Plant Archives Vol. 20, Supplement 1, 2020 pp. 38-43 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

EFFECT OF THE METHOD AND LEVEL OF ADDING NPK NANOPARTICLES AND MINERAL FERTILIZERS ON THE GROWTH AND YIELD OF YELLOW CORN AND THE CONTENT OF MINERAL NUTRIENT OF SOME PLANT PARTS

Ahmed Jassim Kazem AL-Gym and Maher Hameed Salman Al-Asady
College of Agriculture, Al-Qasim Green University, Iraq

Abstract

A field experiment was conducted during the autumn agricultural season of 2018 in Shomali district, 68 km southeast of Hilla city, within 32.18 degrees north latitude and 44.18 degrees east longitude, during autumn season 2018. To know the effect of NPK (20:20:20) nanoparticle and mineral fertilizer adding methods and fertilizer levels on the growth and productivity of corn *Zea mays* L., The experiment was conducted according to the Complete Randomized Blocks Design with three replications. the averages were compared according to Duncan polynomial test at a probability level of 0.05%.The results showed the following: The spraying treatment with NPK nanoparticles ($1.5g.L^{-1}$ 7.5 $kg.ha^{-1}$) mixing with soil was significantly excelled in vegetative growth and yield by giving the highest mean in plant height (191.2 cm), the total number of leaves (16.07 $leaves.plant^{-1}$), The leaves area index (0.391), plant content of total chlorophyll (60.17 SPAD), number of grains per cop (632.7 $grains.cob^{-1}$), weight of 500 grains (186.7 g), grain yield (11.38 tones. ha^{-1}) and biological yield (23.07 $Ton.ha^{-1}$. The spraying treatment with NPK nanoparticles 1.5 $g.L^{-1}$ + 7.5 $kg.ha^{-1}$ mixing with soil achieved significantly increased and recorded the highest averages in root content of nutrients (N, P, K) amounted to 0.412, 0.143 and 0.427 g. Leaves 5.712, 1.088 and 4.397 $g.plant-^{1}$, respectively, and the absorption rate of these elements amounted to 38.39, 7.73 and 30.19 $mg.plant-^{1}$ and the transfer rate of those elements above which amounted to 35.85, 6.85 and 27.56 g .plant. Day $^{-1}$ respectively.

Keyword **:** *Zea mays* L, NPK nanoparticles ,mineral fertilizers

Introduction

Corn is one of the important strategic crops in Iraq and the world, and It ranks third order after the wheat and rice crops in the cultivated area and productivity, Corn has many uses, which are directly or indirectly in human food, and used as an essential ingredient in animal feed and diets, in addition to nutritious, medicinal, and other industrial purposes, so it is known as the queen of grain crops (Bukhsh *et al.*, 2010). The productivity of grain crops, including corn, is greatly influenced by the availability and abundance of the essential nutrients NPK necessary for plant growth and production. Nitrogen is the main component of protein and protoplasm that has a Biologically role in increasing plant biomass (Meharg and Marschner, 2012). the lack of supplying the plant with nitrogen leads to reduces plant size and disrupts many bio-functions (Muchow and Davis, 1988). Phosphorus is the second largest nutrient identified for crop production after nitrogen, and crop response to nitrogen is influenced by plant phosphorus availability (Goulding *et al.*, 2008). It is directly involved in many physiological processes such as photosynthesis, cell division, grain formation, production of energy compounds, nucleic acids and protein, stimulating root growth and promoting crop growth (Havlin *et al.*, 2005). Potassium plays an essential role in the effectiveness of enzymes, photosynthesis, osmotic regulation, protein synthesis, stomatal closing and opening mechanism, ion balance, energy transfer and stress resistance in the plant (Marschner, 2011). The adding of mineral fertilizer NPK is necessary to increase the growth and yield of corn, but the traditional method, in adding, do not without problems, The use of mineral fertilizers continuously and rapidly decomposition and loss of quantities of nutrients through volatilization or washing and filtration or converted into complex compounds, It cannot be used by the plant. It is also harmful to soil and the environment as it leads to increased soil acidity, nutrient imbalance and groundwater pollution (Stewar *et al.*, 2005). Therefore, it is necessary to use the best modern methods and techniques to supply the plant with nutrients. These techniques are the technique of using nano fertilizers, including balanced NPK nano fertilizer and adding them either by spraying the total vegetative or mixing it with the soil or using them together. Nanotechnology can provide the solution to increasing the value of agricultural products and environmental problems by using fertilizers with nanoparticles with sizes (1-100 nanometers). Thus we can control the release of mineral elements added as fertilizers, The basis of the work of nano fertilizers is the rapid supply of nutrients and increase the duration of the fertilizer effect. Nanotechnology has a significant impact on improving the solubility of other soil elements, displacing and replacing insoluble elements, reducing nutrient mineralization, increasing bioavailability and Easily absorbed by the plant (Naderi and Danesh-Shahraki, 2013).

