Response of Greenhouse Perennial Sweet Pepper Plants to Spraying with Silicate Levels Under Varying Nitrogen and Potassium Fertilizers Levels

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ABSTRACT

There are many problems in the field of agriculture to improve the sustainability of farmed products. Increasing the production costs are one of these problems. In order to investigate the effects of silicate under varying nitrogen and potassium fertilizer levels on perennial sweet pepper plants cultivated in a greenhouses for two consecutive years of (2018/2019 and 2019/2020) by maintaining a balance between vegetative and fruit growth. The experiments were conducted in four greenhouses; the area of each greenhouse was 240 m^2. Each experiment included 12 treatments, three potassium silicate concentrations (0.0, 0.5 and 1.0 g l^{-1}) under four combined treatments of NK (25, 50, 100, 125%) of the recommended dose. Nitrogen doses were 47.5, 71.25, 95.0 and 118.75 kg N fed-1 added via irrigation water while K doses were 0.5, 0.75, 1.0 and 1.25 g as K_2O doses, which was added by spraying on the leaves of sweet pepper plants (Marvel F1). The results showed that sweet pepper plants fertilized with NK fertilizers at 125 % with potassium silicate at concentrations of 0.5 and 1.0 g l^{-1} achieved the highest significant increases in mean values of total leaf area plant^{-1} compared to untreated plants in both seasons. In addition, increasing levels of NK fertilizers from 50 to 125% of the recommended dose led to increases in relative fruit yield. Furthermore, the results showed that the addition of 0.5 g l^{-1} of potassium silicate to sweet pepper plants led to a significant increase in the total yield and average fruit weight.

Keywords: Greenhouses, Sweet Pepper, *Capsicum annum*, Nitrogen, Potassium silicate.

INTRODUCTION

Pepper is grown as an annual crop due to its sensitivity to chill climates, although it is actually a herbaceous perennial plant when grown under favorable conditions; semi-tropical or tropical climate (Kelley & Boyhan, 2009; Nkansah *et al*., 2017). Egypt is ranked as the sixth country worldwide in 2020 concerning pepper production after China, Mexico, Indonesia, Turkey and Spain (FAO, 2022). It is one of the crucial, common and favorite vegetables planted in Egypt not only for local consumption but also for exportation. It ranks as the second amongst vegetables cultivated area under the greenhouses in Egypt (ATB, 2020). The total cultivated area, yield and the production of sweet pepper under greenhouse were about (9.68 million m^2, 8.193 Kg m^{-2} and 81330 tons, respectively) (ATB, 2020).

Sweet pepper (*Capsicum annum* L.) is an important position among solanaceous fruity vegetables known for its high income and nutritional values for human health (El-Gazzar *et al*., 2020). Pepper has an important nutritional status, related to high contents of ascorbic acid (vitamin C) and zinc, which are vital for a strong and healthy immune system (Wang *et al*., 2021). Also, it has a high contents of bioflavonoid, vitamin A, ß carotene, calcium, iron and potassium. It is used in soup and salad preparation. Hundred grams of an edible part of pepper fruit contains; protein (1.3 g), of energy (24 Kcal), fat (0.3 g) and carbohydrate (4.3 g) (Sharma, 2016; USDA, 2019).

The growth and quality of the winter-spring vegetable, sweet pepper, grown in greenhouse is affected by nutrients. As pepper plants have a shallow root system that is disproportionate to the huge volume of the vegetative and fruiting growth, it needs an available and balanced mineral nutrients during the different growth stages (Lodhi *et al*., 2019). The large amounts of nitrogen N (31%) and potassium K (40%) as mineral fertilizers are intensively applied in pepper production in greenhouses are commonly associated with appreciable loss and consequent negative environmental impacts (Thompson *et al*., 2017), as well as proving uneconomical production by soaring costs of the agricultural practice (Ortas, 2013; Bouchet *et al*., 2016). Consequently, there is a critical demand to determine the appropriate amount of N and K fertilizers. In addition, the cost of the seedlings and fertilizers used in the production of hybrid pepper under the greenhouse represents more than 75% of total production costs (El-Sayed *et al*., 2015; Sobczak & Sobczak, 2021). A way to reduce costs can be achieved through improving agricultural practices, such as the use of foliar application of potassium silicate (PS) with diverse dosages (NK) fertilizers.

The use of silicon-based (Si) fertilizers has been reported to improve N uptake. It is evident that some field crops (e.g., sugarcane, rice, wheat and maize) can absorb Si quickly and in great quantities (Tubana *et al*.,

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2016). In recent years, the number of studies reporting the effects of Si application to crops has increased substantially, especially in vegetable crops such as pea (Dann *et al*., 2002), cowpea (Heath *et al*., 1986), and cucumber (Chérif *et al*., 1994).Potassium silicate (PS) is a well known source of soluble silicon that is used in farming production system primarily (Kamal, 2013). Foliar application of PS may improve N uptake (Hassan *et al*., 2021), can be used as a source of K (not as satisfactorily as commercial K fertilizers) and can improve plant K availability and assimilation (Basak *et al*., 2017; Elsokkary, 2018).

