Effect of adding polymer, organic and chemical fertilizer and spraying with potassium silicate on traits of fruit growth and the content of chemical elements in the leaves and fruits of pepper plant, Karizma cultivar

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Abstract

The experiment was conducted in one of the fields in Al-Azzawiya area - Al-Musayyab district (40 km) north of the center of Babylon province during the spring season 2022 within longitude 44.07° and latitude 32.76°, to study the effect of adding polymer, organic and chemical fertilizer and spraying with anti-transpiration (potassium silicate) on traits of vegetative growth of pepper plant. Karizma cultivar was chosen, using anti-transpiration (potassium silicate) at three concentrations (0, 2, 4 ml. L-1) and the second factor is adding organic matter and polymers with the following parameters (F0 = organic matter (10 tons. ha-1) (vermicompost + palm fronds at a ratio of 1:1), F1 = using NPK (fertilizer recommendation), F2 = using polymer (Super Ab 200) + organic matter (10 tons. ha), F3 = use of polymer (Super Ab 200) + NPK, F4 = use of polymer (Super Ab 200) + organic matter (10 tons. ha-1) + NPK, F5 = use of polymer (Super Ab 200) + organic matter (10 tons. ha) + ½ NPK). The experiment was implemented as a 6*3 factorial experiment according to the RCBD randomized complete block design according to the split plot system such as anti-transpiration main plots and fertilization-polymer treatments sub plots. The results were as follows: The potassium silicate spraying treatment at a concentration of 2 ml. L-1 gave the highest average of 31.42 gm2. plant-1, the yield of one plant was 636.2 gm. plant-1, the total yield was 25.50 tons. ha-1, and the potassium silicate spraying treatment at a concentration of 4 ml. L-1 gave the highest average percentage of nitrogen, phosphorus and potassium in pepper leaves(3.527,0.1439, 4.182%) respectively, and gave the highest percentage of phosphorus in the fruits, which amounted to 0.1655%, and control treatment (spraying water only) gave the highest percentage of nitrogen and potassium in the fruits, which amounted to (2.929, 2.392%) respectively. The results showed that the F3 treatment (polymer + NPK) was excelled on the rest of the treatments, with a significant difference in the highest average fruit weight, which amounted to 30.83 g. plant-1, and the highest average percentage of phosphorus, which amounted to 0.1687% in the fruits. The F1 treatment (NPK fertilizer recommendation) achieved the highest average yield per plant, which amounted to 627.0 g. plant-1, and the highest average total yield, which amounted to 25.13 tons. ha-1 and treatment F5 (polymer + organic matter + 2/1 NPK) achieved the highest average phosphorus percentage of 0.1472%, while treatment F2 (polymer + organic matter) recorded the highest average potassium percentage of 4.478%. The results of the bi-interaction between spraying potassium silicate and fertilizer-polymer treatments showed significant differences in the average fruit weight, as the interaction treatment of spraying potassium silicate at a concentration of 2 ml. L-1 + F5 (polymer + organic matter + 2/1 NPK) gave the highest average fruit weight of 37.40 g. plant-1 and the highest average yield per plant of 742.2 g. plant-1 and the total yield of 29.70 tons. ha-1

The control treatment (spraying water only) + F0 (organic matter 10 tons. ha-1) gave the highest average nitrogen percentage in the leaves, reaching 4.177%. The interaction treatment spraying

ISSN 2072-3857

potassium silicate at a concentration of 4 ml. L-1 + F4 (polymer + organic matter + NPK) gave the highest average phosphorus percentage in the leaves, reaching 0.1698%. The interaction treatment (spraying water only) + F3 (polymer + NPK) recorded the highest average nitrogen percentage, reaching 3.320%. The interaction treatment spraying potassium silicate at a concentration of 4 ml. L-1 + F4 (polymer + organic matter + NPK) gave the highest average phosphorus percentage, reaching 0.1928%

Introduction

Sweet pepper Capsicum annuum L. is an annual herbaceous plant of the Solanaceae family, native to Central and South America. Globally, sweet pepper is considered an economically important plant, grown in 116 countries around the world, with Asian countries covering 0.59% of the total cultivated area worldwide. It is the third most important crop in terms of economic importance after tomatoes and potatoes, and is one of the five most widely distributed and widespread species in the United States [10]. Pepper is grown for its fruits that are eaten fresh or cooked and is used in the food industry to add color, aroma and flavor. [6]. Organic matter is a good source of supplying plants with the necessary nutrients for growth, in addition to improving porosity, regulating water and air movement, gas exchange, increasing the soil's ability to retain water, increasing cation exchange capacity (CEC), and reducing soil pH [3]. Organic matter is also one of the most important natural components that have an impact on fertility, composition, and components due to the influence of microorganism activity [10]. Chemical fertilization is one of the necessary fertilizers for developing and increasing production in arid and semi-arid areas. One of the important things in this field is the availability of the nutrients required by the plant in appropriate quantities so that they are not limiting for production. Feeding with major nutrients is very important because it improves and accelerates the growth of fruit seedlings. Nitrogen is one of the basic nutrients that the plant needs, as it accelerates and stimulates the vegetative growth of the plant, and the most common way to provide it is [2.[

