The Role of Some Growth Stimuli on Mango Growth Performance

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ABSTRACT: Mango (*Mangifera indica* L.) is one of the most important fruit crops. The present experiment was carried out during 2020- 2021 seasons, in order to study the effect of some growth stimuli on growth behavior, nutritional status and productivity of 10-year old Keitt mango trees grown in sandy soil at a private orchard, Badr city, El-Beheira governorate, Egypt. The treatments were the control (untreated trees), chitosan at 30, 60 and 90 ppm, spermidine at 5, 10 and 20 ppm, vermicomposting leachate (VLC) at 10, 15, and 20% and potassium silicate at 400, 500 and 600 ppm and sprayed four times a month before flowering, at the beginning of flowering, at full bloom and three weeks after the contract. The obtained results showed that, all treatments caused an improve in traits under study, the highest values of the number of flowering panicle (353.3 and 352.3), the number of hermaphrodites/ panicle (695 and 696.6), hermaphrodites flowers (46 and 45.6 %), fruit set (18.4 and 18.6 %) and the number of fruits / tree (128 and 127) were obtained by 5 ppm spermidine, in the two seasons also followed by the lowest concentration of chitosan (30 ppm). The highest value of total yield was obtained by 5 ppm (70 and 71.6 kg/ tree,) and 10 ppm (67.6 and 66.3 kg/tree) concentrations of spermidine also followed by the lowest concentration of chitosan (30 ppm) in 2020 and 2021. The highest values of fruit weight (556.3 and 557.3 g.), vitamin C content (50 and 52 mg/ 100 ml juice) and leaf K content (3.3 and 3.3 % resp.) were obtained by 600 ppm potassium silicate treatment. In the meantime, the highest value of fruit TSS (%), total sugars (%) and leaf N and P content was obtained by potassium silicate at 600 ppm and VCL at 20 % treatments. As for acidity (%), the highest values were recorded when using the three concentrations of spermidine (5, 10 and 20 ppm) compared to the control, while the lowest values were obtained by using the highest concentration of VCL (20%) and potassium silicate (600 ppm) (0.20 and 0.22 %) for the two treatments, resp., in the two seasons.

Keywords: *mango, fruit set, yield, fruit quality, leaf mineral*

1-INTRODUCTION

The mango tree (*Mangifera indica* L.) is an evergreen species of the Anacardiaceae family and is regarded as one of the most major fruits in tropical and subtropical regions of the world. It may grow in a variety of soil and climate conditions**(Alshallash *et al*., 2022),** with a fruit area of 289 thousand acres and a yield of 1351316 tonnes, mangoes in Egypt rank third in terms of economic importance in the fruit trade after grapes and citrus **(FAO, 2017).**

Mangoes come in a wide range of varieties, all of which are high in nutrients and flavonoid antioxidants. Keitt cultivar has an oblong form and light to dark green skin, occasionally they have a yellow bluish shade and a tangy sweet flavour with a hint of honey (**Lenucci *et al*., 2022)**. In addition, mango is consumed all above the world for its delectable flavour. As a result of its abundance in vitamins A and C, mango is frequently used in the production of juice, nectars, fruit leather and frozen pulp (**Ernesto *et al.* 2018).**

A natural polysaccharide produced by N-DE acetylating chitin, chitosan is a key component of the shells of crustaceans like crabs, shrimp, and crawfish **(Maleki *et al*., 2022)**. Chitosan and its derivatives are non-toxic, friendly environment and have the potential to stimulate growth and increase yield in a variety of agricultural and horticultural applications **(Mohan *et al*., 2022)**. It has a wide range of physio-chemical and biological properties because of its cationic nature, including antioxidant and antibacterial abilities; because it has positively charged amino group that interact with the negatively charged bacteria membrane **(Aranaz *et al*., 2021),** protect plants against oxidative stress and stimulate plant growth **(Parvin*et al*., 2019)**.

Spermidine is an aliphatic polyamine, polycationic, has low molecular weight and classified as a secondary hormone messenger, it is involved in a variety of physiological processes in plants, including morphogenesis, floral differentiation and initiation, pollen viability, senescence prevention and biotic and abiotic stress reactions **(Childs *et al*., 2003 and Chen *et al*., 2022).** Without changing the amount of ethylene produced by the flower, polyamines increased pollen tube ovule penetration and postponed ovule senescence. **Abbasi *et al*. (2017)** discovered that spraying polyamine significantly boosted yield and yield component of mango trees.

Vermicomposting leachate contains (VCL) mineral content, humic acid, fulvic acid, vitamins, enzymes, amino acids, actinomycetes, as well as some growth hormones, it is a liquid phase, functions asa plant tonic **(Suthar, 2010 and Arslan *et al*.., 2022).** Foliar spray of VCL induced salt tolerance by reducing the accumulation of Na+, increased vegetative growth and productivity of fruit trees by about 15% also, increased disease resistance **(Abd El–Hamied, 2018).** Additionally, VCL increased the activity of antioxidant, enzymes, decreased oxidative stress and stopped electrolyte leakage **(Siamak *et al*., 2017)**

Potassium silicate is source of silicon and potassium that are soluble **(El Khol*yet al.*, 2018)**. It contributes a silica amendment in agricultural production systems primarily with added benefit of delivering trace levels of potassium **(EL-Sayed*et al.*, 2018)**. A suitable potassium nutrition helps many horticultural crops by increasing tree yields, fruit size, color, soluble solids and ascorbic acid concentrations **(Kanai *et al*., 2007).** Additionally, silicon is crucial for photosynthesis, nutrient and water intake, plant pigmentation and all types of cell division for raising and improving the resistance to biotic and a biotic challenges **(Zargar *et al.*, 2018).** Therfore, the current study was conducted to investigate the effect of spraying mango trees cv. Keitt with various concentrations of chitosan, spermidine, vermicompost leachate, and potassium silicate.