Therefore, the objective of present research is an attempt to reduce the production costs through mentoring the effect of spraying sweet pepper with silicate under varying nitrogen and potassium fertilizer levels on some biometric characters using drip irrigation system in greenhouse.

MATERIALS AND METHODS

Experimental materials

A greenhouse experiment was carried out at the Experimental Station Farm of the Faculty of Agriculture, Alexandria University, Abies, Alexandria, Egypt, during the two growing seasons of 2018/2019 and 2019/2020, to study the effect of NK fertilizers and potassium silicate (PS) concentrations as well as its interactions on some biometric characters of the growth, fruits yield and its quality of perennial sweet pepper plants (Marvel F1 cv.) that grown under drip irrigation. The aim of this study is to maintain the balance between the vegetative growth and fruit production of pepper plants using drip irrigation system in greenhouse, with the continuous growth of plants for more than a year, this will reduce production costs. Each experiment was conducted in four greenhouses unit. The area of each greenhouse was 240 m^2 (3 rows x 2 m width x 40 m long), with 2.8 m height.

Preceding the initiation of the experiment, random soil samples were collected, from the four greenhouses, at 15-30 cm depth, and was analyzed at the Unit of Analysis and Scientific Services (ALEX-Soil), Faculty of Agriculture, Alexandria University; for some soil's physical and chemical properties according to the published procedures (AOAC, 1995; AOAC International Arlington, 2019).The results of this analysis are listed in Table (1).

Experimental treatments and design

NK fertilizers treatments were four combined treatments of ; 50%, 75%, 100%, and 125% of recommended dose from each fertilizer (FAO, 2005), where N fertilizer levels were 47.5, 71.25, 95.0 and 118.75 kg N fed^{-1}, as ammonium nitrate that was applied as fertigation, while K fertilizer levels were 0.5, 0.75, 1.0 and 1.25 g K_2O l^{-1}, as potassium sulphate. The potassium fertilizer was applied as a foliar application; at two doses weekly starting in the 2^{nd} week after transplanting (WAT) up to the 14^{th} week. Furthermore, Potassium silicate (K_2SiO_3) was used as a foliar spray at 0.0, 0.5 and 1.0 g l^{-1} concentrations for four times application at 15, 30, 45 and 60 days after transplanting (DAT). The experimental design used was split-split-plot system in a Randomized Complete Blocks Design, with three replications. NK fertilizers were arranged randomly in the main plots, while Potassium silicates (PS) concentrations were distributed randomly within each greenhouse as a sub-plots

Table. 1. Some soil chemical and physical properties of the experimental site, in the growing seasons of 2018/2019 and 2019/2020

Soil properties		Seasons	
		2018/2019	**2019/2020**
Chemical properties	EC (dS m^{-1})	3.5	4.43
	PH	7.78	7.57
	N (%)	0.462	0.476
	P (ppm)	6194	6552
	K (ppm)	483	676
	HCO_3^-(meq l^{-1})	3	2.5
	Ca^{++} (meq l^{-1})	28.5	41
	Mg^{++} (meq l^{-1})	7.5	12.75
	Cl^- (meq l^{-1})	9	15.75
	So_4^{--} (meq l^{-1})	23	25.8125
Physical properties	Sand %	67	70
	Silt %	11	8
	Clay %	22	22
	Textures	**Sandy clay loam**	**Sandy clay loam**

The transplants of sweet pepper (Marvel F1) were transplanted, on September 20th, in the first season 2018/2019, in two lines on each row. The row spacing was 40 cm between the plants and 50 cm between the two lines. At the end of the first season in August 2019 pepper plants were pruned at 30 cm above the ground, to encourage initial vegetative growth in the second season of 2019/2020, which was the beginning on 20th September 2019. All the previous treatments that have been executed during the first season were applied accordingly.

All other agro-managements practices were carried out whenever; they were necessary and as recommended for the greenhouse commercial sweet pepper production. Harvesting starting from the10th of November till the 30th of June on the two seasons.

Measurements and calculations

Vegetative characters

Four plants were randomly chosen at 120 DAT from each sub-plot, to determine total fresh and dry biomass per plant, in both the seasons. The dry biomass was determined by drying fresh samples (100 gm) of different organs, at 70°C till a constant weight then dry biomass was calculated as g plant^{-1} (Ryan *et al*., 2001; Estefan *et al*., 2013)., leaves area per plant (cm^2) which it was calculated using the fresh weight method as used by (Fayed, 1997).