Recently, some researchers have become increasingly interested in using polymers in many applications, especially agricultural ones. Given the abundance of polymers in Iraq and their low prices, in addition to the small amount required to be added to the soil, we have been led to use super-absorbent polymers to improve some physical properties of the soil [5]Super-absorbent polymers are characterized by their ability to absorb very large amounts of water compared to their weight, and to retain this water and release it when needed, thus protecting water from deep seepage, which reduces the loss of nutrients and contributes to increasing the efficiency of water and fertilizer use [7]. It is also necessary to clarify the techniques used to withstand high temperatures, the most important of which are anti-transpiration, which are biodegradable compounds on the surface of leaves to reduce transpiration and partially close the stomata, including potassium silicate, which are chemical compounds that control the movement of the stomata and prevent complete opening. the research aims to study the effect of adding polymer, organic and chemical fertilizers, and spraying with

ISSN 2072-3857

antitranspirants (potassium silicate) on the vegetative growth characteristics of pepper plants.

Materials and methods

The experiment was carried out in one of the fields in the Al-Azzawiyah area - Al-Musayyab district (40 km) north of the center of Babylon Governorate during the spring agricultural season of 2022 within longitude 44.07° and latitude 32.76°, to study the effect of adding polymer, organic and chemical fertilizers, and spraying with Anti-transpiration (potassium silicate) on the vegetative growth characteristics of pepper plants. The variety Charisma was chosen.

Land preparation and service operations:

The land designated for agriculture was prepared after removing the plants The growing bushes were then ploughed, smoothed and leveled well and homogeneously in a perpendicular manner. Samples were taken from the field soil before planting randomly and from different areas at depths ranging from the soil surface to 30 cm. They were then air dried, ground and passed through a sieve with a 2 mm diameter and analyzed to determine some chemical and physical properties of the field soil. The analysis results are shown in Table (1). The land was divided into three replicates, with each replicate including 18 experimental units. The number of plants in the experimental unit was 14 plants. The distance between one plant and another was 50 cm. They were planted on both sides of the terrace, as the area of the experimental unit was 3.5 m (3.5 x 1 m). The distance between one terrace and another was 1 m, leaving a distance of 1 m between the experimental units as an insulator to prevent mixing between the treatments, leaving an insulating distance at the beginning and end of each sector. A drip irrigation system was used in the process of watering the plants. Organic fertilizer palm frond waste and vermicompost (1:1) were added before planting the seedlings and were added to all experimental units during land preparation for planting and mixed well and homogeneously with the soil .

Table 1 Physical and chemical properties of field soil before planting*

values	**units**	traits
7.52	**---**	Soil pH
3.0	**$Ds.m^{-1}$**	Electrical Conductivity
1.15	**%**	Organic Matter
13.4	**$mg.kg^{-1}$**	Nitrogen Available
2.53		Phosphorus Available
128.87		Potassium Available
1.13	**$g.cm^{-3}$**	Bulk Density
200	**$g.kg^{-1}$**	Sand
560		Silt
240		Clay

*

ISSN 2072-3857

The analysis was conducted in the Graduate Studies Laboratory, College of Agriculture - Al-Qasim Green University

Study factors:- The study includes two factors-:

The first factor-:

Use of antitranspirants (potassium silicate) in three concentrations (0,2 ,4 ml. L-1) and the spraying process was repeated at a rate of four sprays between one spray and another (15) days and the date of the sprays was (1/5, 15/5, 1/6, 15/6 /2023) until complete wetting, and the spraying process was carried out in the early morning with the addition of a few drops of (liquid soap) as a spreading material and to break the surface tension of the water during spraying the solution and according to the concentrations

The second factor:- Includes adding organic matter and polymers to the soil as follows-:

F0 = Organic matter (10 tons. Hectare) (Vermicompost + palm fronds at a ratio of 1:1(

1F = Use of NPK (fertilizer recommendation(

F2 = Use of polymer (Super Ab 200) + organic matter (10 tons. ha-1(

F3 = Use of polymer (Super Ab 200) + NPK

F4 = Use of polymer (Super Ab 200) + organic matter (10 tons. ha-1) + NPK

F5 = Use of polymer (Super Ab 200) + organic matter (10 tons. ha-1) + ½ NPK

Organic fertilizer was added before planting, while chemical fertilizer was divided into two stages, the first before planting and the second before flowering.

Experimental design-:

The experiment was implemented as a 6*3 factorial experiment according to the complete randomized block design (RCBD) according to the split plot system such as Antitranspirants main plots and fertilization treatments - polymer sub plots.

Traits studied:

Studied traits

Fruit weight (g/fruit-1(

According to the average by dividing the total yield by the total number of fruits in each experimental unit.

Yield per plant (g. plant-1(

According to the cumulative yield of the experimental unit plants from the beginning of harvesting to the last harvest, and divided by the number of plants in the experimental unit as follows:

Yield per plant = Yield of the experimental unit and all harvests / Number of plants from which fruits were taken

Total yield (ton ha-1(

According to the total yield of each experimental unit starting from the first harvest until the last harvest cumulatively for all harvests and continuing throughout the plant growth period, which is nine harvests starting from 5/25/2022 to 8/25/2022, based on the number of plants in the hectare multiplied by the cumulative yield of one plant for the eight harvests, and according to the following equation:

Total yield (ton ha-1) = Yield per plant/1000000 × Number of plants in the hectare, noting that productivity was calculated considering that the total number of plants in the hectare is 40,000 plants hectare-1 .

