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EFFECT OF THE FERTILIZER TYPE ON THE GROWTH AND YIELD OF TWO TOMATO HYBRIDS

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ABSTRACT

A field experiment was conducted at the research station of the College of Agricultural Engineering, University of Baghdad, to study of N.P.K nanoscale and conventional fertilizer on the growth and yield traits improving of two tomato hybrids during the summer season 2019, according to Nested design. The experiment consisted of two factors, the first were Shams and the GS-12 hybrids, which were approved by the Iraqi Ministry of Agriculture, it has a symbol (V1 and V2), the second factor involves the use of N.P.K nanoparticles fertilizer with three levels (50%, 100%, 150% of the fertilizer recommendation), symbol (N1, N2, and N3) respectively, and N.P.K Traditional fertilizer with 3 levels (50%, 100%, 150% of the fertilizer recommendation), symbols (F1, F2, and F3) respectively, in addition to the comparison treatment (T0) with three replicates. The results showed that the Shams hybrid was significantly superior to the GS-12 hybrid, on most traits vegetative growth (plant height, number of leaves and leaf area), and the fruiting characteristics (the fruits number, the fruits weight, plant yield, and the total yield), the values were recorded as 104.10 cm, 99.85 leaves, 195.38 dm^{-2}, 2,22.05 fruits. $vegetable^{-1}$, 100.05 g, 2.28 kg. $Plant^{-1}$,87.60 ton. ha^{-1}, respectively, compared to the GS-12 hybrid, recorded 82.71 cm, 88.31 leaves, 167.79 dm^{-2}, and 19.76 fruits. $vegetable^{-1}$, 95.71 g, 2.02 kg. $plant^{-1}$, 77.60 ton. ha^{-1}, respectively. The results also showed that the combination of N3 was significantly superior, on most of the traits of vegetative and fruiting growth, which included plant height, number of leaves, leaf area, leaf content of chlorophyll, number of fruits, fruit weight, plant yield and total yield, the values were recorded at 111.67 cm, 125.35 leaves, 259.46 dm^{-2}, 64.97 SPAD, 30.33 fruits, 117.33 g, 3.64 kg. $plant^{-1}$, 139.80 ton. ha^{-1}, respectively, with an increase of 63.13%, 49.86%, 30.89%, 66.36%, 48%, 62%, 31% and 30%, respectively, compare with the comparison, were recorded 70.50 cm, 62.50 leaves, 80.16 dm^{-2}, 43.12 SPAD, 14.83 fruits, 73.50 g, 1.13 kg. $plant^{-1}$, 43.30 ton. ha^{-1}, respectively. The results showed the interaction between hybrids and fertilization, the treatment of N3V1 was significantly superior in most indicators of vegetative and fruiting growth, which included a plant height (127.33 cm), the number of branches (18.67), the number of leaf (132.00 leaves), the leaf area (284.00 dm^{-2}), chlorophyll content of the leaf (66.00 SPAD), dry weight of the vegetative (254.00 g), dry weight of the root total (35.67), the number of fruits (122.33 fruits), the weight of the fruits (122.33 g), the plant yield (4.03 kg. $Plant^{-1}$), the total yield (154.90 ton. ha^{-1}), respectively. Compared with T0V2, the values were recorded as 63.33 cm, 3.00 branches, 58.00 leaves, 72.33 dm^{-2},111.67 g, 12.67 g, 42.20 SPAD, 14.33 fruits, 70..00 g, 1.07 kg. $plant^{-1}$, 41.20 $ton.ha^{-1}$, respectively.