Fruit yield and its components

Sweet pepper fruits at a marketable stage were harvested, starting from 50 DAT and continued until 280 DAT. The harvested fruits in each picking were weighed and counted. Twenty random matured fruits were taken to measure average fruit fresh weight (g). Additionally, at the end of fruiting period, total fruits yield as weight, was calculated per square meter. Furthermore, Relative yield % was calculated as follows:

$$Relative\ yield\ \% = \frac{\text{Fruit yield } (\text{kgm}^{-2})\ of\ specefic\ treatment}{\text{Fruit yield } (\text{Kg m}^{-2})\ of\ control\ treatment} * 100$$

Chemical constituents for leaves and fruits

Random samples from fresh leaves of four sweet pepper plants from each sub-plot, at 120 DAT, were collected to determine total chlorophyll, nitrogen (N) and potassium (K) contents. Total chlorophyll content (SPAD) of fresh leaves was determined by using Minolta SPAD chlorophyll meter model, according to the method described by Yadawa (1986). The N and K contents were determined in the dried leaves. The leaves were ground, and then a 0.3 g sample was digested with H_2O_2. Nitrogen and potassium contents as percentage were calorimetrically determined according to the methods described in **(**AOAC, 1995**)**.

Previous fruits that were used to measure the fruit quality characters, were used to determine fruits chemical constituents; the ascorbic acid was estimated by titration with 2,6-Dichloroindophenol according to (AOAC, 1995) and total soluble solids (TSS, %) was measured in fruit flesh juice using a portable digital refractometer.

Statistical analysis

All obtained data was analyzed statistically according to the design used by the Co-state computer software program 2005. The comparisons among means of the different treatments were carried out, using the revised L.S.D. test (Al-Rawi & Khalaf-Allah, 1980) at (P>0.05).

RESULTS AND DISCUSSION

Biomass and vegetative growth characters

The results in Table (2**)** clarified significant impacts of NK levels and their interactions with potassium silicate (PS) concentrations on plant fresh and dry biomasses, plant height and total leaf area per plant, in the two growing seasons. All biomass and vegetative growth characters showed significant and gradual increases with increasing NK levels from 50% up to 125% of the recommended dose, while foliar application of 0.5 g l^{-1} PS was associated with the highest mean values of all characters in both growing seasons. These results are boosted by N and K nutrients. Nitrogen as an essential element for assimilation of proteins and chlorophyll pigments, and enzymes, that are involved in catalyzing most biochemical processes (Hochmuth *et al*., 2012; Njira & Nabwami, 2015), as well as coenzymes and some non-proteins compounds (Brady & Weil, 2008). Also, K acting as parting many important regulatory roles in the plant, i.e. osmo-regulation process, translocation of sugars and formation of carbohydrates, regulation of plant stomata and water use efficiency, the regulation of enzyme activities, energy status of the plant, protein synthesis, facilitation of cell division and growth by helping to move sugars and starch amongst plant portions (Havlin *et al*., 2016). Consequently, it affects positively the assimilation of the photosynthetic reaction and promotes the meristematic activity for producing more tissues and organs related to growth (Marschner, 1994).

highest significant mean values of the plant fresh and dry biomass were resulted from 0.5 g l^{-1} of PS with the two highest levels of NK (100 and 125% of the recommended dose), in both seasons. The interaction effect between NK and PS on biomass and vegetative growth characters are presented in Table (2). The combined treatment of NK at 125 % of the recommended dose and PS at 0.5 g l^{-1} showed, generally, the highest significant differences on biomass and vegetative growth characters in both seasons.Such favorable effects of NK application on biomass and vegetative growth characters could be caused by the limited initial soil nutrients' composition of the experimental site **(Table 1)**. Additionally, the beneficial effects of using PS fertilizers increased the root development, more effective tillers and an increment in plant mass. Si supplementation may enhance water storage in leaves and lead the formation of the silicate crystals in the epidermal cells working as a barrier reduces water loss through the cuticle (Metwally *et al*., 2018). Silicon application increased the vegetative growth, which was reflected significantly on enhancement antioxidant enzymes' activities (Kaya *et al*., 2020) and higher photosynthesis rates (Pereira *et al*., 2013). Si increased, also, the thickness and the roughness of leaves thus improving light reception (Abou Basha *et al*., 2013). Leaves, stems and culms of plants grown in the presence of adequate silicon levels are enhanced strength and rigidity and an erect growth (Laane, 2017), as well as PS contains a considerable amount of K_2O, that improved the total dry biomass of sweet pepper plants (Abdel-Aziz & Geeth, 2018).