2. MATERIALS AND METHODS

2.1 Location and date of the experiment

Mango (*Mangifera indica* L.) is one of the most important fruit crops. The present experiment was carried out at two places i.e. Plant production department, Faculty of Agriculture, Saba Basha, Alexandria university, Egypt and a private orchard in Badr city, El-Beheira governorate, Egypt during 2020 and 2021, in order to study the horticultural characteristics of 10-year old Keitt cultivar grown in sandy soil using some growth stimuli (Chitosan, spermidine, vermicomposting leachate (VCL) extract and potassium silicate) to improve the growth behavior, nutritional status and productivity of mango trees. The selected trees were uniform in vigor as possible spaced 5x5, fertilization and other agricultural practices were the same for all trees, Physical and chemical properties of the experimental soil are presented in **Table (1)**. The treatments were chitosan at30, 60 and 90 ppm, spermidineat 5, 10 and 20 ppm, vermicomposting leachate VLC at) 10, 15, and 20%, potassium silicate at400, 500 and 600 ppm and the control and sprayed four times a month before flowering, at the beginning of flowering, at full bloom and three weeks after the contract.

2.2.The soil of the experimental site

Table (1): Some physical and chemical properties of the experimental soil

Particle size Distribution (%)			Texture soil	Ecds m^{-1}	pH	Available nutrients (Cation)					Available nutrients(Anion)			
Sand	Silt	Clay				N%	P %	K %	Ca ml/L	Mg ml/L	CO_3	HCO_3 mg/L	Cl	SO_4
90	5	5	Sandy	1.50	8.20	0.15	0.44	0.57	2.65	2.40		3.85	53	55.65

2.3 The chemical composition of the materials used in the research

- **Chitosan**

Formula: C6H11NO4X2, chitosan-from shrimp shells 75% AR (deacetylated), chitosan a linear polymer consisting of two subunits linked together: N-acetyl-D-glucosamine and D-glucosamine. Lot No.Sample COA- Code No.02697, LOBA CHEMIE PVT. LTD. ISO 9001-2015 CERTIFIED, India.

- **Spermidine**

Spermidine (99%), Synonym(s):1, 8-Diamino-4-azaoctane, N-(3-Amino propyl)-1, 4-diaminobutane. Linear Formula: NH2(CH2)3NH(CH2) 4NH2- CAS Number: 124-20-9 EC Number: 204-689-0 M.W:145.25 Lot: A014080101, Sigma- Aldrich Company, India

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• **Vermicomposting leachate(VLC): the component of VCL illustrated in Table 2**

Table (2): Characteristics of vermicomposting leachate obtained from cattle manure

Characteristic	Ph	OM (dS/m)	EC	C/N	N (%)	P (mg/kg)	K (mg/kg)	Fe (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	Mn (mg/kg)	Purity (%) Humic	Fulvic
VCL	7.08	20.06	2.78	5.38	2.42	1865	2487	11.08	0.08	24.57	0.49	18	15

• **Potassium silicate**

The formula can be written as K2O3Si, the compound consists of potassium oxide 10% and silicon oxide 25%. (Alpha Chemika Company - Batch No.: P 43256 Sr. No. AL 10332/02); company certified ISO 9001- 2008, made in India), M.W 154.28

Randomized Complete Block Design (RCBD) was used with three replicates (each duplicate is composed of three trees) and random distribution of factors.

2.4 Flowering characteristics

On March, 15 and 20 in 2020 and 2021, respectively; the number of flowers panicle for each replicate was counted also, panicle length (cm) and the percentage of hermaphrodite flowers /panicle was calculated as the following equation:

$$\text{Hermaphrodite flowers (\%) per panicle} = \frac{\text{No. of perfect flowers}}{\text{Total No. of flowers}} \times 100$$

2.4.1 Fruit set percentage were recorded as follow

The number of fruit set/tree was counted after 15 days of full bloom according to the following formula:

$$\text{Fruit set (\%)} = \frac{\text{No. of retained fruits}}{\text{No. of perfect flowers}} \times 100$$

2.5 Yield and yield components:

At harvest time (September 22 and 25 in 2020 and 2021, respectively), yield (kg/tree) per each replicate was calculated by multiplying the number of fruits with average fruit weight, average fruit weight (g/ fruit) and the number of fruits/tree also, recorded.

2.5 The Chemical fruit characteristics

2.5.1 Total soluble solids (%)

The percentage of TSS was determined in mango fruit juice using a hand refract meter according to **A.O.A.C (1995).**

2.5.2 Total acidity (%)

The percentage of total acidity was colorimetrical measured based on estimated citric acid using five milliliters of the fruit juice of each fruit sample and titrated with sodium hydroxide solution of a known normality using phenolphthalein as an indicator **(A.O.A.C., 2005).** The results of these titrations were converted to percent of treatable acidity using the following equation: percent of treatable Where: 0.064= mille equivalent factor of citric acid.

2.5.3 Vitamin C (Ascorbic acid) (mg/ 100g pulp)

The ascorbic acid content of the juice was determined by titration with 2, 6 dichloro phenol-indo-phenol **(A.O.A.C., 1995)** and calculated as milli-grams per 100 ml of juice.