Materials and Methods

A field experiment was conducted during the autumn agricultural season of 2018 in Shomali district, 68 km southeast of Hilla city, within 32.18 degrees north latitude and 44.18 degrees east longitude, To know the effect of NPK (20:20:20) nanoparticle and mineral fertilizer adding methods and fertilizer levels on some growth indicators of growth and yield of corn and the content of some plant parts of nutrients N, P, K and measure the rates of absorption and transfer of those elements for the corn crop(cultivar Furat). Soils sample were randomly taken and analyzed for some physical and chemical traits as shown in Table (1).

Table 1: Some physical and chemical traits of field soils

Unit	Value	Traits
sandy silt loam	322.4 $g.k^{-1}$	sand
	447.4 $g.k^{-1}$	Silt
	230.2 $g.k^{-1}$	Clay
$g.k^{-1}$	1.86	Organic matter
$mg.k^{-1}$	68.32	Nitrogen availability
$mg.k^{-1}$	10.28	phosphorus availability
$mg.k^{-1}$	204	Potassium availability
$ds.m^{-1}$	1.15	EC
-	7.10	pH

Table 2 : The treatments of the experiment and the method of applying them

Treatments	
Control (add distilled water only)	T1
Spraying NPK nano fertilizers ($2 g.L^{-1}$)	T2
Spraying NPK nano fertilizers ($3 g.L^{-1}$)	T3
Spraying NPK mineral fertilizers ($1.5 L.ha^{-1}$)	T4
Spraying NPK mineral fertilizers ($3 L.ha^{-1}$)	T5
Mixing NPK nano fertilizers with soil ($8 kg.ha^{-1}$)	T6
Mixing NPK nano fertilizers with soil ($15 kg.ha^{-1}$)	T7
Mixing NPK mineral fertilizers with soil ($200 kg.ha^{-1}$)	T8
Mixing NPK mineral fertilizers with soil ($400 kg.ha^{-1}$)	T9
Nano- fertilizers (sprayed $1 g.L^{-1}$ + Mixing with soil $4 kg.ha^{-1}$)	T10
Nano- fertilizers (sprayed $1.5 g.L^{-1}$ + Mixing with soil $7.5 kg.ha^{-1}$)	T11
Mineral-fertilizers (sprayed $0.75 L.ha^{-1}$ + Mixing with soil $100 kg.ha^{-1}$)	T12
Mineral-fertilizers (sprayed $1.5 L.ha^{-1}$ + Mixing with soil $200 kg.ha^{-1}$)	T13

The growth indicators, yield, nitrogen and phosphorus were measured according to Cresser and Parsons (1979) and potassium according to Horneck and Hanson (1998).The absorption rates of the elements (N, P, K) were estimated according to Williams equation (1948).

$$\text{Im} = \frac{\text{In}\, W_2 - \text{In}\, W_1}{T_2 - T_1} \times \frac{M_2 - M_1}{W_2 - W_1}$$

Where :

Im = absorption rate of the element during the duration (T1, T2)

W1 = initial weight of dry roots in grams at time T1

W2 = final weight of dry roots in grams at time T2

M1 = initial element content (for root and vegetative groups) at time T1

M2 = final element content (for root and vegetative groups) at time T2

T = Time is calculated by days

In=Natural Logarithm

The transport rates for the elements (N, P, K) were estimated according to the equation (Robson *et al.*, 1970).

$$\bar{v} = \frac{\text{In}\, W_2 - \text{In}\, W_1}{T_2 - T_1} \times \frac{M_2 - M_1}{W_2 - W_1}$$