Fruit yield characters

Yield potential was evaluated using fruit weight, total yield m^{-2} and relative yield % **(Table 3 & Figures 1, 2 and 3)**. The highest significant mean values were resulted from the two highest levels of NK fertilizers (100 and 125% of recommended dose) in both the seasons. It was, also, noticed that increasing NK level from 50 up to 125% of recommended dose was associated with increments in relative yield. At the same time, Foliar application of 0.5 g l^{-1} PS caused significant increases of fruit weight, total yield m^{-2} and, relative yield % compared with the other treatments, in the two seasons **(Table 3)**. In terms of the interaction between NK fertilizers at level 100 % of recommended dose and sprayed with PS at 0.5 g l^{-1} recorded significantly the highest mean values of the fruit weight, total yield m^{-2} and, relative yield % characters, in the first and second seasons (**Figures 1, 2 and 3)**.

Table. 2.Effects of NK fertilizers levels (% of recommended dose) and PS concentrations and their interactions on plant fresh and dry biomasses and total leaf area plant^{-1} of sweet pepper plants, in the two seasons of 2018/2019 and 2019/2020

Treatments		2018/2019 Season			2019/2020 Season		
NK % Rec.[Z]	PS Conc. (g l^{-1})	Plant fresh biomass (g)	Plant Dry Biomass (g)	leaf area (cm^2 $plant^{-1}$)	Plant fresh biomass (g)	Plant dry biomass (g)	leaf area (cm^2 $plant^{-1}$)
50	-	873.06 D[*]	119.75 D	1125.09 D	899.39 D	150.01 D	890.01 D
75		1025.58 C	159.46 C	1459.16 C	1154.26 C	213.43 C	1312.74 C
100		1253.41 B	213.35 B	2003.28 B	1375.10 B	273.46 B	1777.44 B
125		1290.65 A	218.71 A	2238.87 A	1437.53 A	290.33 A	1974.49 A
-	0	1047.66 C	159.95 C	1567.06 C	1152.99 C	211.70 C	1360.04 C
	0.5	1175.10 A	190.55 A	1832.98 A	1279.18 A	247.96 A	1582.55 A
	1.0	1109.26 B	182.95 B	1719.76 B	1217.54 B	235.76 B	1523.42 B
50	0	829.95 k	109.18 k	1052.00 l	823.32 i	130.67 l	791.07 j
	0.5	926.36 i	128.81 i	1220.13 j	981.81 g	167.38 j	990.42 h
	1.0	862.88 j	121.25 j	1103.15 k	893.05 h	151.98 k	888.55 i
75	0	976.68 h	145.34 h	1354.36 i	1106.85 f	197.05 i	1179.85 g
	0.5	1086.61 f	170.63 f	1575.13 g	1208.40 d	226.72 g	1406.37 e
	1.0	1013.44 g	162.40 g	1448.00 h	1147.51 e	216.51 h	1352.01 f
100	0	1157.84 e	188.54 e	1803.13 f	1294.17 c	251.71 f	1628.92 d
	0.5	1347.21 a	231.81 a	2171.09 c	1453.51 a	291.72 c	1879.62 b
	1.0	1255.19 c	219.69 c	2035.60 e	1377.62 b	276.94 d	1823.78 c
125	0	1226.18 d	196.73 d	2058.73 d	1387.62 b	267.37 e	1840.34 c
	0.5	1340.22 a	230.95 ab	2365.56 a	1473.02 a	306.03 a	2053.79 a
	1.0	1305.54 b	228.46 b	2292.31 b	1451.96 a	297.58 b	2029.33 a

[*] Values marked with the same letter (s) are statistically similar using Revised LSD test at p= 0.05.

[Z] Recommended dose of fertilizers for pepper production in the experimental area are 95 kg N fed^{-1} by fertigation and 1 kg K fed^{-1} as a foliar application.

Table 3. The main effects of NK fertilizers levels (% of recommended dose) and PS concentrations on fruit weight, total yield and relative yield of sweet pepper plants, in the two seasons of 2018/2019 and 2019/2020

Treatments	levels	Average Fruit weight (g)	Total yield (kg m^{-2})	Relative yield%
		2018/2019 Season		
NK % Rec.[Z]	50	39.48 D	6.635 C	100
	75	41.75 C	7.931 B	119.54
	100	44.98 B	9.806 A	147.8
	125	45.41 A	9.751 A	146.97
PS Conc. (g l^{-1})	0	42.15 C	8.058 C	100
	0.5	43.48 A	8.831 A	109.6
	1.0	43.08 B	8.703 B	108.01
		2019/2020 Season		
NK % Rec.[Z]	50	33.30 D	4.877 C	100
	75	35.93 C	6.247 B	128.1
	100	39.25 B	7.603 A	155.9
	125	39.79 A	7.643 A	156.72
PS Conc. (g l^{-1})	0	36.06 C	6.181 C	100
	0.5	37.82 A	6.861 A	111.01
	1.0	37.32 B	6.736 B	108.98

[*] Values marked with the same letter (s) are statistically similar using Revised LSD test at p= 0.05.
[Z] Recommended dose of fertilizers for pepper production in the experimental area are 95 kg N fed^{-1} by fertigation and 1 kg K fed^{-1} as a foliar application.