Estimation of chemical nutrients in leaves and fruits

Estimation of NPK in leaves and fruits

The percentage of nutrients (NPK) in leaves and fruits was estimated by taking a part of the fully grown leaves and fruits amounting to 100 g, then washing them well, then cutting them and air drying them inside a room for a period of time and placing them inside perforated

ISSN 2072-3857

paper envelopes, then placing them in an electric oven at a temperature of 68 °C until the weight was stable, then grinding them and placing them in tightly sealed plastic containers and storing them in a dry place until the elements in them were estimated (Al-Sahaf, 1989). After that, 0.2 g of the powder of the dry ground plant sample was weighed and then placed in Pyrex flasks and digested by adding 5 ml of concentrated sulfuric acid and 3 ml of concentrated perchloric acid, then placed on a hot plate. After the digestion process was completed and the color turned transparent, the flasks were lifted, then left to cool, and then The sample was transferred to a 50 ml volumetric flask and the solution was completed with 50 ml of distilled water. The elements were then estimated according to the method mentioned in [12]. The elements were estimated as follows:

Nitrogen content in leaves and fruits (%) Micro Kjeldahl device) According to the method mentioned in [9.[

Potassium content in leaves and fruits (%) The percentage of leaves in the digested sample was estimated according to the method [8] using a Flame Photometer.

Phosphorus content in leaves and fruits (%) was estimated according to the method in [1[

Results and discussion

Fruit weight (g. plant-1(

The results of Table 2 show that there are significant differences between the concentrations of potassium silicate spray in the average fruit weight, as the potassium silicate spray treatment at a concentration of 2 ml gave. The highest average of 31.42 gm2. plant-1 was recorded by the treatment of potassium silicate spraying at a concentration of 4 ml. L-1, followed by a significant difference in the average fruit weight of 27.22 gm. plant-1, while control treatment (spraying water only) recorded the lowest average fruit weight of 26.31 gm. plant-1. The results of the same table also indicate that there are significant differences between the addition of fertilizer-polymer treatments in the average fruit weight. The results showed that the F3 treatment (polymer + NPK) was excelled on the rest of the treatments, with a significant difference in the highest average fruit weight of 30.83 gm. plant-1, followed by the F1 treatment (NPK fertilizer recommendation) with an average of 29.10 gm. plant-1, while the F4 treatment (polymer + organic matter + NPK) recorded the lowest average fruit weight with the rest of the treatments, as well as the F0 treatment (organic matter 10 tons. ha-1) with an average of 26.57 gm. Plant-1 The results of the bi-interaction in Table 7 between spraying potassium silicate and fertilizer-polymer treatments showed significant differences in the average fruit weight, as the interaction treatment of spraying potassium silicate at a concentration of 2 ml. L-1 + F5 (polymer + organic matter + 2/1 NPK) gave the highest average fruit weight of 37.40 g. Plant-1, followed by the interaction treatment of spraying potassium silicate at a concentration of 2 ml. L-1 + F3 (polymer + NPK) with an average of 34.17 g. Plant-1, while the treatment of spraying potassium silicate at a concentration of 4 ml. L-1 + F5 (polymer + organic matter + 2/1 NPK) recorded the lowest average fruit weight of 19.73 g. Plant-1 .

ISSN 2072-3857

Table 2: Effect of spraying potassium silicate and fertilizer-polymer treatments and their interaction on the fruit weight of pepper (g. fruit-1(

average concentration	Fertilizer treatments – polymer*						concentration K_2SiO_3
	F5	F4	F3	F2	F1	F0	
26.31 b	26.30 fg	22.37 h	29.60 cde	27.07 efg	27.70 Defg	24.80 Gh	0
31.42 a	37.40 a	29.93 cde	34.17 b	27.40 defg	30.17 cd	29.43 cde	2ml. L^{-1}
27.22 b	19.73 i	27.40 defg	28.73 def	32.10 bc	29.43 cde	25.90 fg	4ml. L^{-1}
	27.81 bc	26.57 c	30.83 a	28.86 b	29.10 b	26.71 C	average treatments

*Means with the same letter within the same factor or the interaction have no significant differences at the 0.05 probability level under Duncan's multiple range test
F0 = Organic matter (10 tons.ha(
F1 = Use of NPK (fertilizer recommendation(
F2 = Use of polymer (Super Ab 200) + organic matter (10 tons.ha(
F3 = Use of polymer (Super Ab 200) + NPK
F4 = Use of polymer (Super Ab 200) + organic matter (10 tons.ha) + NPK
F5 = Use of polymer (Super Ab 200) + organic matter (10 tons.ha) + 1/2 NPK