***Keywords* :** Tomato, N.P.K., nano fertilizer, traditional fertilizer.

Introduction

Tomato (*Solanum lycopersicum* L.) is a major vegetable crop, belongs to the Solanaceae family, high nutritional value, the fruits contain nutrients such as potassium, a number of acids such as ascorbic (vitamin C), citric, malic, vitamins such as vitamin E and some phenolic compounds, contains some pigments such as carotene and lycopene (Gerszberg *et al*., 2015), not considered the richest vegetable, however, consuming in large quantities gives priority in the nutrients and vitamins they give (Al-Mandalawi, 2002). The reality of soils in Iraq indicates a lack of ready-made nutrients in the soil, to increase the demand for the tomato crop, which was a stressful crop for the soil, responds to fertilization, consumes large amounts of fertilizer, therefore, it is necessary to provide nutrients throughout growth period, hence the importance of adding chemical fertilizers in batches during the growing season (Habib, 2014). Most plants consume large amounts of nutrients (N, P, and K), for the obtaining large production and good quality purpose, however, the rational use of fertilizers, leads to getting harmful to plants by increasing the vegetative growth of the plant and reducing yield, quality and disease, in addition to negative effects on the environment, soil and groundwater pollution (White *et al*., 2007), in the past few years, some researchers have tried to study the possibilities of using nanotechnology to improve the efficiency of fertilizer use, these efforts led to the design and development of nanofertilizers, were fertilizer a type made from organic and mineral materials, compatible with the environment and plants, it has a role in increasing nutrient efficiency, reducing soil toxicity and ill-advising use of mineral fertilizers (Naderi and Shahraki, 2011).

It was more effective and efficient than traditional fertilizers, because of positive effects on the quality of food crops and the lack of added quantities and costs, rapid absorption by the roots, penetration into cells, transport and representation within plant tissues (Morales-Diaz *et al*., 2017 and Singh *et al*., 2017), the genetic hybrids of tomato vary in their response to fertilization, to choose the appropriate genetic crosses, determining the level of fertilization is important in obtaining a higher and better quality yield (Habib, 2014). The study aims to determine hybrids and the type of fertilizer on the growth and yield improving of two tomato hybrids in open cultivation.

Materials and Methods

The experiment was conducted at one of the fields of the Faculty of Agricultural Engineering Sciences, University of Baghdad, Jadriya Station B, during the spring agricultural season 2019, under open cultivation conditions

The experiment was carried out as a factor experiment (7×2) and with three replicates, according to the Nested Design, as the distribution of hybrids was the main factor, fertilizers were included in the secondary factor, a hybrid approved by the Ministry of Agriculture was Hybrid Tomato Shams with symbol V1, the GS-12 hybrid, symbol, V2, and the dominance of limited growth hybrids.

The nanocomposite fertilizer N.P.K. (20:20:20) was used, with the following concentrations of 50, 100 and 150% of the fertilizer recommendation according to the recommendation of the producing company, which ranges from (8-15) kg. ha^{-1}, as the rate was chosen for the company's recommendation 11.50 kg. ha^{-1}, the fertilizer was added in three equal batches, the first batch was added after a month of seedlings, added the two batches after twenty days between one and another, in addition, the N.P.K. compound regular fertilizer was used, at the following concentrations 50, 100 and 150% of the recommended fertilizer 160: 160: 200 kg. ha^{-1} (Al-Abdi, 2010), Dab fertilizer was used as a source of (nitrogen and phosphorous), the nitrogen was supplemented with urea fertilizer, and use potassium sulfate fertilizer as a source of potassium, the fertilizer was added in three equal batches, the first batch was added after a month of seedlings, and added the two batches after twenty days between one and another.

Traits studied

Vegetative traits: a sample of five plants was taken randomly from each experimental unit and according to the rate:

Plant height (cm): It was measured from the area of contact of the stem with the soil to the growing apex of the longest branch of the plant by metric tape and for (5) plants.

The leaves number (leaf. $Plant^{-1}$): The total number of leaves in the plant was calculated for five plants, then the rate was extracted.

Leaf area (dm^{-2}. $plant^{-1}$): The leaf area was calculated on the basis of dry weight, as 30 leaf disks of known size were taken, dry until the stability of weight and five plants from each experimental unit in an electric oven (Oven) at a temperature of 70 °C and from the total dry weight of the leaves of the plants, the leaf area was calculated by the following formula:

Leaf area (dm^2) = leaf area of disks x total dry weight of leaves of the plant / dry weight of disks.