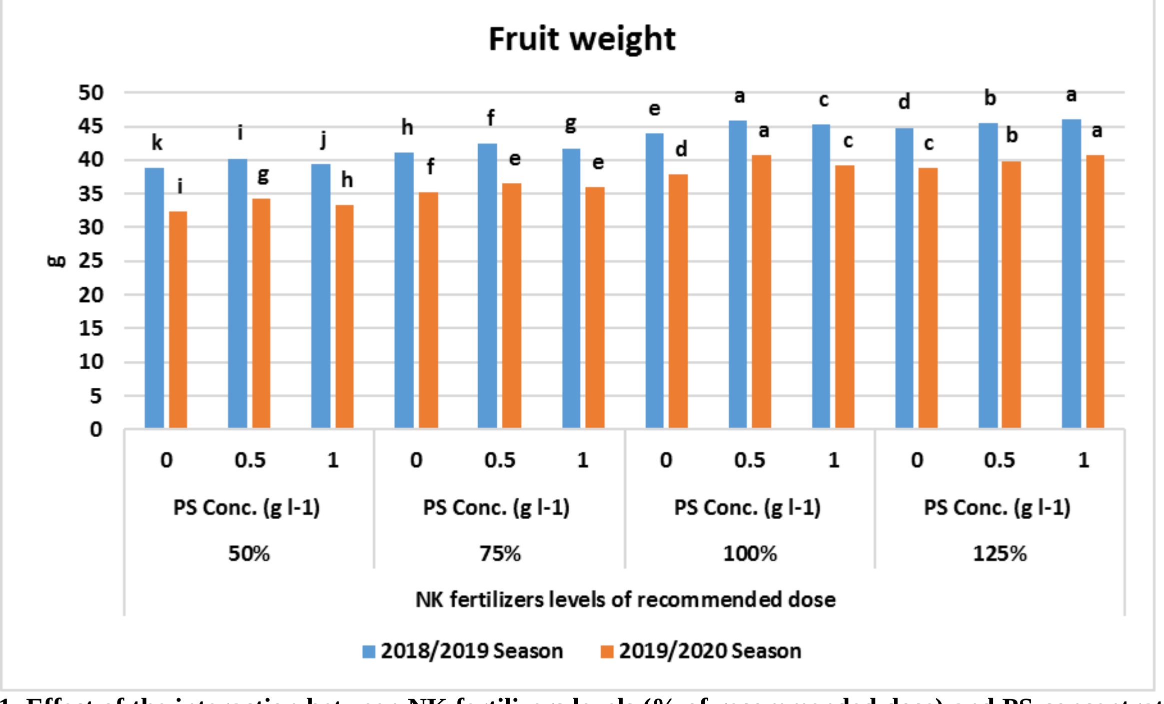

Fig. 1. Effect of the interaction between NK fertilizers levels (% of recommended dose) and PS concentrations on the fruit weight of sweet pepper plants, in the two seasons 2018/2019 and 2019/2020