Plant yield (g. plant-1(

The results of Table 3 show that there are significant differences between the concentrations of potassium silicate spraying in the average plant yield, as spraying potassium silicate at a concentration of 2 ml gave. The highest average was 636.2 g.plant-1, followed by a significant difference in the potassium silicate spray treatment at a concentration of 4 ml.L-1 with an average of 553.9 g.plant-1, while control treatment (spraying water only) recorded the lowest average yield per plant of 545.8 g.plant-1. The results of the same table also indicate that there are significant differences between the addition of fertilizer-polymer treatments in the average yield per plant, as the F1 treatment (NPK fertilizer recommendation) achieved the highest average yield per plant of 627.0 g.plant-1, which differed significantly from the rest of the treatments except for the F3 treatment (polymer + NPK) with an average of 617.6 g.plant-1, while the F4 treatment (polymer + organic matter + NPK) recorded the lowest average yield per plant. The results of the bi-interaction in Table 10 between spraying potassium silicate and fertilizer-polymer treatments show significant differences in the average yield of one plant, as the interaction treatment of spraying potassium silicate at a concentration of 2 ml. L-1 + F5 (polymer + organic matter + 2/1

NPK) gave the highest average yield of one plant, reaching 742.2 g. plant-1, followed by the treatment of spraying potassium silicate at a concentration of 4 ml. L-1 + F1 (recommended NPK fertilizer) with an average of 676.6 g. plant-1, while the interaction treatment of spraying potassium silicate at a concentration of 4 ml. L-1 + F5 (polymer + organic matter + 2/1 NPK) recorded the lowest average yield of one plant, which reached 362.2 g. plant-1 .

Table 3: Effect of spraying potassium silicate and fertilizer-polymer treatments and their interaction on pepper plant yield (g. plant-1(

average concentration	Fertilizer treatments – polymer*						concentration K_2SiO_3
	F5	F4	F3	F2	F1	F0	
545.8 b	549.4 ef	434.4 gh	602.1 bcdef	556.4 def	598.3 bcdef	534.2 ef	0
636.2 a	742.2 a	591.3 cdef	693.9 ab	526.2 fg	606.0 bcdef	657.3 abcd	2ml. L-1
553.9 b	362.2 h	578.3 cdef	556.7 def	631.0 bcde	676.6 abc	518.5 fg	4ml. L-1
	551.3 c	534.6 c	617.6 ab	571.2 bc	627.0 a	570.0 bc	average treatments

*Means with the same letter within one factor or overlap have no significant difference at the 0.05 probability level under Duncan's multiple range test

F0 = Organic matter (10 tons.ha(

F1 = Use of NPK (fertilizer recommendation(

F2 = Use of polymer (Super Ab 200) + organic matter (10 tons.ha(

F3 = Use of polymer (Super Ab 200) + NPK

F4 = Use of polymer (Super Ab 200) + organic matter (10 tons.ha) + NPK

F5 = Use of polymer (Super Ab 200) + organic matter (10 tons.ha) + 2/1 NPK

Total yield (ton.ha-1(

The results of Table 4 show that there are significant differences between spraying with potassium silicate in the average total yield, as the treatment of spraying potassium silicate at a concentration of 2 ml gave. The highest average of 25.50 tons. ha-1 was followed by a significant difference by the potassium silicate spray treatment at a concentration of 4 ml. l-1 with an average of 22.19 tons. ha-1, which did not differ significantly with control treatment (spraying water only), which recorded the lowest average total yield of 21.88 tons. ha-1. The results of the same table also indicate that there are significant differences between the addition of fertilizer-polymer treatments in the average total yield, as treatment F1 (NPK fertilizer recommendation) achieved the highest average total yield of 25.13 tons. ha-1,

ISSN 2072-3857

which did not differ significantly from treatment F3 (polymer + NPK), but it differed significantly with the rest of the treatments, while treatment F4 (polymer + organic matter + NPK) recorded the lowest average total yield with a difference of 21.43 tons. ha-1. The results of the bi-interaction in Table 11 between spraying with potassium silicate and fertilizer-polymer treatments show significant differences in the average total yield, as the interaction treatment of spraying with potassium silicate at a concentration of 2 ml. L-1 + 5F (polymer + organic matter + 2/1 NPK) gave the highest average in the total yield, reaching 29.70 tons. ha-1, followed by the treatment of spraying with potassium silicate at a concentration of 2 ml. L-1 + F3 (polymer + NPK) with an average of 27.80 tons. ha-1, while the treatment of spraying with potassium silicate at a concentration of 4 ml. L-1 + F5 (polymer + organic matter + 2/1 NPK) recorded the lowest average, which reached 14.53 tons. ha-1 .

Table 4: Effect of spraying with potassium silicate and fertilizer-polymer treatments and their interaction on the total yield of the plant (ton. ha-1(

average concentration	**Fertilizer treatments – polymer***						**concentration K_2SiO_3**
	F5	**F4**	**F3**	**F2**	**F1**	**F0**	
21.88 b	**22.00 ef**	**17.43 gh**	**24.13 bcdef**	**22.30 def**	**24.03 bcdef**	**21.40 ef**	**0**
25.50 a	**29.70 a**	**23.73 bcdef**	**27.80 ab**	**21.10 fg**	**24.27 bcdef**	**26.40 abcd**	**2ml. L-1**
22.19 b	**14.53 h**	**23.13 cdef**	**22.30 def**	**25.30 bcde**	**27.10 abc**	**20.77 fg**	**4ml. L-1**
	22.08 c	**21.43 c**	**24.74 ab**	**22.90 bc**	**25.13 a**	**22.86 bc**	**average treatments**

*Means with the same letter within one factor or overlap have no significant difference at the 0.05 probability level under Duncan's multiple range test