Levels of NPK (20:20:20) nanoparticles and levels of NPK (20:20:20) mineral fertilizer were added to the soil of the experimental units requiring mixing with the soil according to the experimental treatments. The NPK (20:20:20) liquid mineral fertilizer 20 BIO was used and the experimental unit included four lines for the cultivation distance between one line and another 75 cm and the distance between one plant and another 25 cm so that the plant density is 53333 With 64 plants per experimental unit. Urea fertilizer containing 46% nitrogen was added at the level of 176 $kg.\ ha^{-1}$, In two batches, the first batch after 14 days of cultivation and the second batch after 30 days of cultivation per treatments, The experiment included several treatments for adding methods of NPK nanoparticles and mineral fertilizers as shown in Table 2. The field was divided into three equal sections and then divide each sector into 13 experimental units, the area of each experimental unit is 12 m^2 with dimensions of 4×3 m, left intervals between the experimental units up to 0.5 m. The treatments were randomly distributed within each sector and according to the Complete Randomized Blocks Design with three replications. Data collected from field and laboratory experimental measurements were analyzed according to the ANOVA table and the averages were compared according to Duncan polynomial test at a probability level of 0.05 using the ready statistical analysis program V.12 Genstat. AL-Asady, 2019).

Results and Discussion

Traits of vegetative growth

The treatment (T11) achieved a significant increase and recorded the highest averages in plant height, The number of leaves in the plant, leaves area index and the leaves content of chlorophyll amounted 191.2 cm and 16.07 leaves. $plant^1$, 0.391 and 60.17 SPAD respectively. compared to the control treatment T1 which gave the lowest mean amounted 165.0 cm and 14.17 leaves. $Plant^{-1}$, 0.310 and 50.02 SPAD respectively in Table (3). The results shown in tables (3) indicate significant differences in the effect of the method and level of adding NPK nanoparticles and mineral fertilizer .The treatment T11 was significantly excelled in plant height, the total number of leaves in the plant, leaves area index and the leaves content of chlorophyll, compared to other the treatments of method and levels of adding NPK nanoparticles and mineral fertilizer. This may be due to the role of nano fertilizers in improving the solubility and dispersion or spread of insoluble nutrients in the soil and reducing nutrient mineralization and stabilization of soil and its effect on increasing the bioavailability resulting from the increased effectiveness of soil biology leading to more efficient absorption of additives (Veronica *et al.*, 2015), Or this may be due to the ability of nano fertilizers to release nutrients for a longer period of time. This helps in sustaining the nutrient supply of the plant, which has a positive effect on improving plant growth (Subramaniain and Sharmila, 2009). Or, the increase in traits above may be due to the rapid arrival of nutrients added by foliar spraying through stomata or cuts and scratches in the leaves to the cells faster, which helps in the speed and continuity of the supply of nutrients necessary for plant metabolic processes (Rajaseker *et al.,* 2017).

The results of this experiment agreed with Manikandan, Subramaian (2016), Gomaa *et al.* (2017), Kandil and Marie (2017), Burhan and AL-Hassan (2019), who confirmed a significant increase in traits vegetative growth effect of nanofertilizer used, The significant role of the fertilizer components in the increase in plant height, which is the result of the effect of nitrogen levels that stimulate the production of Auxins that encourage cell division and elongation of cells of the total vegetative plant also has a direct impact on the plant height as it is the necessary element to build the amino acid Tryptophan It is the main building material for building indol acetic acid (IAA), which is the main hormone in the plant (Wareaing, 1983; AL-Asady and AL-Kikkhani, 2019). Nitrogen also has an important role in the molecular structure of essential biomolecules in photosynthesis and respiration, as well as the role of phosphorus in the construction and activation of coenzymes necessary for the work of many enzymes and the production of amino acids that contribute to the construction of protein (Espinosa, 1999). Potassium is mainly responsible for the enzymatic activity and stability of proteins (Hänsch and Mendel, 2009), and the regulatory role in the mechanism of closing and opening stomata, which is positively reflected in increasing the efficiency of photosynthesis process and thus increase its growth due to the good balance between the elements of nitrogen, phosphorus and potassium (Shabala, 2003).