Leaf chlorophyll content determination (SPAD): The chlorophyll percentage in tomato leaves was determined, using SBAD 10 days after adding the last batch of fertilizers, the reading was taken from 6 plants per experimental unit, leaves were mature and full-sized at most physiological activity are selected, the mean was then taken with a chlorophlmeter and measured in units of SPAD (Jemison and Williams, 2006).

Fruits traits:

The fruits number (fruit. $plant^{-1}$): The number of fruits of the experimental unit was calculated cumulatively from the beginning of reap until the end of the season up to (8) reaps, was divided by the number of plants of the experimental unit.

The fruit weight (g. $fruit^{-1}$): Take the cumulative reaps sum, divide on total weight by the cumulative number of fruits.

The plant yield (kg. $Plant^{-1}$): It was calculated by taking the cumulative experimental unit yield and dividing on the number of plants and recording the rate.

Total yield (ton. ha^{-1}): The sum of the experimental unit was calculated from the cumulative sum of the reaps yield until the end of the season, then the total yield was calculated on the basis of the yield of the experimental unit (tons) multiplied by the number of experimental units per hectare, according to the following formula:

Total yield (ton. ha^{-1})= quotient of the experimental unit (tons) x hectare area (m^2) / area of the experimental unit (m^2)

Results and Discussion

Plant length (cm. $plant^{-1}$):

Table (1) indicates that a significant superiority of the V1 hybrid, with the highest plant length (104.10 cm. $Plant^{-1}$), compared to the V2 hybrid (82.71 cm. $Plant^{-1}$), the treatment of N3 nanofertilizers was also superior at the highest plant height (111.67 cm. $Plant^{-1}$), compare with comparison, T0 (70.50 cm. $Plant^{-1}$), as for the interaction between hybrids and fertilization, the N3V1 treatment was superior to the highest plant height (127.33 cm. $Plant^{-1}$), compared with T0V2, gave the minimum length (63.33 cm. $Plant^{-1}$).

Leaves number of (leaf. $Plant^{-1}$):

Table (2) indicated that there were significant differences between hybrids, outperformed the hybrid V1 with the highest number of leaves (99.85 leaf. $Plant^{-1}$), compared to the V2 hybrid (88.31 leaf. $Plant^{-1}$), fertilization treatments showed a significant effect, the treatment of N3 nanofertilizer outperformed with the highest number of leaves (125.35 leaf. $Plant^{-1}$), compared to the comparison treatment T0, which gave the lowest number of leaves (62.50 leaf. $Plant^{-1}$. As for the interaction between hybrids and fertilization, the treatment of N3 V1 was significantly higher, with the highest number of leaves (132.00 leaf. $Plant^{-1}$) compared with T0 V2, the minimum number of leaves (58.00 leaf. $Plant^{-1}$).

Leaf area (dm^2. $plant^{-1}$)

Table (3) show that there were significant differences between hybrids, outperformed the V1 hybrid with the highest leaf area (195.38 dm^2. $Plant^{-1}$), compared to the V2 hybrid (167.79 dm^2. $Plant^{-1}$), fertilization treatments showed a significant effect, the treatment of N3 nanofertilizer outperformed with the highest leaf area (259.46 dm^2. $Plant^{-1}$) compared with the comparison treatment T0, gave the least leaf area (80.16 dm^2. $Plant^{-1}$), the interaction between hybrids and fertilization was significantly superior to the treatment of N3V1 with the highest leaf area (284.00 dm^2. $Plant^{-1}$), compared with T0V2 treatment, gave the least leaf area (72.33 dm^2. $Plant^{-1}$), it was found that increasing the level of added fertilizer had a significant effect on increasing leaf area for both hybrids.

Leaf chlorophyll content determination (SPAD)

Table (4) indicated that there was no significant difference between hybrids, the interaction between fertilization treatments and hybrids did not show significant differences, while fertilization treatments showed significant differences, the treatment of nanofertilization exceeded N3, with the highest value (64.97 SPAD), compare with the comparison, the comparison treatment gave the lowest value (43.12 SPAD).