F0 = Organic matter (ton. ha-1(

F1 = Use of NPK (fertilizer recommendation(

F2 = Use of polymer (Super Ab 200) + organic matter (ton. ha-1(

F3 = Use of polymer (Super Ab 200) + NPK

F4 = Use of polymer (Super Ab 200) + organic matter (ton. ha-1) + NPK

F5 = Use of polymer (Super Ab 200) + organic matter (ton. ha-1) + 2/1 NPK

Nitrogen percentage in pepper leaves(%)

The results of Table 5 show significant differences between the concentrations of potassium silicate spraying in the average percentage of nitrogen in the leaves, as the potassium silicate spraying treatment gave a concentration of 4 ml. L-1 had the highest average of 3.527%, followed by control treatment (spraying water only) with an average of 3.297% without any significant difference, while the potassium silicate spray treatment at a concentration of 2 ml. L-1 recorded the lowest average nitrogen percentage of 3.121%. The results of the same table also indicate that there are significant differences between the addition of fertilizer-polymer treatments in the average nitrogen percentage in the leaves, as the F0 treatment (organic matter 10 tons. ha-1) achieved the highest average nitrogen percentage of 3.707%, which did not differ significantly from the F1 treatment (NPK fertilizer recommendation), F4 (polymer + organic matter + NPK) and F5 (polymer + organic matter + 2/1 NPK), while the F2 treatment (polymer + organic matter) recorded the lowest average nitrogen percentage of 3.020%. The results of the bi-interaction in Table 13 between spraying with potassium silicate and fertilizer-polymer treatments showed significant differences in the average nitrogen percentage. The controt treatment (spraying water only) + F0 (organic matter 10 tons. ha-1) gave the highest average nitrogen percentage of 4.177%, followed by the treatment of spraying with potassium silicate at a concentration of 4 ml. L-1 + F0 (organic matter 10 tons. ha-1) with an average of 4.000%, while control treatment (spraying water only) + F2 (polymer + organic matter) recorded the lowest average of 2.433% .

Table 5: Effect of spraying with potassium silicate and fertilizer-polymer treatments and their interaction on the nitrogen percentage in leaves(%)

average concentration	Fertilizer treatments – polymer*						concentration K_2SiO_3
	F5	F4	F3	F2	F1	F0	
3.297 ab	3.417 bcd	3.290 bcd	3.377 bcd	2.433 e	3.087 cde	4.177 a	0
3.121 b	3.367 bcd	3.477 abcd	2.843 de	2.873 de	3.223 bcd	2.943 de	2ml. L-1
3.527 a	3.183 cde	3.250 bcd	3.110 cde	3.753 abc	3.863 Abc	4.000 ab	4ml. L-1
	3.322 ab	3.339 ab	3.110 b	3.020 b	3.391 ab	3.707 a	average treatments

*Means with the same letter within one factor or overlap have no significant difference at the 0.05 probability level under Duncan's multiple range test

F0 = Organic matter (10 tons.ha(

F1 = Use of NPK (fertilizer recommendation(

F2 = Use of polymer (Super Ab 200) + organic matter (10 tons.ha(

F3 = Use of polymer (Super Ab 200) + NPK

F4 = Use of polymer (Super Ab 200) + organic matter (10 tons.ha) + NPK

Phosphorus percentage in leaves

The results of Table 6 show that there are significant differences between the concentrations of potassium silicate spray in the average percentage of phosphorus in leaves, as the potassium silicate spray treatment at a concentration of 4 ml gave. L-1 had the highest average of 0.1439%, followed by a significant difference in the potassium silicate spray treatment at a concentration of 2 ml. L-1 with an average of 0.1258%, while control treatment (spraying water only) recorded the lowest average of phosphorus percentage of 0.1189%. The results of the same table also indicate that there are significant differences between the addition of fertilizer treatments in the average percentage of phosphorus in the leaves, as treatment F5 (polymer + organic matter + 2/1 NPK) achieved the highest average percentage of phosphorus, reaching 0.1472%, which did not differ significantly from treatment F0 (organic matter 10 tons. ha-1) with an average of 0.1349% and treatment F1 (recommended fertilizer NPK) with an average of 0.1312% and treatment F4 (polymer + organic matter + NPK) with an average of 0.1370%, while treatment F2 (polymer + organic matter) recorded the lowest average percentage of phosphorus with an average of 0.1117%. The results of the bi-interaction in Table 14 between spraying with potassium silicate and fertilizer-polymer treatments show significant differences in the average percentage of phosphorus, as the interaction treatment gave a spray of potassium silicate at a concentration of 4 ml. L-1 + F4 (polymer + organic matter + NPK) had the highest average phosphorus percentage of 0.1698%, followed by the potassium silicate spray treatment at a concentration of 4 ml. L-1 + F5 (polymer + organic matter + 2/1 NPK) with an average of 0.1567%, while the potassium silicate spray treatment at a concentration of 2 ml. L-1 + F3 (polymer + NPK) recorded the lowest average of 0.0958% .