Table 3 : Effect of the method and level of adding NPK nanoparticles and mineral fertilizers on the Plant height (cm), number of leaves (leaf. Plant^{-1}), Leave area index (LAI) and Chlorophyll (SPAD)

Chlorophyll (SPAD)	Leave area index (LAI)	Number of leaves / plant	Plant height (cm)	Treatment
50.02 c	0.310 c	14.17 d	165.0 c	T1
58.33 ab	0.367 b	15.27 bc	182.1 ab	T2
58.47 ab	0.382 ab	15.87 abc	186.3 ab	T3
56.50 b	0.367 ab	15.33 abc	185.7 ab	T4
57.13 b	0.366 b	15.13 c	176.3 b	T5
58.13 ab	0.370 b	15.27 bc	182.0 ab	T6
57.10 b	0.368 b	15.53 abc	185.1 ab	T7
57.13 b	0.373 b	15.40 abc	178.2 b	T8
59.10 ab	0.383 ab	15.93 ab	186.8 ab	T9
57.80 ab	0.367 b	15.60 abc	186.1 ab	T10
60.17 a	0.391 a	16.07 a	191.2 a	T11
58.30 ab	0.375 ab	15.60 abc	180.5 ab	T12
58.13 ab	0.371 b	15.60 abc	178.5 b	T13
2.6	2.5	2.6	3.1	C.V

*Treatments that take the same letters in the same column do not have a significant difference according to the Duncan polynomial test at a probability level of 0.05

The traits of the yield

The treatment (T11) differed significantly from the other treatments in the number of grains in-ear, weight of 500 grains, grain yield per hectare and biological yield. The highest averages amounted 632.7 (grain. Cob^{-1}), 186.7 (g), 11.38 (Ton. ha^{-1}) and 23.07 (Ton ha^{-1}) respectively, compared with treatment TI, which recorded the lowest averages amounted 325.3 (grain; Cob^{-1}), 151.1 (g), 6.58 (ton.ha^{-1}) and 16.42 (ton.ha^{-1}) respectively, as shown in Table 4. The results in tables (4) showed a significant increase in the number of grains in cob, the weight of 500 grains, grain yield per hectare and biological yield by the effect of method and level of addition of NPK nanoparticles and mineral fertilizers. This may be due to the increase in vegetative growth indicators and thus increase the efficiency of photosynthesis by increasing the efficiency of the source and thus increase the accumulation of dry matter in the Sink, which resulted increasing the yield components of the weight of the grain and the number of grains in Cob per plant the fertilizer treatment (T11) was excelled in the above traits than the other of the treatments may be due to the size of the nanoparticle fertilizer 100-100 nano which led to easy absorption and improved growth and the crop yield while increasing the efficiency of the use of fertilizer by the plant (Liu and Lal, 2015), Nano fertilizers also give more area for various metabolic reactions in the plant, increasing the rate of photosynthesis and producing more dry matter (Qureshi *et al.*, 2018). And its role in stimulating enzymes involved in the influence of these traits by increasing the activity of chemical reactions and reduce the impact of free radicals that negatively affect the efficiency of the work of some organelles in the plant (Sorooshzadah *et al.*, 2012 and Morteza *et al.*, 2013).

The results of this experiment agree with those obtained by Manikandan, Subramaian (2016), Gomaa *et al.* (2017), Abdel-Aziz et al (2016), Burhan and AL-Hassan (2019),The results of this experiment agree with those obtained by Manikandan, Subramaian (2016), Gomaa *et al.* (2017), Abdel-Aziz *et al.* (2016), Burhan and AL-Hassan (2019). They indicated that there was a significant effect on the yield and components of the product as a result of the use of NPK. The adding of nitrogen is great importance in increasing vegetative growth and thus increasing the activity of photosynthesis and thus the accumulation of dry matter in the grain and its role in prolonging the period of full-grain and delaying senescence of leaves (Otung, 2014). Phosphorus also has an important role in the formation of nucleic acids and energy compounds ATP and GTP, in addition to its involvement in the synthesis of enzymatic companions such as NADP, which depends on its activity many of metabolic processes, and has a role in the division of cells and thus the development of roots, which helps in their proliferation and increased absorption of nutrients (Havlin *et al.*, 2005). The role of potassium in the formation and storage of starch, sugars and proteins, which was positively reflected on the increase of grain weight and thus increase the yield, as well as its role in influencing the traits of the total vegetative and increase the efficiency of photosynthesis process and the transfer of its products to the places of growth in the plant and stimulate many bioprocesses in the plant Potassium also has a regulatory role in maintaining the nutritional balance between nitrogen and phosphorus, which positively affects plant growth, yield and quality (Shenker and Huang, 2002).