The reason may be attributed to the addition of nanofertilizers, especially nitrogen fertilizers, which have an effect on increasing the activity of the meristematic peaks, increase cell division and elongation, as a result of increasing the concentration of auxins or the readiness of basic materials, needed by plants in the building process such as amino acids and some enzymatic adjuvants such as NAD and NADP, which enters the element nitrogen in its composition, or due to the efficiency of nutrient absorption in addition to the increase in plant height in Table 3, and thus the number of leaves increases (Taiz and Zeiger, 2006).

The nitrogen fertilizer stimulates the plant to produce IAA, which release the process of cell division and elongation, as well as the role of nitrogen in increasing the production of gibberellins, act to elongate cells, thus an increase in plant height or the role of nitrogen in increasing chlorophyll synthesis, thus increasing the frequency of photosynthesis, and the production of proteins of great importance in stimulating plant growth (Al-Muhammad. 2011).

As the number of leaves increases the green surface that blocks the sun, thus increasing the photosynthesis process and products reflected positively on growth, or, may be attributed to added phosphorous, as it activates the carbon representation process, through its inclusion in the synthesis of the enzymatic conjugates NADP and NAD and the energy-rich compounds such as ATP important in the process of carbonization (Habib, 2014; Al-Maamouri, 2020).

This can also be attributed to the addition of potassium, which is one of the essential elements for plant growth and development, it has an important role in transmitting the products of carbon representation, thus an increase in plant height, or, may be due to the different response of hybrids and interaction with different environmental factors (Habib, 2014; Al-Shami, 2019; Al-Maamouri, 2020).

The increase, which occurred in the chlorophyll content of SPAD tomato leaves, to the f nitrogen in the synthesis of porphyrins, involved in building the chlorophyll pigment molecule, or due to nitrogen activation of the process of building protein and nucleic acids, led to increased division of green plastids and increased chlorophyll pigments in the cell (Al-Muhammad, 2011). Chlorophyll is considered mainly in the process of photosynthesis and responsible for the process of making food in plant leaves (Havlin *et al.*, 2005), the effect increases as the level of added fertilizer increases, the addition of nano fertilizers leads to an increase in the availability of ready-made nutrients to the plant for a longer period and liberally commensurate with the stages of plant growth, which leads to an increase in the formation of chlorophyll and thus an increase in the rate of photosynthesis, and improving the overall plant growth (Al-Shami, 2019; Al-Maamouri, 2020).

Fruits traits:

Fruits number (fruit. $Plant^{-1}$):

Table (5) indicated that the hybrid V1 was significantly superior, with the highest number of fruits (22.05 fruit. $Plant^{-1}$), compared to the V2 hybrid, which gave the least number of fruits (19.76 fruits. $Plant^{-1}$), the treatment of N3 nanofertilization was also significantly superior, with the highest number of fruits (30.33 fruit. $Plant^{-1}$), the interaction between hybrides and fertilization also had a significant effect, the treatment exceeded N3V1 with the highest number of fruits (33.00 fruit. $Plant^{-1}$), compared to the treatment T0V2, which gave the lowest values for the number of fruits (14.33 fruit. $Plant^{-1}$).

Fruit weight (g. $Fruit^{-1}$):

Table (6) show that there were no significant differences between hybrids on the weight of the fruit, while fertilization treatments had a significant effect, the treatment of nanofertilization N3 was significantly exceeded with the highest fruit weight (117.33 g. $fruit^{-1}$), compared with the comparison treatment T0, which gave the lowest fruit weight (73.50 g. $fruit^{-1}$), the interaction between hybrids and fertilization also had a significant effect on fruit weight (122.33 g. $fruit^{-1}$), compare with comparison with the lowest fruit weight obtained at treatment T V2 (70.00 g. $fruit^{-1}$).