2.5.4 Total sugars (%)

Total sugars (%) were determined calorimetrically using phenol and sulphuric acid, according to **Malik and Singh (1980)** extracted from 5-gram fresh.

2.6 Leaf mineral compositions (N, P and K)

Samples of the third pairs of leaves from the base of none fruiting shoots were collected in mid - August in both seasons of the study. Samples of 40 leaves /tree were taken at random from the previously tagged shoots, the leaf samples were washed with tap water and distilled water then oven dried at 70°C to constant weight and then ground. To determine the leaf mineral contents, ground material of each sample was digested with H_2SO_4 and H_2O_2 according to **Wolf (1982)**. In the digested material, total nitrogen and phosphorus were determined colorimetrically (**Evenhuis and De waard, 1980; Murphy and Riley, 1962),** and potassium was determined by flame photometer as described by **Chapman and Pratt (1978)** and the concentrations of N, P and K were expressed as percent.

2.7 Statistical analysis

Results of the measured parameters were subjected to computerized statistical analysis using MSTAT package for analysis of variance (ANOVA) and means of treatments were compared using LSD at 0.05 according to **Snedecor and Cochran (1980).**

3. RESULTS AND DISCUSSION

3.1 Effect of spraying chitosan, spermidine, vermicomposting leachate and potassium silicate treatments on the number of flowering panicle, panicle length (cm), the number of hermaphrodite flowers /panicle, and hermaphrodite flowers/panicle (%) in Keitt mango cultivar during 2020 and 2021 seasons

Data presented in **Table (3)** showed that, 60ppm chitosan caused a significant increase in the number of flowering panicle and panicle length (cm) compared to the control. While, 30 ppm concentration caused a significant increase in the

number of hermaphrodite flowers/ panicle compared to the control and 60 and 90 ppm concentrations, in the meantime, significant differences were found in hermaphrodite flowers (%) between 30, 60 and 90 ppm concentrations compared to the control. In the first season, significant increase in the number of flowering panicle was found between 60ppm concentration compared to 30 ppm concentration. 30 ppm concentration caused a significant increase in hermaphrodite flowers (%) compared to 90 ppm concentration, in the first season, in one side and compared to 60 and 90 ppm concentrations in the second season, in other side.

As for spermidine in **Table (3)**, 5, 10 and 15 ppm concentrations of spermidine caused a significant increase in the number of flowering panicle, hermaphrodite flowers /panicle and hermaphrodite flowers (%) compared to the control, except for 20 ppm concentration for the number of flowering panicle in the first season. 5 ppm concentration caused a significant increase in the panicle length compared to the control, in one side and compared to 10 and 20 ppm concentrations in the number of flowering panicle, in the second side.

In **Table (3)**, 20 % concentration of VCL caused a significant increase in the number of flowering panicle compared to the control and 10 and 15 % concentrations, in the first season, in one side and compared to control and 10 % concentration for panicle length in the two seasons in the other side. In the meantime, 20% concentration caused a significant increase in panicle length (cm) compared to the control and 10% concentration, in the two seasons. 10 % concentration caused a significant increase in the number of hermaphrodite flowers /panicle compared to the control and 20 and 15% concentrations. Significant increase was found in hermaphrodite flowers (%) between 10, 15 and 20 % concentrations compared to the control. In the second season, 15 and 20 % concentrations caused a significant increase in the number of flowering panicle compared to the control and 10 % concentration.

As for potassium silicate in **Table (3)**, in the first season, 500 and 600 ppm concentrations caused a significant increase in the number of flowering panicle compared to the control and 400 ppm concentrations. While, in the second season, significant differences were found between 500 and 600 ppm treatments compared to the control. In the first season, 500 and 600 ppm concentrations caused a significant increase in the panicle length (cm) compared to the control, while significant differences were found between 600 ppm concentration compared to 400 ppm concentration.

These results are agreed with the findings of **(Kasem and Fawzy, 2020)**, they found that, the foliar application of chitosan on olive significantly promoted the shoot length, length of inflorescence as well as number of flowers rather than the control. These results might be attributed to the positive action of spraying chitosan on enhancing cell division, the biosynthesis of organic foods and uptake of nutrients. Chitosan acts also as chelators to minerals and metals, also reports to bind mycotoxins and reduces the damage of the host tissues due to toxins and it has antimicrobial properties linked thus reducing fungal spoilage **(El Hadrami*et al*., 2010).** In the same line, **Malik and Singh(2006**), found that spraying polyamine markedly enhanced fruit set, fruit retention and size of fruits, whereas, polyamines utilized to regulate fruit development to reveal the flower buds and increase their numbers **(Wolukau *et al*., 2004**). Polyamines are implicated in a wide range of plant physiological processes such as flower differentiation and initiation, pollen viability and anti-senescence (**Childs *et al.*, 2003).**

In addition, **Sathe and Patil (2014)** recorded that, VCL is a good bio-fertilizer and tonic to mango, which increased the fruit production of mango. Use VCL as a liquid fertilizer provides the advantage of homogeneity, when applied to growth media (**Quaik *et al.*, 2012; Quaik*et al.*, 2012).** The hormonal concept of flowering in mango implies that cyclic synthesis of floral stimulus in leaves and the gap between the two cycles would decide flowering behavior of mango **(Singh*et al.*, 2001** ; **Kumar and Reddy, 2008).**

Abdel Gawad (2017) reported that potassium silicate increased the number of panicles per tree. Total number of flowers per panicle, number of male flowers and number of perfect (hermaphrodite) flowers and the sex ratio significantly improved with spraying potassium silicate. Similar findings were reported by **(Singh *et al.*, 2001 ; Kumar and Reddy, 2008),** they found that spraying potassium silicate significantly accompanied with enhancing shoot length, number of leaves/ shoot and leaf area of mango trees.

