-1055.

Raskin, I.; Skubatz, H.; Tang, W. and Meeuse, B.J.D. (1990). Salicylic acid levels in thermogenic and nonthermogenic plants. Ann. Bot, 66: 376-383.

Souza, A.C.; Rezende, R.; Lorenzoni, M.; Seron, C.C. and Santos, F.A.S. (2018). Agronomic efficiency and growth of eggplant crop under different potassium and nitrogen doses. Rev. Caatinga, Mossoró, 31(3): 737–747.

Stevens, J.; Senaratna, T. and Sivasithamparam, K. (2006). Salicylic acid induces salinity tolerance in tomato (*Lycopersicon esculentum* cv. Roma): associated changes in gas exchange, water relations and membrane stabilization. Pl. Gro. Reg., 49 (1): 77-83.

Wiedenhoeft, A.C. (2006). Plant Nutrition. Hopkins WG (eds) The Green World, Chelsea House Publisher, New York NY, 16-43.

الملخص العربي

تأثير معدل الأسمدة النيتروجينية والبوتاسية بالتداخل مع حمض الساليسيليك على النمو، والمحصول، وجودة الفلفل الحار صنف شامبيون

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قسم البساتين (خضر)، كلية الزراعة، جامعة الزقازيق، مصر.

أجريت تجربة حقلية من أجل دراسة تأثير معدل التسميد بالنيتروجين والبوتاسيوم (صفر، 50، 75 و100% من المعدل الموصى به)، تركيز حمض الساليسيليك (صفر و50 و100 جزء في المليون) ومعاملات التفاعل بينهما على نباتات الفلفل الحار صنف شامبيون. كان المعدل الموصى به من النيتروجين والبوتاسيوم كما هو متبع في منطقة الزراعة هو 90 و76 كجم ن وبو$_2$أ/ فدان، على التوالي. صممت التجربة كقطع منشقة مرة واحدة في تصميم القطاعات العشوائية الكاملة بثلاثة مكررات في مزرعة البحوث الزراعية، بكلية الزراعة، جامعة الزقازيق، مصر خلال موسمي الصيف المتتاليين لأعوام 2019 و2020. أشارت النتائج إلى أن التأثير الإيجابي لوحظ بين معدل التسميد النيتروجيني والبوتاسي وصفات النمو لنباتات الفلفل الحار مثل ارتفاع النبات، وعدد الأفرع لكل نبات، وقطر الساق، والوزن الطازج والجاف للنبات، والتي زادت مع زيادة معدل التسميد بالنيتروجين والبوتاسيوم مقارنة بالكنترول. أدت زيادة معدلات التسميد النيتروجيني والبوتاسي إلى زيادة تدريجية في مكونات محصول الثمار وجودتها والمحتوى من الكابسياسين. بالإضافة إلى ذلك، أعطى حمض الساليسيليك بتركيز 100 جزء في المليون أعلى القيم في صفات نمو النبات والمكونات المحصولية لنباتات الفلفل الحار مقارنة بالكنترول. تم الحصول على أفضل القيم فيما يتعلق بمحصول الثمار المبكر والمحصول الكلي وكذلك المواد الصلبة الذائبة الكلية ومحتوى الكلوروفيل الكلي وفيتامين ج مع تركيزات 50 و100 جزء في المليون من حمض الساليسيليك مقارنةً بالكنترول (تم رشها بالماء العادي). بشكل عام، للحصول على أفضل نمو وأعلى محصول من نباتات الفلفل الحار وكذلك جودة جيدة للثمار يمكن تسميدها بمعدل 100% من المعدل الموصى به من النيتروجين والبوتاسيوم ورشها بـحمض الساليسيليك بتركيز 100 جزء في المليون.

الكلمات الاسترشادية: الفلفل الحار، النيتروجين، البوتاسيوم، حمض الساليسيليك، النمو.