Plant yield (kg. $plant^{-1}$)

Table (7) indicated that the V1 hybrid was significantly superior, with the highest plant yield value (2.28 kg. $plant^{-1}$), compared to the V2 hybrid (2.02 kg. $plant^{-1}$), the treatment of N3 nanofertilization was also significantly superior, with the highest plant yield (3.64 kg. $plant^{-1}$), the interaction between hybrid and fertilization also had a significant effect, the treatment increased N3V1, with the highest plant yield (4.03 kg. $plant^{-1}$), compared to the treatment T0V2, which gave the lowest value (1.07 kg. $plant^{-1}$).

Total yield (ton. ha^{-1}):

Table (8) indicated that the V1 hybrid was significantly outperformed with the highest total yield value (ton. ha^{-1}), compared to the V2 hybrid (77.60 ton. ha^{-1}), the treatment of N3 nanofertilization was also significantly superior, with the highest total yield (139.80 ton. ha^{-1}), the interaction between the hybrid and fertilization also had a significant effect, as the treatment exceeded N3V1 with the highest total yield (154.90 ton. ha^{-1}), compared to the treatment T0V2, which gave the lowest value (41.20 ton. ha^{-1}), it is noticed from Table (8) that there were significant differences between the parameters in the total yield per unit area of tomato crop.

The reason for the increased number of fruits may be attributed to the effect of the added fertilizer treatments, leads to an increase in the process of carbon representation after increasing the indicators of vegetative growth in tables (1, 2, 3, 4), this positive effect continued until the end of the season, led to an increase in the number of fruits (Amara, 2004; Ibrahim *et al.*, 2015; Al-Fahdawi, 2019).

The reason may be attributed to added fertilizers and the availability of important nutrients, for the occurrence of good nutrition and to increase the efficiency of vital processes, especially in the manufacture of carbohydrates, proteins, vitamins and fats, regularity of transmission and storage in fruits, led to an increase in the number of fruits (Table 5), and increase the plant yield, increasing the average weight of the fruit and thus increasing the yield of one plant (Shams Allah, 2007).

This is an indication of the plant's good nutritional status, as a result of added nano fertilizers and increasing the readiness and absorption of the necessary elements, reflected in the physiological processes in the plant, such as the formation of carbonate and the formation of proteins and sugars, reflected in the overall outcome (Wahab *et al*., 2016; Al-Fahdawi, 2019), the addition of phosphorus is important in organizing vital processes, release to root growth, vegetative growth and early ripening is important in flowering and fruiting processes (Al-Mandalawi, 2002), the availability of potassium during the fruiting stage was important and essential for converting the processed materials in the leaves into fruits, to complete composition and fullness and thus increase the weight of the fruit, the reason may also be attributed to the genetic nature of hybrids (Amara, 2004).

Table 1 : The effect of added nanofertilizers, conventional and hybrid fertilizers and interaction on plant height (cm. Plant^{-1}) of tomato plants during the spring season 2019.

Hybrid (V)	Treatment (T)							Hybrid mean
	C	N1	N2	N3	F1	F2	F3	
V1	77.67	108.67	113.33	127.33	88.67	98.33	114.67	104.10
V2	63.33	89.67	91.33	96.00	72.00	77.33	89.33	82.71
L.S.D$_{0.05}$	Hybrid		Treatment		Hybrid × Treatment			
	1.26		3.92		5.20			
Treatment mean	70.50	99.17	102.33	111.67	80.33	87.83	102.00	

Table 2 : The effect of added nanofertilizers, conventional and hybrid fertilizers and interaction on leaf number (leaf. Plant^{-1}) of tomato plants during the spring season 2019.

Hybrid (V)	Treatment (T)							Hybrid mean
	C	N1	N2	N3	F1	F2	F3	
V1	67.00	93.67	118.33	132.00	77.67	98.00	112.33	99.85
V2	58.00	77.33	97.66	118.70	72.50	89.33	104.66	88.31
L.S.D$_{0.05}$	Hybrid		Treatment		Hybrid × Treatment			
	2.91		2.01		3.46			
Treatment mean	62.50	85.50	107.99	125.35	75.08	93.66	108.49	

Table 3 : The effect of added nanofertilizers, conventional and hybrid fertilizers and interaction on leaf area (dm^2. Plant^{-1}) of tomato plants during the spring season 2019.