Table (3): Effect of spraying chitosan, spermidine, vermicomposting leachate and potassium silicate treatments on the number of flowering panicle, panicle length (cm), the number of hermaphrodite flowers /panicle and hermaphrodite flowers/panicle (%) in keitt mango cultivar during 2020 and 2021 seasons

Treatments	Number of flowering panicle		Panicle length (cm)		Number of hermaphrodite flowers /panicle		Hermaphrodite flowers /panicle (%)	
	2020	2021	2020	2021	2020	2021	2020	2021
Control water only	339 f	338 e	32.6 d	33 c	645 f	650 d	35 f	35.3 f
Chitosan (30 ppm)	339.6 f	341.3 ecd	34.3 bcd	34.3 bc	673.3 bc	673.6 b	43 bc	43.3 b
Chitosan (60 ppm)	347.3 bcde	345.3 bcd	37 abc	36.3 ab	653 ef	651.3 cd	40.3 cde	40.6 cd
Chitosan (90 ppm)	342 ef	342 becd	35.6 abcd	35.3 abc	649.6 ef	644.6 d	39 e	39.6 de
Spermidine (5 ppm)	353.3 a	352.3 a	37.3 ab	37.6 a	695 a	696.6 a	46 a	45.6 a
Spermidine (10 ppm)	347.3 bcd	345.3 bcd	35 abcd	34.3 bc	675.3 b	673.3 b	44.6 ab	44.3 b
Spermidine (20 ppm)	343.2 def	346 bcd	34.6 bcd	34 bc	663.3 cd	664.3 bc	43.6 ab	43.3 b
Vermicomposting leachate (10 %)	339.3 f	338.3 e	34 cd	33.3 bc	667.6 bc	672.3 b	43.6 ab	43.6 b
Vermicomposting leachate (15 %)	342.6 cefd	344.3 bcd	35.3 abcd	35 abc	653 ef	651.3 cd	42.6 bc	41 c
Vermicomposting leachate (20 %)	348 b	347.3 ab	38 a	37.6 a	649.6 ef	644.6 d	39.3 de	39 e
Potassium silicate (400 ppm)	342 ef	340.3 de	34 cd	35 abc	654 def	652.6 cd	42 bcd	40.3 cd
Potassium silicate (500 ppm)	347.6 bc	344.3 bcd	37 abc	35 abc	653 ef	651.3 cd	40.3 cde	39.6 de
Potassium silicate (600 ppm)	347.3 bcd	346.3 bc	37.3 ab	35.6	656 de	654 cd	39.6 de	39.6 de

Means followed by the same letter(s) within a separate column are not significantly different at 0.05 level of probability.

.2 Effect of spraying chitosan, spermidine, and vermicomposting leachate and potassium silicate treatments on fruit set (%), number of fruits/tree, total yield (kg) /tree, fruit weight (g) in Keitt mango cultivar during 2020 and 2021 seasons

As for chitosan, the results in Table (4) showed that, in the two seasons, significant increase was found in fruit set (%), the number of fruits/tree, the total yield (kg) /tree between 30, 60 and 90 ppm concentrations compared to the control in. 30 ppm treatment caused a significant increase in fruit set compared to 60 and 90 ppm concentrations, in the second season only. Significant increase in the number of fruits/tree was found between 30 ppm treatment compared to 60 ppm and 90 ppm treatments. In the meantime, significant increase in total yield was found between 30 ppm concentration compared to 60 ppm and 90 ppm concentrations, in the first season and between 30 and 60 ppm concentrations compared to 90 ppm concentration, in the second season. Chitosan treatment at 30 ppm caused a significant increase in the fruit weight compared to the control and 60 and 90 ppm concentrations, in the first season, while in the second season, 30 and 60 ppm treatments caused a significant increase in fruit weight compared to the control.

Data in Table (4) showed that, there were statistically significant differences in fruit set (%), the number of fruits per tree and total yield between 5, 10 and 20 ppm concentrations of spermidine compared to the control. In the meantime, there was significant increase in fruit set (%) between 5 and 10 ppm concentrations compared to 20 ppm concentration, in the first season, while, 5 ppm concentration caused a significant increase in fruit set (%) compared to 10 and 20 ppm concentrations, in the second season. In the two seasons, 5 ppm concentration caused a significant increase in the fruit weight compared to the control.

The results for VCL in Table (4) showed that, in the two seasons, there were statistically significant differences in fruit set (%), the number of fruits per tree, total yield and fruit weight between 10, 15 and 20 % concentrations of VCL compared to the control, except for 15% concentration in the second season. In the meantime, in the second season, there was significant increase in fruit set (%) between 10 % concentration compared to 15 and 20 %. There were significant differences among the three concentrations in the number of fruits, in the two seasons. In the meantime, there were statistically significant increase in the total yield between 20 % compared to 10 and 15% treatments, in the first season, while, in the second season, there were significant differences among the three concentrations.