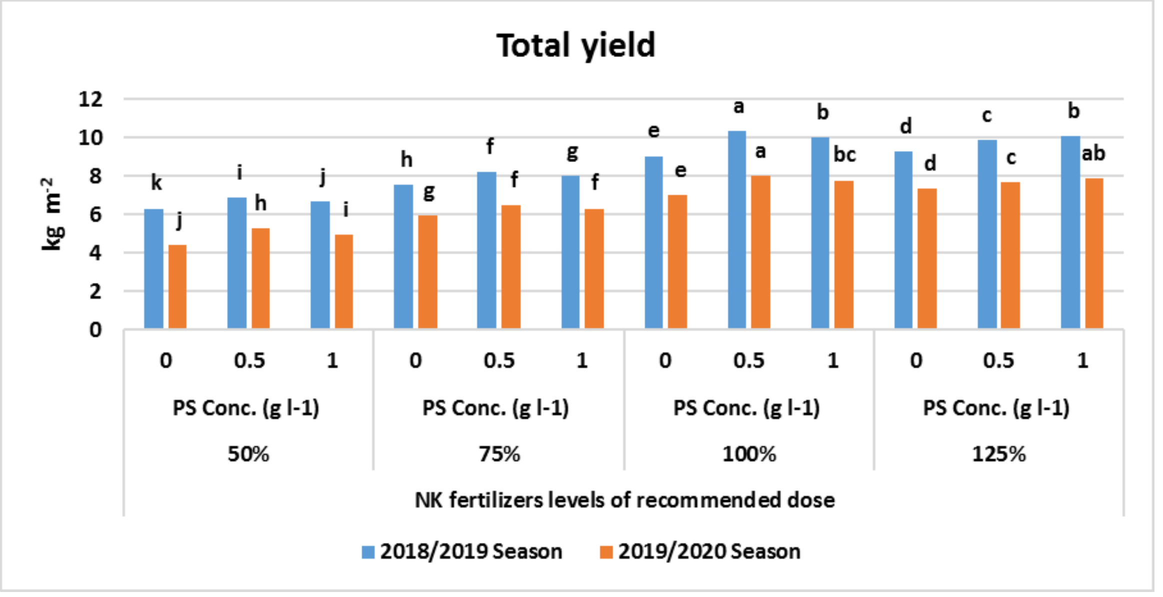

Fig. 2.Effect of the interaction between NK fertilizers levels (% of recommended dose) and PS concentrations on the total yield m^{-2} of sweet pepper plants, in the two seasons 2018/2019 and 2019/2020

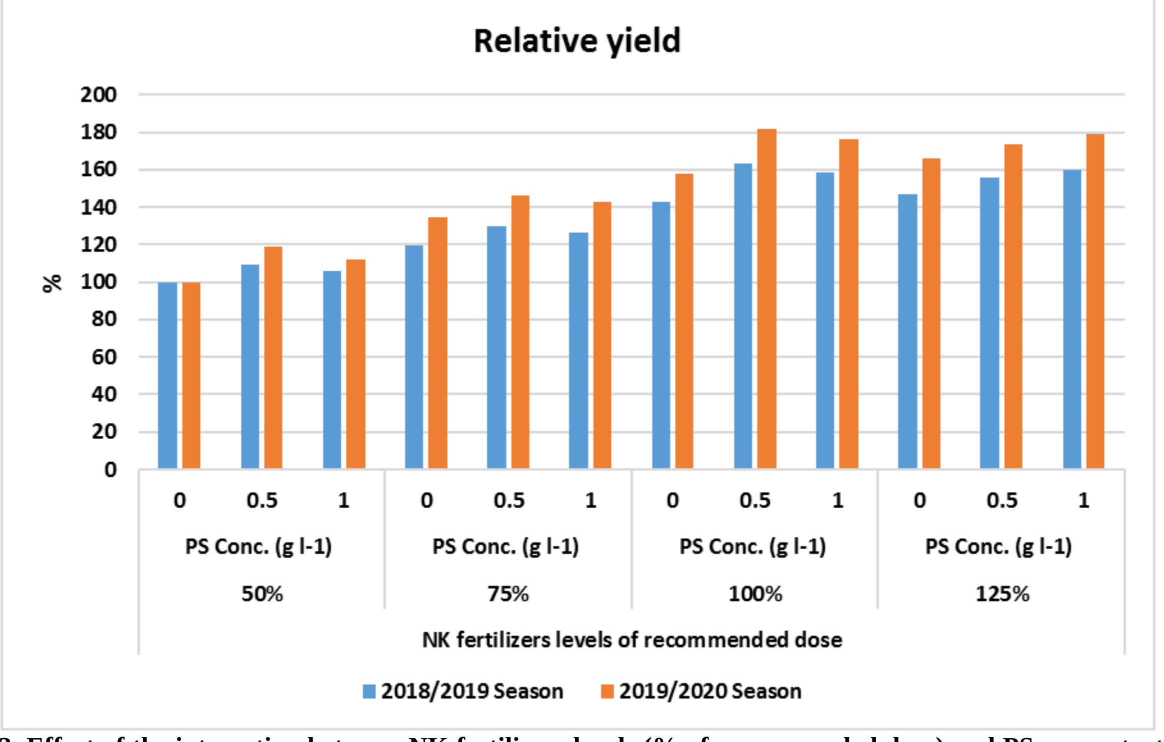

Fig. 3. Effect of the interaction between NK fertilizers levels (% of recommended dose) and PS concentrations on the relative yield of sweet pepper plants, in the two seasons 2018/2019 and 2019/2020

