Impacts of Nano-Fertilizers and Chemical Fertilizers on Plant Growth and Nutrient Uptake by Faba Bean (Vicia faba L.) Plant.

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ABSTRACT

The conducted experiment aimed to study the effect of NPK Nano-fertilizers applied at similar or less rates that could replace the recommended levels of NPK conventional fertilizers without having a negative impact on plant growth, yield, nutritional content, plant growth, crop yield and nutrient content. A complete randomized pot experiment in the three replicates was carried out in green house of Soils and water Department, Faculty of agriculture, Al -Azhar University (Nasr City, Cairo, Egypt), during the winter season of 2019. Nano fertilizers have been added at rates of (15%, 25% ,50 % and 75%) of recommended doses from N, P and K and their interactions compared to chemical fertilizers on the growth, crop yield and nutrient uptake of faba bean (Vicia faba L.) planting in sandy loam soil. There are (8) fertilization treatments in this study: single Nano N, P, K, di-combination Nano (N+P), (N+K), (P+K), tri-Nano (N+P+K), and control treatment. six faba bean seeds were planted in each pot. Results showed that the application of NPK Nano-fertilizers at under rates of recommended levels (NPK) of Chemical fertilizers (traditional fertilizers). led to increase in dry weight, crop yield, and nutrient uptake. In this regard, the most suitable treatment was 25% (NPK) Nano fertilizers from RD., which gave the highest values of all the aforementioned traits.

Keywords: Nano-fertilizers, chemical fertilizers, faba bean, Nitrogen, phosphorus, Potassium.

INTRODUCTION

Faba bean is one of the most important legumes in Egypt, that is highly consumed as it is a source of vegetable protein, which compensates the lack of animal protein, especially after skyrocketing prices of red meat and poultry. It contains a large proportion of protein, iron and mineral salts. However, the quantities produced decreases constantly.

(Guo *et al.,* 2005) found that it is observed that between 40% - 70% of the nitrogen and 80% - 90% of the phosphorus in applied fertilizers are either lost at the environment or become unavailable for plants use. It does not only cause significant economic and resource losses, but it is also a main source of environmental contamination. (Lubkowski, 2016) found that when conventional fertilizers such as urea, nitrogen phosphorus and potassium (NPK), and di-ammonium phosphate (DAP)etc., are applied to soil, only a small amount of these fertilizers are taken up by the plants and the rest of the fertilizers are lost into the environment through various physical and chemical processes such as nutrient leaching, volatilization, rinsing out, and immobilization.

(Fansuri *et al*., 2008) found that using nano-fertilizers improves agricultural output. This is due to greater photosynthesis as lead to increased plant growth and metabolism and nutrient uptake. (Al-Eskandarany, 2009) concluded that Nanotechnology is a modern technique, first announced by the American physicist Richard Feynman in 1959, where he predicted the possibility of creating and inventing small and high precision technologies in their various scientific purposes. He referred to the possibility of changing the properties of any material and maximizing its characteristics, by arranging their atoms. (Subramanian and Tarafdar, 2009) found that the nutrient release pattern of nanofertilizer formulations carrying nitrogen fertilizer. The findings reveal that nano-zeolite with dimensions of 30–40 nm) may release nutrients, especially N, for a longer length of time (>1,000 h) than traditional fertilizers (500 h). (Mukhopadhyay *et al.,* 2009) Nanotechnology is derived from a Greek term meaning "dwarf," and a nanometer is one billionth of a meter (1 nm= 10^{-9} m). Nanotechnology is described as the study and control of materials at scales of 1 to 100 nanometers, where special physical features allow for innovative applications. (Moharami and Jalali, 2015) zeolites have also been reported to improve phosphorus uptake by plants. (Rao, 2016) Agriculture is regarded as the most promising field in the world, and nanotechnology has the potential to be used to soil research. Controlling nutrient release and availability, the development of soil properties, the nature of the soil Rhizosphere, nutrient ion transport in soil plant systems, soil and water conservation, water treatment, and active management and remediation of soil and ground water pollution are all potential applications for nanotechnology. (Mahmoud and Swaefy, 2020) reported that the improvement of wheat plant output under drought stress when the application of nanozeolite nitrogen fertilizer at a rate of 41 kg ha^{-1}. (Kubavat *et al.,* 2020) showed that applying of KNFs as a slow-release formula, can minimize the potassium losses in the soil, and at the same time keeping the potassium supply of the plants for more time.

The aim of this work is to study the effect of NPK Nano fertilizers applied in equivalent or lower rates that could replace the recommended levels of NPK chemical fertilizers without retrograde effects upon plant growth, crop yield and nutrient content and uptake by wheat and faba bean plants grown in sandy loam soil.

MATERIALS AND METHODS

Soil sample.

The surface soil sample (0 - 30 cm) was collected to represent sandy soil (sandy loam) from Sadate El Menofia Governorate. The soil was air -dried, ground, sieved through 2 - mm sieve, then stored in glass bottles and kept. The sample is analyzed for some physical and chemical properties, the data are shown in Table (1)

Pot experiments

The plastic pots diameter is 35 cm and 40 cm depth were filled by 14 kilograms of airdried soil under investigation. The moisture content of the soil was kept at field capacity by weighting each pot every day taking into consideration the weight of plant.