As for potassium silicate, the results in Table (4) showed that, there were significant differences between 400, 500 and 600 ppm concentrations of potassium silicate compared to the control in fruit set (%), the number of fruits per tree, total yield and fruit weight, except for 400 ppm concentration in the second season only. There were significant increase in the number of fruits per tree and total yield between 600 ppm concentration compared to 400 and 500 ppm concentrations, in the second season. 600 ppm concentration caused a significant increase in fruit weight compared to 400 ppm concentration in the two seasons.

Saied and Radwan (2017) found that spraying 'Succary' mango trees with chitosan significantly accompanied with improving the percentage of fruit retention, yield (kg) and number of fruits/tree compared to the control treatment. This may be due to the beneficial role of chitosan in stimulating the biosynthesis of natural hormones, nutrient uptake, photosynthesis, biosynthesis of plant pigments and sugars as well as protecting the plants from various stresses **(Roshdy *et al.*, 2011; Al- Wasfy , 2013; Kasem and Fawzy, 2020).**

It has been reported by many authors that application with putrescine significantly increased the yield in mango (Burondkar et al., 2009; Babu *et al.*, 2017) and in date palm (Naser *et al.*, 2016). Spraying of putrescine increased significantly fruit set %, fruit retention % and significantly reduced fruit drop percentage (**Shaban*et al.*, 2017).** Polyamines as anti aging is reported to reduce the fruit drop and increase the yield **(Ali*et al.*, 2017),** increase cell division which leading to improve weight and diameter of fruit **(Ayad *et al.*, 2011)**. The beneficial role of polyamines (phyto-hormone) due to the increase of free auxin levels in fruit petiole and inhibite ethylene production **(Malik and Singh, 2006; Dutta *et al.*, 2018**).

VCL increased disease resistance capacity in many agricultural plants against various bacterial, vital and fungal diseases and these characteristics increased vegetative growth and productivity of fruit trees by about 15% **(Suthar, 2010)**. **Sathe and Patil (2014)** mentioned that VCL is a good biofertilizers, that provide mango trees with most of the essential inputs for metabolism and growth.

It has been reported that the spraying of VCL increased significantly the number of fruits, fruit weight, pulp weight, pulp/fruit and the total yield (**Abd El–Hamied, 2018**; **Sathe and Patil, 2014). Abdel Gawad (2017)** found that the spraying of potassium silicate at different concentrations significantly gave the highest percentage of fruit set, number of fruits per tree, fruit weight and yield. Spraying mango trees with potassium silicate can overcome frost injury; improved flowering and number of panicles per shoot, sex ratio, fruit set, number of fruit per tree, fruit weight as well as yield per tree (**Habasy, 2016).**

Table (4): Effect of spraying chitosan, spermidine, vermicomposting leachate and potassium silicate treatments on fruit set (%), number of fruits/tree, total yield (kg) /tree and fruit weight (g) in Keitt mango cultivar during 2020 and 2021 seasons

Treatments	Fruit set (%)		Number of fruits/tree		Total yield (kg) /tree		Fruit weight (g)	
	2020	2021	2020	2021	2020	2021	2020	2021
Control water only	15.9 e	16.1 f	102 e	103 e	53.6 g	55.3 g	527.6 d	526 d
Chitosan (30 ppm)	17.9 abc	18.1 ab	120 b	121 b	66.6 b	64.8 d	545 abc	544.6 abc
Chitosan (60 ppm)	17.5 bcd	17.1 e	114 cd	115 c	62 de	65.3 bc	535 cd	547.6 abc
Chitosan (90 ppm)	17.5 bcd	17.4 de	115 cd	113 cd	63 cd	61.3 f	539.3 bcd	540 bcd
Spermidine (5 ppm)	18.4 a	18.6 a	128 a	127 a	70 a	71.6 a	545 abc	544.6 abc
Spermidine (10 ppm)	18 ab	18 bcd	122 b	122 b	67.6 a	66.3 a	553.6 cd	536 bcd
Spermidine (20 ppm)	17.3 cd	17.6bcde	115 cd	116 c	62.6 de	64 d	539.3 bcd	540 bcd
Vermicomposting leachate (10 %)	17.6 bcd	18 abc	113 c	114 c	62.6 f	63 e	543.6 bc	544.6 abc
Vermicomposting leachate (15 %)	17.3 bcd	17.3 e	114 cd	114 c	61 f	61.6 f	542 bc	533.6 cd
Vermicomposting leachate (20 %)	17.1 d	17.2 e	118 bc	120 b	65.6 c	64.5 bc	548.3 ab	550 ab
Potassium silicate (400 ppm)	17.4 bcd	17.5 cde	115 cd	116 c	62.3 de	63 e	541 bc	540.3 bcd
Potassium silicate (500 ppm)	17.4 bcd	17.2 e	114 cd	114 c	63.6 de	62.6 de	546.3 abc	544 abc
Potassium silicate (600 ppm)	17.2 cd	17.3 e	118 bc	120 b	65.6 de	66.8 bc	556.3 a	557.3 a

Means followed by the same letter(s) within a separate column are not significantly different at 0.05 level of probability.

3.3 Effect of spraying chitosan, spermidine, vermicomposting leachate and potassium silicate on TSS%, Total sugars %, Acidity % and Vitamin C (mg/ 100 ml)) in Keitt mango cultivar during 2020 and 2021 seasons

Data presented in Table (5) showed that, 30, 60 and 90 ppm concentrations of chitosan caused a significant increase in the TSS (%), total sugars (%) and vitamin C (mg/ 100ml) content compared to the control, except for 90 ppm concentration to TSS (%) in the second season. Significant increase was found between 30 ppm concentration compared to 60 ppm and 90 ppm, for the three properties, except for total sugars (%) in the first season. In contrast, 30, 60 and 90 ppm concentrations caused a significant decrease in fruit acidity (%) compared to the control, also significant differences were found among 30, 60 and 90 ppm concentrations.