Table 6: Effect of spraying with potassium silicate and fertilizer-polymer treatments and their interaction on the percentage of phosphorus in leaves(%)

average concentration	**Fertilizer treatments – polymer***						**concentration K_2SiO_3**
	F5	**F4**	**F3**	**F2**	**F1**	**F0**	
0.1189 b	**0.1471 abc**	**0.1080 cd**	**0.1161 bcd**	**0.1079 cd**	**0.1103 bcd**	**0.1239 abcd**	**0**
0.1258 b	**0.1377 abcd**	**0.1333 abcd**	**0.0958 d**	**0.1196 bcd**	**0.1380 abcd**	**0.1304 abcd**	**2ml. L-1**
0.1439 a	**0.1567 ab**	**0.1698 a**	**0.1338 abcd**	**0.1077 cd**	**0.1454 abc**	**0.1503 abc**	**4ml. L-1**
	0.1472 a	**0.1370 ab**	**0.1152 b**	**0.1117 b**	**0.1312 ab**	**0.1349 ab**	**average treatments**

ISSN 2072-3857

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Means with the same letter within one factor or overlap have no significant difference at the 0.05 probability level under Duncan's multiple range test

F0 = Organic matter (10 tons.ha(

F1 = Use of NPK (fertilizer recommendation(

F2 = Use of polymer (Super Ab 200) + organic matter (10 tons.ha(

F3 = Use of polymer (Super Ab 200) + NPK

F4 = Use of polymer (Super Ab 200) + organic matter (10 tons.ha) + NPK

F5 = Use of polymer (Super Ab 200) + organic matter (10 tons.ha) + 1/2 NPK

Percentage of potassium in pepper leaves(%)

The results of Table 7 show that there are no significant differences between the concentrations of potassium silicate spray in the average percentage of potassium in the leaves, as the potassium silicate spray treatment gave a concentration of 4 ml. L-1 had the highest average of 4.182%, followed by the potassium silicate spray treatment with a concentration of 2 ml liter-1 without significant difference. with an average of 4.048%, while control treatment (spraying water only) recorded the lowest average potassium percentage of 3.915%. The results of the same table also indicate that there are significant differences between the addition of fertilizer-polymer treatments in the average potassium percentage, as treatment F2 (polymer + organic matter) achieved the highest average potassium percentage of 4.478%, which did not differ significantly from treatment F0 (organic matter 10 tons. ha-1) and F3 (polymer + NPK) and F5 (polymer + organic matter + 2/1 NPK) with an average of 4.095, 4.159 and 4.119%, respectively, while it differed significantly from treatment F4 (polymer + organic matter + NPK) with an average of 3.806%, while treatment F1 (NPK fertilizer recommendation) recorded the lowest average potassium percentage in the leaves and with a significant difference with the rest of the treatments except treatment F0 (organic matter 10 t.h-1) and F2 (polymer + organic matter) and F3 (polymer + NPK) reached 3.632%.

The results of the bi-interaction in Table 15 between spraying with potassium silicate and fertilizer-polymer treatments also showed significant differences in the average potassium percentage in the leaves, as the controt treatment (spraying water only) + F5 (polymer + organic matter + 2/1 NPK) gave the highest average potassium percentage of 4.997%, followed by the treatment of spraying potassium silicate at a concentration of 4 ml. L-1 + F0 (organic matter 10 t.h-1) with an average of 4.967%, while control treatment (spraying water only) + F1 (recommended NPK fertilizer) recorded the lowest average of 3.131%.

ISSN 2072-3857

Table 7: Effect of spraying with potassium silicate and fertilizer-polymer treatments and their interaction on potassium in the leaves(%)

average concentration	Fertilizer treatments – polymer*						concentration K_2SiO_3
	F5	F4	F3	F2	F1	F0	
3.915 a	4.997 a	3.422 ef	4.270 abcde	4.167 abcde	3.131 f	3.505 def	0
4.048 a	3.674 cdef	3.646 cdef	4.213 abcde	4.814 ab	4.125 abcde	3.814 cdef	2ml. L-1
4.182 a	3.685 cdef	4.351 abcd	3.994 bcdef	4.454 abc	3.638 cdef	4.967 a	4ml. L-1
	4.119 abc	3.806 bc	4.159 ab	4.478 a	3.632 c	4.095 abc	average treatments

*Means with the same letter within one factor or overlap have no significant difference at the 0.05 probability level under Duncan's multiple range test

F0 = Organic matter (10 tons.ha(

F1 = Use of NPK (fertilizer recommendation(

F2 = Use of polymer (Super Ab 200) + organic matter (10 tons.ha(

F3 = Use of polymer (Super Ab 200) + NPK

F4 = Use of polymer (Super Ab 200) + organic matter (10 tons.ha) + NPK

F5 = Use of polymer (Super Ab 200) + organic matter (10 tons.ha) + 1/2 NPK

Nitrogen percentage in fruits

The results of Table 7 show significant differences between the concentrations of potassium silicate spraying in the average percentage of nitrogen in fruits, as control treatment (spraying water only) gave the highest average of 2.929%, followed by a significant difference by the spraying treatment Potassium silicate at a concentration of 4 ml. L-1 averaged 2.691%, while the potassium silicate spray treatment at a concentration of 2 ml. L-1 recorded the lowest average nitrogen percentage of 2.638%. The results of the same table also indicate that there are significant differences between the addition of fertilizer-polymer treatments in the average nitrogen percentage in the fruits, as the F0 treatment (10 tons. ha-1 organic matter) achieved the highest average nitrogen percentage of 2.960%, which did not differ significantly from the rest of the treatments except for the F1 treatment (NPK fertilizer recommendation), which recorded the lowest average nitrogen percentage of 2.548%. The results of the bi-interaction in Table 7 between spraying with potassium silicate and fertilizer-polymer treatments show significant differences in the average nitrogen percentage, as the interaction treatment (spraying water only) + F3 (polymer + NPK) gave the highest average nitrogen percentage of 3.320%, followed by the treatment of spraying potassium silicate at a concentration of 2 ml.