Fertilization

Organic fertilizer.

Chicken manure (C K M) as a source of organic manure was taken from the Farm animal production, Faculty of Agriculture, Al - Azhar University Nasr City, Cairo. The analysis of Chicken manure is determined in Table (2). Before planting of faba bean, all pots were mixed with (C K M) at the rate of 23.8 m^3/ha.

Mineral fertilization.

The inorganic fertilizers were added to the soil as ammonium nitrate (33.5 %), super phosphate (15.5 %) and potassium sulphate (48 %) to respective of N, P and K respectively, each four treatments of N P K fertilizers at the rates of 15, 25, 50 and 75 % from the recommended doses. Ammonium nitrate fertilizer was added in two batches with the cultivation and after 20 days from planting. while the super phosphate and potassium sulphate were added to the soil before planting.

Nano-fertilizers.

Nano fertilizers were brought from the National Research Center in Dokki, Giza, Egypt. Treatments consisted of Nano-fertilizers (15%) of recommended doses (N, P, K) kg/ha. The experiment has included 7 treatments of fertigation single Nano (N, P, K) di combination Nano (N+P), (N+K), (P+K), tri-Nano (N+P+K) compared with control treatment. Ordinary ammonium nitrate (33.5% N-NH_4 - NO_3) was used as a source of nitrogen Nano-fertilizer. On the other hand, super phosphate (15%P_2O_5) was used as a source of phosphorus Nano fertilizer. Potassium sulphate (48% K_2O) was used as a source of potassium Nano fertilizer.

Synthesis of Nano-Fertilizer- Synthesis of Surfactant Modified Zeolite.

According to Banishwal *et al.,* (2006) surfactant modification of the zeolite was carried out using hexadecyl trimethyl ammonium bromide (HDTMABr). A pre-weighed quantity of zeolite was mixed with HDTMABr solution (200 mg/L) in a 1:100 (solid: liquid) ratio. The mixture was agitated for 7-8 h at 150 rpm on an orbital shaker and then filtered. The solid residue was washed with double-distilled de-ionized water and oven dried for 4-6h. The synthesized Surfactant Modified Zeolite (SMZ) was then mechanically ground with a mortar and pestle into fine particles. As the surfactant is the only source of carbon in the system, the surfactant loading was monitored by total organic carbon (TOC) analysis of the initial and final solutions obtained during the synthesis of SMZ. After completing the reaction, the pH level of the solution was neutralized. Later, the sample was filtered, dried at 105 °C and finally was annealed at 650 °C to obtain the desired porous grey colored zeolite.

Experiment

The conducted experiment aimed to study the effect of NPK Nano-fertilizers applied in equivalent or lower rates that could replace the recommended levels of NPK chemical fertilizers without retrograde effects upon plant growth and nutrient content. A complete randomized pot experiment in the three replicates was carried out in green house of Soils and water Department, Faculty of agriculture, Al -Azhar University (Nasr City, Cairo, Egypt), during the winter season of 2019. Nano fertilizers have been added at rates of (15%, 25% ,50 % and 75%) of recommended doses from N, P and K and their interactions compared to chemical fertilizers (control treatments) on the growth, crop yield, nutrient content of Faba bean (Vicia faba L.) plant in sandy loam soil. The experiment has included 8 treatments of fertilization single Nano N, P, K, di combination Nano (N+P), (N+K), (P+K), tri Nano (N+P+K) compared with control treatment. Six faba bean seeds were planted in each pot. Pots were watered daily to adjust its moisture around the soil field capacity by weighting each pot every day. At the end of the experiment at harvest (150 days) from planting, the plants were harvested just above soil surface. dry weight, crop yield N, P and K uptake in straw and seeds of plant was recorded.

Soil analysis: -

Particle size distribution was carried out using the hydrometer method (Ryan *et al.*, 1996).

Calcium carbonate was estimated using Collin's calcimeter (Jackson1973).

Organic matter content was determined using Walkely and Balk's method (Jackson 1973).

Soil reaction, (pH value) was measured in a 1:2.5 soil suspension (Jackson, 1973).

Electrical Conductivity (E C) was determined in 1:2.5 soil water extract using (Jackson, 1973).

Available nitrogen was estimated by micro kildahl (Jackson, 1973).

Available phosphorus was determined by colorimeteric according to Olsen method, (Jackson, 1973).

Available potassium estimated by flame photometer (Jackson, 1973).

Sodium was determined using the flame photometer, (Jackson, 1973).

calcium Ca^{++} and magnesium Mg^{++} were determined volumetrically by Versenate solution using ammonium purpurate as indicator for calcium and with Eriochrome black T as indicator for magnesium + calcium (Jackson, 1973).

Soluble Carbonates (CO_3) and bicarbonates (HCO_3) were titrated by HCl to the end point of phenolphthalein indicator to be formed and methyl orange indicators to the later (Jackson, 1973).

Sulphate was calculated by the difference between the sum of anions and cations.