Data presented in Table (5) showed that, 5, 10 and 20 ppm concentrations of spermidine caused a significant increase in the TSS, total sugars, acidity and vitamin C compared to the control. Significant differences were found among the three concentrations for TSS (%), in the two seasons and in vitamin C content in the first season.

The results shown in Table (5), 10 %, 15 % and 20 % of VCL caused a significant increase in fruit TSS, total sugars and vitamin C content compared to the control, except for 10% concentration to TSS, in the second season. Significant increase in fruit TSS and total sugars content was found between 20% concentration compared to 10 and 15% concentrations, while, significant differences were found among the three concentrations for vitamin C content. In contrast, 10 %, 15 % and 20 % concentrations caused a significant decrease in the fruit acidity (%) compared to the control, and significant differences were found among the three concentrations, in the two seasons.

The results shown in Table (5), 400, 500 and 600 ppm concentrations of potassium silicate caused a significant increase in fruit TSS, total sugars and vitamin C content compared to the control. In the first season, significant differences were found among the three concentrations in total sugars and vitamin C content in the two seasons and in TSS (%) in the first season and the increase in fruit vitamin C content increased by increasing the concentration of potassium silicate. In contrast, the three concentrations caused a significant decrease in fruit acidity compared to the control, also, significant decrease was found between 600 ppm concentration compared to 400 and 500 ppm concentrations.

Saied and Radwan (2017) found that applied Succary mango trees with chitosan significantly improved fruit quality as decreasing total acidity % and increasing total sugars, total soluble solids and vitamin C. **Malerba and Cerana (2016)** attributed the positive action of chitosan to induce numerous biological responses in plants such as stress resistance and increased productivity, which due to its chemical

composition, it also, encourages the absorption of minerals and increases the process of cell division and elongation, which reflected in the quality of the plant. **Guan *et al.* (2009)** reported the role of chitosan, which enhances the photosynthesis process that positively correlated with the synthesis of sugars, polysaccharides and vitamins.

Abo-El-Ez *et al.* (2019) treated mango cv. Alphonse trees with polyamine improved greatly the fruit quality, also these results are in agreement with the findings of (**Malik and Singh, 2006; Shaban *et al.*, 2017; Ali*et al.*, 2017**; **Akula Venu and Ramdevputra, 2018)**, they worked on mango. additionally, **Ayad *et al.* (2011)** mentioned that the foliar application of putrescine significantly increased fruit quality characteristics and this may be the role of putrescine which is as bio regulatory stimuli on enzymatic activity and translocation processes from leaves to fruits, linking or converting to other plant metabolites **(Serafini-Fracassini and Del Duca, 2008)**.

Abd El–Hamied (2018) cleared that VCL treatment gave the lowest total acidity and increase in the proportions of sugars and TSS. Furthermore, several studies have hypothesized those physiological mechanisms through, which humic substances exert that their effects may depend on hormones and in particular, the presence of auxin or auxinlike components in their structure**,** So VCL enhances quality of fruits (**Nardi *et al.*, 2002)**.

Habasy (2016) found a significant improve in quality of the fruits in terms of increasing vitamin C content and decreasing total acidity when, treated Navel orange trees with potassium silicate. The same results are obtained by **(El Kholy *et al.*, 2018; Lokesh *et al.* (2020).** In the meantime, **Hanumanthaiah *et al.*, (2015)** reported that application of silicon and potassium aids in synthesis of sugars in the fruit and increased TSS, this may be due to the essential roles of silicon (Si) on improving growth **(Ma, 2004)**, increasing activates of enzymes, protecting plants from aging and biosynthesis of carbohydrates (**Ma and Takahashi, 2002).**

Table (5): Effect of spraying chitosan, spermidine, vermicomposting leachate and potassium silicate on TSS%, Total sugars %, Acidity% and Vitamin C (mg/ 100 ml) in Keitt mango cultivar during 2020 and 2021 seasons

Treatments	TSS (%)		Total sugars (%)		Acidity (%)		Vitamin C (mg/ 100ml)	
	2020	2021	2020	2021	2020	2021	2020	2021
Control water only	16.6 e	17.3 ef	15.3 d	15.6d	.28 b	.31 b	33 j	35 i
Chitosan (30 ppm)	19.3 a	20 b	17 bc	18 b	.22 g	.24 f	41.4 ef	43.3 f
Chitosan (60 ppm)	18 bc	18.6 cd	16.3 c	16.6 c	.23 f	.25 d	38.6 i	40.6 h
Chitosan (90 ppm)	17.3 cd	18 de	16.3 c	16.6 c	.26 c	.28 c	38.3 i	40.3 h
Spermidine (5 ppm)	15.3 f	15.6 gh	14.3 d	14.6 g	.31 a	.33 a	44.6 d	46.6 d
Spermidine (10 ppm)	15.6 f	16 g	14.3 d	14.6 g	.31 a	.33 a	40.3 h	42.3 g
Spermidine (20 ppm)	16 f	16 g	14.3 d	14.6 g	.31 a	.33 a	41.6 ef	42.6 fg
Vermicomposting leachate (10	17.3 cd	18 de	16.6 bc	17.6 b	.21 h	.23 g	38.3 i	40.3 h
Vermicomposting leachate (15	18 bc	18.6 cd	17.3 b	18 b	.23 f	.25 e	40.6 h	43.3 f
Vermicomposting leachate (20	19.3 a	21 a	18.6 a	19.3 a	.20 i	.22 h	48.6 b	50.6 b
Potassium silicate (400 ppm)	17.3 cd	18.3 cd	16.3 c	17 bc	.21 h	.23 g	42.6 de	44.3 e
Potassium silicate (500 ppm)	18.3 b	19 c	17.3 b	17.6 b	.21 g	.23 g	45.7 c	47.6 c
Potassium silicate (600 ppm)	20 a	21.3 a	18.6 a	19.6 a	.2 i	.22 h	50 a	52 a