Leaf's and fruit's chemical constituents

The results in **(Table 4)** illustrated significant influences of the effects of NK levels and PS concentrations and their interactions on leaf's chemical constituents. The different comparison indicated obviously that leaf's total chlorophyll and N contents reached the highest significant mean values with NK at 100% of recommended dose in both seasons. Furthermore, it was noticed that leaf's K content showed significant and gradual increases with increasing NK levels from 50% up to 125% of recommended dose, in the two seasons. Additionally, the foliar application of 0.5 and 1.0 g l^{-1} PS concentrations were associated with the highest significant mean values of leaf's chlorophyll and N contents, while the leaf's K content were the greatest with 0.5 g l^{-1} PS concentration only, in the two seasons. In terms of the interactions between NK and PS, spraying of PS at 0.5 or 1.0 g l^{-1} combined with NK at the rate of 100 or 125 % (of recommended dose) resulted in the highest significant mean values of total chlorophyll and N content of sweet pepper leaves, in both seasons. On the other side, the highest significant mean values of leaf's K content were recorded when PS at 0.5 g l^{-1} with NK at level 125% of recommended dose, in both seasons. The highest significant mean values of TSS and ascorbic acid contents of the fruits were recorded at 125% of recommended dose, in the two seasons **(Table 4)**. Moreover, increasing PS concentrations from 0.0 to 1.0 g l^{-1} was accompanied by successive and significant increments in fruits content of TSS and ascorbic acid of sweet pepper plants, in the two seasons. In terms of NK and PS interaction, the highest significant mean values of fruit's TSS, ascorbic acid and N contents were resulted by spraying of PS at 1.0 g l^{-1} combined with NK at the rate of 100 % (of recommended dose), in both seasons **(Table 4)**.The results value previously reported are attributed the roles of NK in promoting the growth of pepper plants.

Major nutrient elements i.e., NK associated of photosynthetic activities and thus cooperate with the other variables in promoting roots and vegetative growth, and high relationship between chlorophyll and nitrogen content (EL-Shimi *et al*., 2015). The ascorbic acid and TSS of fruit are composed of carbohydrate constituting compound and that are influenced by both N and K application, the increase in ascorbic acid content with higher doses of N and K and their combination were apparent (Nanda & Mahapatra, 2004; Mishra *et al*., 2016). Positive consequence for enhancing the silicon for root structures that led to improve the root growth leading to more absorption of nutrients from the soil, which increases the concentration of nutrients in leaf tissue. The effect of silicon on K uptake may be due to the activation of H-ATPase in the membranes (Putra *et al*., 2010; Shalaby *et al*., 2017). The supply of Si increased leaf water status and proline content in pepper plants (Kaya *et al*., 2020). In addition, Abdel-Aziz & Geeth, (2018) who defined that foliar application by various rates of silicon sources treatments, gave significant increases in all fruit quality parameters of sweet pepper i.e. total soluble solids (%), total sugars (%), total acidity (%) and ascorbic acid (mg/100 g fresh weight).

Table 4. Effect of NK fertilizers levels (% of recommended dose) and PS concentrations, and their interactions on leaf's total chlorophyll, N and K contents of sweet pepper plants; fruit's TSS and ascorbic acid in the two seasons of 2018/2019 and 2019/2020

Treatments		2018/2019 Season					2019/2020 Season				
NK % Rec.[Z]	PS Conc. ($g\ l^{-1}$)	Total chlorophyll (SPAD)	N (%)	k (%)	fruit's TSS %	Ascorbic acid (Mg 100 g^{-1} F.W)	Total chlorophyll (SPAD)	N (%)	k (%)	fruit's TSS %	Ascorbic acid (Mg 100 g^{-1} F.W)
50	-	43.13 D*	2.17 D	2.93 D	6.65 D*	61.68 D	42.55 C	1.75 D	2.66 D	6.44 D	55.99 D
75		47.40 C	2.42 C	3.28 C	7.15 C	68.11 C	44.82 B	1.99 C	3.01 C	6.92 C	63.71 C
100		53.22 A	2.75 A	3.76 B	8.05 B	79.38 B	47.28 A	2.27 A	3.50 B	7.81 B	75.60 B
125		52.48 B	2.71 B	4.00 A	8.08 A	81.11 A	46.89 A	2.25 B	3.74 A	7.86 A	77.22 A
-	0	47.68 B	2.43 B	3.39 C	7.13 C	68.00 C	44.49 B	2.00 B	3.13 C	6.92 C	63.02 C
	0.5	49.83 A	2.55 A	3.59 A	7.55 B	73.38 B	45.60 A	2.11 A	3.33 A	7.33 B	69.17 B
	1.0	49.66 A	2.56 A	3.50 B	7.76 A	76.33 A	46.06 A	2.10 A	3.23 B	7.52 A	72.19 A
50	0	42.25 d	2.11 i	2.85 k	6.29 k	57.82 k	40.82 f	1.70 j	2.55 j	6.11 k	51.57 j
	0.5	44.03 d	2.22 g	3.00 i	6.70 j	61.60 j	43.55 de	1.80 h	2.78 h	6.45 j	56.19 i
	1.0	43.13 d	2.19 h	2.95 j	6.95 h	65.63 h	43.30 e	1.76 i	2.66 i	6.75 h	60.20 g
75	0	46.35 c	2.36 f	3.20 h	6.83 i	63.64 i	45.91 bc	1.93 g	2.95 g	6.61 i	58.77 h
	0.5	48.20 c	2.47 d	3.34 f	7.21 g	68.96 g	43.78 de	2.03 e	3.06 f	6.99 g	65.00 f
	1.0	47.66 c	2.44 e	3.30 g	7.41 f	71.72 f	44.76 c-e	2.00 f	3.02 f	7.17 f	67.36 e
100	0	50.94 b	2.62 c	3.63 e	7.59 e	73.17 e	45.40 b-d	2.16 d	3.36 e	7.35 e	68.45 d
	0.5	54.56 a	2.81 a	3.89 c	8.17 c	80.84 c	48.26 a	2.34 a	3.61 c	7.95 c	77.41 b
	1.0	54.16 a	2.81 a	3.78 d	8.40 a	84.14 a	48.17 a	2.31 a	3.53 d	8.12 a	80.93 a
125	0	51.18 b	2.64 c	3.88 c	7.84 d	77.38 d	45.83 bc	2.19 c	3.65 c	7.61 d	73.30 c
	0.5	52.56 ab	2.71 b	4.14 a	8.13 c	82.13 b	46.83 ab	2.25 b	3.85 a	7.94 c	78.08 b
	1.0	53.70 a	2.79 a	3.99 b	8.29 b	83.82 a	48.00 a	2.32 a	3.72 b	8.04 b	80.29 a