ISSN 2072-3857

L-1 + F2 (polymer + organic matter) with an average of 2.997%, while the treatment of spraying potassium silicate at a concentration of 4 ml. L-1 + F1 (recommended NPK fertilizer) recorded the lowest average of 2.363% .

Table 8: Effect of spraying with potassium silicate and fertilizer-polymer treatments and their interaction on the nitrogen percentage of pepper fruits(%)

average concentration	Fertilizer treatments – polymer*						concentration K_2SiO_3
	F5	F4	F3	F2	F1	F0	
2.929 a	2.930 abc	2.927 abc	3.320 a	2.493 c	2.703 abc	3.203 ab	0
2.638 b	2.433 c	2.603 bc	2.827 abc	2.997 abc	2.577 bc	2.390 C	2ml. L-1
2.691 b	2.447 c	2.890 abc	2.650 abc	2.507 c	2.363 c	3.287 A	4ml. L-1
	2.603 ab	2.807 ab	2.932 a	2.666 ab	2.548 b	2.960 a	average treatments

*Means with the same letter within one factor or overlap have no significant difference at the 0.05 probability level under Duncan's multiple range test
F0 = Organic matter (10 tons.ha(
F1 = Use of NPK (fertilizer recommendation(
F2 = Use of polymer (Super Ab 200) + organic matter (10 tons.ha(
F3 = Use of polymer (Super Ab 200) + NPK
F4 = Use of polymer (Super Ab 200) + organic matter (10 tons.ha) + NPK

Phosphorus percentage in fruits

The results of Table 8 show that there are significant differences between the concentrations of potassium silicate spraying in the average percentage of phosphorus in fruits, as the potassium silicate spraying treatment at a concentration of 4 ml gave. The highest average of 0.1655% was followed by the potassium silicate spray treatment with a concentration of 2 ml. L-1 with an average of 0.1604%, while control treatment (water spray only) recorded the lowest average of phosphorus percentage with a significant difference with the potassium silicate spray treatment with a concentration of 4 ml. L-1, which reached 0.1521%. The results of the same table also indicate that there are significant differences between the addition of fertilizer treatments in the average percentage of phosphorus in the leaves, as the F3 treatment (polymer + NPK) achieved the highest average percentage of phosphorus, which reached 0.1687%, which did not differ significantly from the rest of the treatments except for the F0 treatment (organic matter 10 tons. ha-1), which recorded the lowest average percentage of phosphorus, with an average of 0.1497%. The results of the bi-interaction in

Table 8 between spraying with potassium silicate and fertilizer-polymer treatments show significant differences in the average percentage of phosphorus, as the interaction treatment of spraying potassium silicate at a concentration of 4 ml. L-1 + F4 (polymer + organic matter + NPK) gave the highest average percentage of phosphorus, reaching 0.1928%, followed by the treatment of spraying potassium silicate at a concentration of 2 ml. L-1 + F2 (polymer + organic matter) with an average of 0.1837%, while the treatment of spraying potassium silicate at a concentration of 2 ml. L-1 + F0 (organic matter 10 tons. ha-1) recorded the lowest average, which reached 0.1263% .

Table 8: Effect of spraying with potassium silicate and fertilizer-polymer treatments and their interaction on the percentage of phosphorus in pepper fruits(%)

average concentration	Fertilizer treatments – polymer*						concentration K_2SiO_3
	F5	F4	F3	F2	F1	F0	
0.1521 b	0.1687 abcde	0.1358 fg	0.1569 bcdef	0.1407 efg	0.1689 abcde	0.1413 efg	0
0.1604 ab	0.1678 abcde	0.1565 bcdefg	0.1762 abc	0.1837 ab	0.1522 cdefg	0.1263 g	2ml. L-1
0.1655 a	0.1575 bcdef	0.1928 a	0.1730 abcd	0.1452 defg	0.1430 defg	0.1815 abc	4ml. L-1
	0.1647 ab	0.1617 ab	0.1687 a	0.1565 ab	0.1547 ab	0.1497 b	average treatments

*

Means with the same letter within one factor or overlap have no significant difference at the 0.05 probability level under Duncan's multiple range test

F0 = Organic matter (10 tons.ha(

F1 = Use of NPK (fertilizer recommendation(

F2 = Use of polymer (Super Ab 200) + organic matter (10 tons.ha(

F3 = Use of polymer (Super Ab 200) + NPK

F4 = Use of polymer (Super Ab 200) + organic matter (10 tons.ha) + NPK

F5 = Use of polymer (Super Ab 200) + organic matter (10 tons.ha) + 1/2 NPK

Potassium percentage in fruits

The results of Table 9 show significant differences between the concentrations of potassium silicate spraying in the average percentage of potassium in fruits, and control treatment (spraying water only) gave the highest average of 2.392%, followed by the treatment of spraying potassium silicate at a concentration of 4 ml. L-1 with an average of 2.263%, while the potassium silicate spray treatment with a concentration of 2 ml. L-1 recorded the lowest average potassium

ISSN 2072-3857

percentage of 2.057%, and the results of the same table indicate that there are no significant differences between the addition of fertilizer-polymer treatments in the average potassium percentage.