Means followed by the same letter(s) within a separate column are not significantly different at 0.05 level of probability.

3.4 Effect of spraying chitosan, spermidine, vermicomposting leachate and potassium silicate treatments on leaf mineral compositions from N, P and K in Keitt mango cultivar during 2020 and 2021 seasons

Data in Table (6), the application of 30, 60 and 90 ppm chitosan increased greatly the leaf nitrogen, phosphorus and potassium content compared to the control in the two seasons. At the same time, significant increase in leaf P content was found between 30 and 60 ppm concentrations compared to 90 ppm, in the two seasons, while, leaf potassium content was significantly increased with 30 ppm rather than 60 or 90 ppm in the second season.

Spraying of spermidine at 5, 10 and 20 ppm enhanced markedly the leaf content from N, P and K compared to the control. In the meantime, significant increase in leaf N content was found with 5 ppm concentration compared to 20 ppm, in the first season. The results showed also that there were significant differences in leaf P content among the three concentrations. The application of VCL at 10, 15 and 20% raised markedly the leaf

content from N, P and K content over untreated trees. Besids, the results also showed that 15 and 20% significantly differed from the application of 10 %, in the second season. In the meantime, in the first season, significant differences were found in leaf P content among the three concentrations, while, a significant increase was found between 20% concentration compared to 10 and 15% for P content, in the second season and for leaf K content, in the first season. Significant increase in leaf K content was also found between 20 % compared to 10 % concentration, in the second season. Treating mango trees with potassium silicate, at 400, 500 and 600 ppm improved statistically the leaf composition from N, P and K contents over untreated trees. Significant differences, in leaf P content, were found among the three concentrations, while 600 ppm concentration caused a significant increase in leaf K content compared to 400 and 500 ppm, in the two seasons, in one side and compared to 400 ppm concentration for leaf N content, in the second season only, in the other side.

Our obtained results are in the same line with the findings of many authors, they reported that the application of chitosan increased greatly the leaf composition from N, P and K in olive **(Kasem and Fawzy, 2020)** and mango (**Saied and Radwan, 2017)**. Additionally, these results were previously explained by **Balusamy et al. (2022),** they reported that chitosan can reduce the free radicals, promotes the antioxidants, and plays as plant growth promoters, which enhances the absorption of minerals and water through adjusting cell osmotic pressure. Polyamines can enhance the activity of metabolic processes and physiological activity (**Youssef, 2007)**. Therefore, polyamines increased photosynthesis intensity and root discharge **(Hosseini *et al.*, 2018).** Moreover, it involved N in their component, so, it acts as a source of N (**Fereshteh *et al.* (2019) and Rezvanypour*e t al.* (2016).** However, spermidine has the greatest effect on root length and root dry weight, and because P is absorbed more from the tip of the roots, spermidine treatment has the greatest effect on the amount of plant P.

Abd El–Hamied (2018) found that VCL significantly raised the leaf mineral content of mango cv. Keitt. These results may be due to that foliar spray of VCL, which can increase salt tolerance by reducing the accumulation of Na+ in the tree **(Siamak *et al.*,2017).** Also significant increase in the growth occurred on VCL treated plants could be due to the proper ratio of macro and micronutrients in the VCL (**Hatti *et al.*, 2010)** and its positive effect, which acts as plant tonic, contains elements, humic acid, fulvic acid, amino acids, vitamins, enzymes, microorganisms, actinomycetes and auxins and cytokines **(Suthar , 2010).** Spraying potassium silicate enhanced leaf N, P, and K of 'Keitt' mango trees, **(Abd El-Rahman, 2015; Abdel Gawad, 2017). Besides, Dat *et al.* (2007)** documented that potassium silicate has a beneficial influence on on 'Hindi' mango by enhancing the cell division, the biosynthesis of carbohydrates and plant pigments, and the resistance of the stress to biotic and a biotic stress.

Table (6): Effect of spraying chitosan, spermidine, and vermicomposting leachate and potassium silicate treatments on some leaf mineral compositions (N, P and K) in Keitt mango cultivar during 2020 and 2021 seasons