Table 4 : Effect of the method and level of adding NPK nanoparticles and mineral fertilizers on the Biological yield (ton.ha^{-1}), Grain yield (ton.ha^{-1}) (500 –grain weight (g), Number of grains (grain.cob^{-1})

Biological yield (ton.ha^{-1})	Grain yield (ton.ha^{-1})	500 –grain weight (g)	Number of grains (grain.cob$^{-1)}$	Treatment
16.42 d	6.58 d	151.1 c	352.3 e	T1
21.66 abc	10.47 abc	169.4 abc	594.9 abcd	T2
22.26 abc	10.81 ab	177.4 ab	603.3 abc	T3
21.02 bc	10.23 bc	172.6 abc	537.9 cd	T4
20.91 bc	9.84 bc	173.4 abc	532.1 d	T5
20.52 c	9.58 c	162.2 abc	554.3 bcd	T6
21.17 abc	9.87 bc	171.5 abc	544.0 cd	T7
21.70 abc	10.09 bc	158.7 bc	565.7 abcd	T8
22.91 ab	10.87 ab	182.1 ab	621.4 ab	T9
21.19 abc	10.68 abc	174.2 abc	575.6 abcd	T10
23.07 a	11.38 a	186.7 a	632.3 a	T11
21.60 abc	10.33 abc	172.3 abc	562.8 abcd	T12
22.04 abc	9.89 bc	168.0 abc	558.8 abcd	T13
4.9	5.7	7.5	6.9	C.V

*Treatments that take the same letters in the same column do not have a significant difference according to the Duncan polynomial test at a probability level of 0.05

The roots and leaves the content of nutrients N, P and K:

The treatment (T11)was significantly excelled which recorded higher average of the root content of nutrients N, P and K was 0.412, 0.143 and 0.427 (g) respectively. The leaves content of nutrients (N, P, K) amounted of (5.712, 1.088 and 4.397 g . plant^{-1}), respectively, compared to the control treatment with the lowest averages in the above traits amounted (0.202, 0.063, 0.225, 3.086, 0.399 and 2. 226 (g.plant-^{1}) respectively as shown in Table 5.

Absorption rate of nutrients N, P and K (mg.Plant.Day $^{-1}$)

Table (6) shows significant differences between the treatments in nutrient absorption rate by the method and level of addition of NPK nanoparticles and mineral fertilizers. The treatment (T11) including spraying of 1.5 g.L^{-1} + mixing 7.5 kg.ha^{-1}, NPK nanoparticle fertilizer which gave the highest average absorption average of nitrogen, phosphorus and potassium at 38.39, 7.73 and 30.19 mg. Day^{-1} respectively, compared to the control treatment (T1)which recorded the lowest averages amounted 29.05, 4.08 and 21.65 mg. Day $^{-1}$ respectively.

The transfer rate of nutrients N, P, K (mg. plant. Day^{-1})

Table (7) showed significant differences between the treatments in nitrogen transfer rate by the method and level of addition of NPK nanoparticles and metallic fertilizers. The treatment(T11) including spraying of 1.5 g. L^{-1} + mixing 7.5 kg, ha^{-1} nanoparticle NPK which gave the highest average N, P and P amounted of (35.85, 6.85 and 27.56 mg. Day^{-1}) respectively, Compared with the control treatment (T1) which gave the lowest averages amounted 27.30, 3.53 and 19.69 mg. Day^{-1} respectively.

Table 5 : Effect of the method and level of adding NPK nanoparticles and mineral fertilizers on N (g. plant^{-1}), P (g. plant^{-1}), K (g. plant $^{-1}$)