The results of the bi-interaction in Table 9 between spraying with potassium silicate and fertilizer-polymer treatments show significant differences in the average potassium percentage in the fruits, as the interaction treatment (spraying water only) + F5 (polymer + organic matter + 2/1 NPK) gave the highest average potassium percentage of 2.608%, followed by the potassium silicate spray treatment with a concentration of 4 ml. L-1 + F4 (polymer + organic matter + NPK) with an average of 2.556%, while the potassium silicate spray treatment with a concentration of 2 ml. L-1 + F3 (polymer + NPK) recorded the lowest average of 1.803%.

Table 9: Effect of spraying with potassium silicate, fertilizer-polymer treatments and their interaction on the potassium content of pepper fruits(%)

average concentration	**Fertilizer treatments – polymer***						**concentration K_2SiO_3**
	F5	**F4**	**F3**	**F2**	**F1**	**F0**	
2.392 a	**2.608 a**	**2.475 abc**	**2.558 ab**	**2.016 cde**	**2.252 abcde**	**2.443 abcd**	**0**
2.057 b	**2.053 bcde**	**1.929 de**	**1.803 e**	**2.151 abcde**	**2.202 abcde**	**2.206 abcde**	**2ml. L-1**
2.263 a	**2.218 abcde**	**2.556 ab**	**2.212 abcde**	**2.296 abcde**	**2.234 abcde**	**2.061 bcde**	**4ml. L-1**
	2.293 a	**2.320 a**	**2.191 a**	**2.154 a**	**2.230 a**	**2.237 a**	**average treatments**

*Means with the same letter within one factor or overlap have no significant difference between them at the probability level of 0.05 within Duncan's multiple range test

F0 = Organic matter (10 tons.ha(

F1 = Use of NPK (fertilizer recommendation(

F2 = Use of polymer (Super Ab 200) + organic matter (10 tons.ha(

F3 = Use of polymer (Super Ab 200) + NPK

F4 = Use of polymer (Super Ab 200) + organic matter (10 tons.ha) + NPK

F5 = Use of polymer (Super Ab 200) + organic matter (10 tons.ha) + 2/1 NPK

As for the effect of spraying with potassium silicate on the yield indicators and chemical characteristics of pepper plants, a significant superiority is observed in most quantitative yield indicators. This superiority is due to the fact that the silicon element plays an effective role in improving and regulating the nutritional balance in the plant, as it works to stimulate and store water within the plant tissues, which allows for a rate of Higher growth and positively reflected in the significant increase in the yield in the sweet pepper plant, silicon also increases the photosynthesis process and the composition of important organelles in plant cells, which leads to increased effectiveness of the roots to absorb important mineral elements. The silicon sources that are usually used to improve plant growth and increase their production are formed in several forms, including potassium silicate (K_2SiO_3) [7] Or the reason may be attributed to the effect of potassium in increasing the yield and its role in improving plant growth and encouraging the absorption of nitrogen and phosphorus and achieving more suitable conditions to improve the nutritional balance and thus increase the vital activities within the plant and increase the vegetative group, which was positively reflected in the yield. These results were consistent with what was obtained [2]. The increase in the effectiveness of enzymes in the leaves as a result of spraying potassium silicate may be due to the fact that selenium acts as a cofactor for many enzymes, and it is believed that it enters instead of sulfur in the rest of the antioxidants containing sulfur as a cofactor, as selenium has an atomic radius equal to the radius of the sulfur atom [3[

Or the reason may be attributed to the increase in the concentration of potassium in the leaves of plants, which in turn leads to the preparation and provision of all the needs of the plant for this element, thus increasing the absorption of this element and increasing its concentration in plant tissues, and this indicates that the addition of potassium silicate caused an increase in the concentration of ready nutrients in the soil, and then increased their absorption by the plant. It increased the content of pepper fruits of chemical compounds including carbohydrates, protein, vitamin C and the percentage of dissolved solids, and also increased the absorption of nitrogen, phosphorus, and potassium in the leaves and fruits, and the formation of an efficient root system, which in turn led to an increase in the manufactured materials and their transfer to the fruits and then improved the quality of the fruits, and these results came with what was reached by[2,4,11] and selenium has a significant effect in increasing nutrients in the leaves, as the reason for this is its role in increasing the rate of vegetative growth and leaf area, which improves the growth of the root system and thus increases the absorption area of nutrients in the growth medium [5.[

The reason may be attributed to the role of organic fertilizers in improving plant metabolism and growth as a result of the ability of the major and minor nutrients included in its composition, Table (2 and 3), which work in an interconnected manner to improve the growth of the various parts of the plant by contributing to the construction of basic compounds and thus increasing carbohydrates and proteins in the leaves [8.[

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ISSN 2072-3857