Treatments	Leaf nitrogen content (%)		Leaf phosphorus content (%)		Leaf potassium content(%)	
	2020	2021	2020	2021	2020	2021
Control water only	1.4 d	1.7d	.26 j	.28 g	1.2 e	1.5 f
Chitosan (30 ppm)	2.4 ab	2.6bc	.37 h	.40 e	2.1 d	2.4 d
Chitosan (60 ppm)	2.2 bc	2.5 b	.37 h	.40 e	2 d	2.1 e
Chitosan (90 ppm)	2 bc	2.5 b	.36 i	.38 f	2.1 d	2.1 e
Spermidine (5 ppm)	2.6 a	2.8ab	.41 e	.44 c	2 d	2.4 d
Spermidine (10 ppm)	2.3 ab	2.5 b	.40 f	.42 d	1.9 d	2.3 de
Spermidine (20 ppm)	2.1 bc	2.4 b	.38 g	.40 e	1.9 d	2.4 d
Vermicomposting leachate (10 %)	2.3 ab	2.6bc	.44 c	.46 b	2.4 c	2.7 c
Vermicomposting leachate (15 %)	2.4 ab	3 a	.46 b	.46 b	2.4 c	2.8 bc
Vermicomposting leachate (20 %)	2.6 a	3 a	.47 a	.50 a	3 b	3b
Potassium silicate (400 ppm)	2.3 ab	2.4 b	.41 e	.44 c	2.5 c	2.7 c
Potassium silicate (500 ppm)	2.5 ab	2.7 ab	.43 d	.46 b	2.4 c	2.8 bc
Potassium silicate (600 ppm)	2.7 a	3 a	.47 a	.50 a	3.3 a	3.3 a

Means followed by the same letter(s) within a separate column are not significantly different at 0.05 level of probability.

CONCLUSION

The application of foliar spraying spermidine, chitosan, VCL and potassium silicate increased significantly the hermaphrodite number, panicle length, fruit set, fruit yield, fruit chemicaland physical characteristics as well as leaf mineral content from NPK rather than untreated tres in 2020 and 2021 seasons. The most obvious effect was obtained by the spraying of 5 ppm spermidine, 30 ppm chitosan, 20 % VCL and 600 ppm potassium silicate comparing with the other applied treatments and control in 2020 and 2021 seasons.

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الملخص العربى

دور بعض محفزات النمو على سلوك النمو فى المانجو

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تعتبر المانجو من أهم محاصيل الفاكهة الاستوائية حيث أجريت التجربة الحالية خلال موسمي 2020–2021، بهدف دراسة تأثيربعض محفزات النموعلى سلوك النمو والحالة التغذوية والإنتاجية لأشجار المانجو صنف كيت البالغة من العمر 10 سنوات والمنزروعة في التربة الرملية بمزرعة خاصة بمدينة بدر، محافظة البحيرة ، مصر. كانت المعاملات عبارة عن استخدام ثلاث تركيزات مختلفة لكل مادة،الشيتوزان بتركيز (30و 60 و 90 جزء في المليون)،والاسبيرميدين بتركيز (5 و 10 و 20 جزء في المليون)،وراشح السماد الدودي (VLC) بتركيز(10و 15 و 20٪) وسيليكات البوتاسيوم بتركيز (400 و 500 و 600 جزء في المليون) وتم الرش أربعة مرات ، الأولى كانت قبل شهر من الإزهار ، والثانية فى بداية الإزهار ، والثالثة عند الإزهار الكامل ، والرابعة بعد ثلاثة أسابيع من العقد.أظهرت النتائج المتحصل عليها أن جميع المعاملات أدت إلى تحسن في الصفات قيد الدراسة وأعلى قيم لعدد العناقيد الزهرية (353.3 و 352.3) وعدد الازهار الخنثى (695 و 696.6) والنسبة المئوية للازهار الخنثى (46 و 45.6٪) تم الحصول على مجموعة الثمار (نسبة العقد) (18.4 و 18.6٪) وعدد الثمار على الشجرة (128 و 127) عند استحدام تركيز 5 جزءفي المليون من الاسبيرميدين على التوالي في الموسمين يلية ايضا التركيزالمنخفض (30٪) من الشيتوزان . تم الحصول على أعلى قيمة لوزن المحصول بالكيلو جرام على الشجرة بتركيز 5 جزء في المليون (70 و 71.6 كجم / الشجرة،على التوالي) و 10 جزء في المليون (67.6 و66.3 كجم / الشجرةعلى التوالي) بتركيزات الاسبرميدين ثم يلية ايضا التركيزالمنخفض (30٪) من الشيتوزان . تم الحصول على أعلى قيم لوزن الثمرة (556.3 و557.3 جم على التوالي) ومحتوى فيتامين سي (50 و 52 مجم / 100 مل عصير) ومحتوى الورقة من البوتاسيوم (3.3 و 3.3٪ على التوالي) بواسطة معاملة بتركيز 600 جزءفيالمليون من سيليكات البوتاسيوم. في غضون ذلك، تم الحصول على أعلى قيمة لمحتوى المواد الصلبة الذائبة الكلية للفاكهة (٪) و السكريات الكلية (٪) ومحتوى الورقة من النيتروجين والفسفوربواسطة سيليكات البوتاسيوم عند استخدام تركيز 600 جزءفيالمليون وراشح سماد الدود (VCL) عند تركيز 20٪. أما بالنسبة للحموضة (٪) ،فقد تم تسجيل أعلى القيم عند استخدام التراكيزات الثلاثة لمعاملةالاسبيرميدين (5 ، 10 ، 20 جزء في المليون) مقارنة بالكنترول، بينماتم الحصول على أقل القيم باستخدام أعلى تركيز لراشح سماد الدود (VCL) 20 ٪ وسيليكات البوتاسيوم (600 جزءفي المليون) (0.20 و 0.22٪) للمعاملتين على التوالي في الموسمين .لذلك أشارت النتائج إلى وجود تأثير إيجابي في تحسين التزهيرو المحصول ومكوناته والخصائص الفيزيائية والكيميائية للثمارومحتوى الأوراق المعدنية باستخدام مواد آمنة.