Hybrid (V)	Treatment (T)							Hybrid mean
	C	N1	N2	N3	F1	F2	F3	
V1	88.00	204.33	255.00	284.00	134.33	189.00	213.00	195.38
V2	72.33	178.10	198.30	234.93	120.93	178.00	192.00	167.79
L.S.D$_{0.05}$	Hybrid		Treatment		Hybrid × Treatment			
	1.67		2.74		3.77			
Treatment mean	80.16	191.21	226.65	259.46	127.63	183.50	202.50	

Table 4 : The effect of added nanofertilizers, conventional and hybrid fertilizers and interaction on Leaf chlorophyll content determination (SPAD) of tomato plants during the spring season 2019.

Hybrid (V)	Treatment (T)							Hybrid mean
	C	N1	N2	N3	F1	F2	F3	
V1	44.03	56.43	60.00	66.47	46.60	55.07	60.47	55.58
V2	42.20	56.13	58.77	63.47	49.67	55.90	58.00	54.88
L.S.D$_{0.05}$	Hybrid		Treatment		Hybrid × Treatment			
	N.S		2.07		N.S			
Treatment mean	43.12	56.28	59.38	64.97	48.13	55.48	59.23	

Table 5 : The effect of added nanofertilizers, conventional and hybrid fertilizers and interaction on fruit number (fruit. Plant^{-1}) of tomato plants during the spring season 2019.

Hybrid (V)	Treatment (T)							Hybrid mean
	C	N1	N2	N3	F1	F2	F3	
V1	15.33	20.67	25.00	33.00	16.00	20.33	24.00	22.05
V2	14.33	16.67	23.33	27.67	18.00	17.33	21.00	19.76
$L.S.D_{0.05}$	Hybrid		Treatment		Hybrid × Treatment			
	1.84		1.90		2.82			
Treatment mean	14.83	18.67	24.17	30.33	17.00	18.83	22.50	

Table 6 : The effect of added nanofertilizers, conventional and hybrid fertilizers and interaction on fruit weigh (g. fruit^{-1}) of tomato plants during the spring season 2019.

Hybrid (V)	Treatment (T)							Hybrid mean
	C	N1	N2	N3	F1	F2	F3	
V1	77.00	102.00	112.67	122.33	89.00	96.67	103.67	100.05
V2	70.00	100.00	106.00	112.33	89.67	93.67	98.33	95.71
$L.S.D_{0.05}$	Hybrid		Treatment		Hybrid × Treatment			
	N.S		3.61		5.71			
Treatment mean	73.50	101.00	109.33	117.33	89.33	95.17	101	

Table 7 : The effect of added nanofertilizers, conventional and hybrid fertilizers and interaction on plant yield (kg. plant^{-1}) of tomato plants during the spring season 2019.

Hybrid (V)	Treatment (T)							Hybrid mean
	C	N1	N2	N3	F1	F2	F3	
V1	1.18	2.11	2.82	4.03	1.42	1.90	2.49	2.28
V2	1.07	1.70	2.47	3.25	1.62	1.79	2.25	2.02
$L.S.D_{0.05}$	Hybrid		Treatment		Hybrid × Treatment			
	0.22		0.21		0.32			
Treatment mean	1.13	1.90	2.65	3.64	1.52	1.85	2.37	

Table 8 : The effect of added nanofertilizers, conventional and hybrid fertilizers and interaction on total yield (ton. ha^{-1}) of tomato plants during the spring season 2019.

Hybrid (V)	Treatment (T)							Hybrid mean
	C	N1	N2	N3	F1	F2	F3	
V1	45.40	80.90	108.30	154.90	54.70	73.40	95.70	87.60
V2	41.20	65.30	94.90	124.70	62.10	68.30	86.50	77.60
$L.S.D_{0.05}$	Hybrid		Treatment		Hybrid × Treatment			
	8.49		7.98		12.18			
Treatment mean	43.30	73.10	101.60	139.80	58.40	70.80	91.10	

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