K (g. plant $^{-1}$)		P (g. plant $^{-1}$)		N (g. plant $^{-1}$)		Treatment
Roots*	Leaves*	Roots*	Leaves*	Roots*	Leaves*	
0.225 b	2.226 e	0.063 d	0.399 g	0.202 d	3.086 d	T1
0.313 ab	3.427 cd	0.101 bc	0.772 bcd	0.291 c	4.413 bc	T2
0.328 ab	3.429 cd	0.088 bc	0.530 efg	0.325 bc	4.242 bc	T3
0.361 a	3.447 cd	0.110 c	0.485 fg	0.337 abc	4.292 bc	T4
0.357 a	3.374 d	0.092 c	0.511 fg	0.312 bc	4.361 bc	T5
0.317 ab	3.721 bc	0.091 c	0.721 cde	0.347 abc	4.689 bc	T6
0.328 ab	3.752 bc	0.125 ab	0.977 ab	0.356 abc	4.558 bc	T7
.349 ab0	3.503 bcd	0.126 ab	0.779 bcd	0.386 ab	4.533 bc	T8
0.373 a	3.658 bcd	0.104 bc	0.832 bc	0.334 abc	4.041 c	T9
0.385 a	3.829 b	0.124 ab	0.789 bcd	0.341 abc	4.637 bc	T10
0.427 a	4.397 a	0.143 a	1.088 a	0.412 a	5.713 a	T11
.327 ab0	3.550 bcd	0.107 bc	def0.608	0.308 bc	4.164 bc	T12
0.333 ab	3.769 bc	0.121 ab	0.855 bc	0.345 abc	4.881 b	T13
13.0	5.4	13.0	13.9	8.6	13.0	C.V

*Treatments that take the same letters in the same column do not have a significant difference according to the Duncan polynomial test at a probability level of 0.05

Table 6 : Effect of the method and level of adding NPK nanoparticles and mineral fertilizers on the absorption rate of nitrogen, phosphorus and potassium (mg).

Treatment	(mg.plant.day^{-1})		
	N*	**P***	**K***
T1	29.05 C	4.08 e	21.65 c
T2	37.25 ab	6.92 ab	29.62 a
T3	35.91 abc	4.83 cde	29.44 a
T4	34.95 abc	4.45 de	28.66 a
T5	36.87 ab	4.72 cde	29.45 a
T6	36.47 ab	5.84 bcd	29.25 a
T7	33.39 abc	7.56 a	27.70 ab
T8	31.05 bc	5.69 bcde	24.37 bc
T9	31.18 bc	6.65 ab	28.97 a
T10	34.01 abc	6.19 abc	28.73 a
T11	38.39 a	7.73 a	30.19 a
T12	34.10 abc	5.42 bcde	29.51 a
T13	37.25 ab	7.01 ab	29.12 a
C.V	9.5	14.6	7.9

*Treatments that take the same letters in the same column do not have a significant difference according to the Duncan polynomial test at a probability level of 0.05

Table 7 : Effect of the method and level of adding NPK nanoparticles and mineral fertilizers on the transfer rate of nitrogen, phosphorus and potassium (mg).

Treatment	(mg.plant.day^{-1})		
	N*	**P***	**K***
T1	27.30 c	3.53 d	19.7 c
T2	34.99 ab	6.13 ab	27.2 a
T3	33.39 abc	4.16 cd	26.9 ab
T4	32.48 abc	3.64 d	26.0 ab
T5	34.43 ab	4.01 cd	26.6 ab
T6	34.00 ab	5.20 abcd	27.0 ab
T7	31.03 abc	6.72 a	25.5 ab
T8	28.65 bc	4.91 bcd	22.2 bc
T9	28.85 bc	5.92 ab	26.4 ab
T10	31.72 abc	5.35 abc	26.1 ab
T11	35.85 a	6.85 a	27.5 a
T12	31.81 abc	4.62 bcd	27.2 a
T13	34.87 ab	6.18 ab	26.8 ab
C.V	10.4	16.9	9.6

The results in tables (5, 6 and 7) showed a significant increase by the effect of method and level of adding of NPK nanoparticle and mineral fertilizer in the content of elements N, P and K in the roots and leaves and the absorption rate and transfer of elements. The reason for the excelled of the fertilizer treatment (T11) may be due to the role of nano fertilizer in increasing the bioavailability which leads to more efficient absorption of the added elements (Veronica *et al.*, 2015), and Increased efficiency of nutrient by slow or controlled supplying of nutrients (Solanki *et al.*, 2015). Nanofertilizers also give more area for different metabolic reactions in the plant that increase the rate of photosynthesis and produce more dry matter which is positively reflected in the increased nutrient content of plant N, P , K (Qureshi *et al.*, 2018). The results of this experiment agree with those obtained by Manikandan, Subramaian (2016), Kandil, Marie (2017), Abdel-Aziz *et al.* (2018), Burhan and AL- Hassan (2019) who indicated a significant effect of fertilizer application. Who indicated a significant effect of nano fertilizer application in the above traits .

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