*** Values marked with the same letter (s) are statistically similar using Revised LSD test at p= 0.05.**

[Z] Recommended dose of fertilizers for pepper production in the experimental area are 95 kg N fed^{-1} by fertigation and 1 kg K fed^{-1} as a foliar application.

CONCLUSION

The current results showed, generally, that the application of NK fertilizers at 125 % of the recommended dose and potassium silicate at 0.5 g l- might be considered as the best treatment for the production of high yield and good quality of sweet pepper plants under greenhouses conditions. Also, it provides an evidence about the possibility of lowering the production costs by using perennial method.

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الملخص العربي

إستجابة نبات الفلفل المعمر النامى تحت الصوب الزراعية للرش بالسيليكات تحت جرعات مختلفة من التسميد النيتروجينى والبوتاسى

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هناك العديد من المشاكل في مجال الزراعة لتحسين استدامة المنتجات المستزرعة. زيادة تكاليف الإنتاج هي واحدة من هذه المشاكل وقد أجريت هذه التجربة فى محطة البحوث الزراعية جامعة الأسكندرية–أبيس – خلال موسمى الزراعة المتتالين ٢٠١٨/٢٠١٩ و ٢٠١٩/٢٠٢٠. في أربعة بيوت بلاستيكية ؛ تبلغ مساحة كل صوبة ٢٤٠ م ٢ ، تحت نظام الري بالتنقيط. بإستخدام صنف مارفيل لنبات الفلفل الحلو تضمنت كل تجربة ١٢ معاملة وهى ثلاث تركيزات من سيليكات البوتاسيوم (٠، ٠,٥، ١,٠ جم لتر–١) تحت أربع معاملات عاملية من النيتروجين والبوتاسيوم (٤٧,٥، ٧١,٢٥، ٩٥,٠ و١١٨,٧٥ كجم نيتروجين للفدان) والتي تم اضافتها من خلال ماء الري و(٠,٥، ٠,٧٥، ١,٠ و١,٢٥ جم من أكسيد بوتاسيوم فى التر) التي تم إضافتها عن طريق الرش الورقى و التي تمثل ٢٥ ٪، ٥٠ ٪، ١٠٠ ٪، ١٢٥ ٪ . أظهرت النتائج أن زيادة مستويات النيتروجين والبوتاسيوم من ٥٠ ٪ إلى ١٢٥ ٪ قد أدى الى زيادات معنوية وتدريجية في الكتلة الحيوية الطازجة، والجافة لمعظم أعضاء نبات الفلفل الحلو وإجمالى المساحة الورقية. كما أرتبطت زيادة مستويات أسمدة النيتروجين والبوتاسيوم من ٥٠ إلى ١٢٥٪ ي بها بزيادات في محصول الثمارالكلى. علاوة على ذلك ، أظهرت النتائج أن إضافة ٠,٥ جرام فى الـتر من سيليكات البوتاسيوم لنباتات الفلفل الحلو كان قد أدى إلى زيادة معنوية في المحصول الكلي ومتوسط وزن الثمار.

الكلمات المفتاحية: الصوب الزراعية ، الفلفل الحلو ، النيتروجين ، سيليكات البوتاسيوم.