Plant analysis: -

0.2 gm. plant samples (straw and seeds) were digested in a mixture of $HClO_4$ and H_2SO_4 according to the procedure of (Chapman, and Pratt 1978)

Nitrogen was estimated by the Microkjelhal (Jackson, 1973).

Phosphorus was estimated colorimetrically by using ammonium molybdate according to the procedure outlined by (Jackson, 1973).

Potassium was determined using the Flame photometrical according to (Jackson, 1973).

Statistical analysis:

The obtained results were exposed to proper statistical analysis of variance (ANOVA) by using Mintab program Barbara and Brain, (1994), then Least significant differences (LSD) were calculated at the level of 5%.

RESULTS AND DISCUSSION

Effect of Nano fertilizer rates on growth parameters of faba bean plant.

Effect of Nano and inorganic fertilizer rates on shoot dry weight and seeds yield (g.pot^{-1}) of faba bean plants grown in sandy loam soil.

The data of Table (4) revealed that it appears to be the result of the shoot dry matter yield (g.pot^{-1}) and seeds yield (g.pot^{-1}). Fertilization of Nano NPK fertilizers combination treatment results in a significant increase in yield of the vegetative dry matter and seeds yield compared to the control treatment and thus significantly exceeded the treatment of the tri combination of the Nano - fertilizers, compared with traditional fertilizers.

In respect of the single application of Nano fertilizers rates, the data in Table (4) showed that the highest value for dry weight (139.46 g pot^{-1}) was recorded with the single application of Nano fertilizers at 15 % P from the recommended doses (RD) and the highest value for seeds yield (47.59 g.pot^{-1}) was recorded with the single application of Nano fertilizers at 25 % N from (RD), also the highest value of dry weight of shoots (113.01g pot^{-1}) was recorded under traditional fertilizers at (75% P) from (RD) and the highest value of seeds yield (43.89 g.pot^{-1}) was recorded under traditional fertilizers at (75% K) from (RD). .

With regard to the lowest values for dry weight and seeds, yield was recorded in application of Nano zeolite fertilizers (NZF) at (75% K) from R.D. treatment as (60.36 g pot^{-1}) and (35.56 g.pot^{-1}), while the lowest values for dry weight and seeds yield were recorded traditional fertilizers at (15% N) from R.D. treatment as (77.31 g pot^{-1}) and (32.53g.pot^{-1}) respectively compared with control treatment. These results are consistent with what has been achieved by (Zheng *et al.,* 2005; Fansuri *et al.,* 2008; Servin *et al.*, 2015 and Arruda *et al.,* 2015).They found that different research investigations have indicated that using Nano-fertilizers increases crop yields. This is mostly due to increased photosynthesis leading to increased plant growth and metabolism, which in turn increases nutrient uptake.

Regarding the effect of dual application of Nano fertilizers on dry weight, the data showed that the highest value of shoots dry weight was recorded with the dual application of Nano fertilizers at (15 % N+P) from R.D. treatment as (135.36 g pot^{-1}) and the highest value of seeds yield was recorded with the dual application of Nano fertilizers at (25 % N +K) from R.D. treatment as (58.98 g.pot^{-1}), as well as the highest value of shoot dry weight that was recorded with the traditional fertilizers at (75% P+ K) from R.D. treatment as (83.31g pot^{-1}) and the highest value of seeds yield was recorded with traditional fertilizers at (75% N+ K) from R.D. treatment as (36.06g.pot^{-1}).

On the other hand, the lowest value of shoots dry weight was recorded with application of Nano fertilizers at (75% N+ K) from R.D. treatment as (71.46 g pot^{-1}) and the lowest value of seeds yield was recorded with application of Nano fertilizers at (75% P+ K) from R.D. treatment as (50.36g.pot^{-1}), while the lowest value of shoots dry weight was recorded with traditional fertilizers at (15% N+ P) from R.D. treatment as (61.71 g pot^{-1}) and the lowest value of seeds yield was recorded with traditional fertilizers at (15% P+ K) from R.D. treatment as (29.23 g.pot^{-1}), compared with control treatment.

In this concern, the effect of mixture application of Nano fertilizers(NPK) on dry weight and seeds yield found that the highest values of shoot dry weight and seeds yield were recorded with the mixture of Nano-fertilizers (NPK) at (25 % N P K) from R.D treatment as (204.46 g pot^{-1}) and (66.29 g pot^{-1}) respectively , as well as the highest values of shoot dry weight and seeds yield were recorded with traditional fertilizers (75% N P K) from R.D. treatment as (108.61 g pot^{-1}) and (43.94 g pot^{-1}) respectively compared with control treatment.

On the other hand, the lowest values of dry weight and seeds yield were recorded with the mixture of Nano-fertilizers (NPK) at (75 % N P K) from R.D treatment as (68.16 g pot^{-1}) and (53.81 g pot^{-1}) respectively. In contrast, the lowest values of dry weight and seeds weight were recorded with traditional fertilizers (15% N P K) from R.D. treatment as (42.81 g pot^{-1}) and (43.94 g pot^{-1}) respectively compared with control treatment. In the same direction, Liu *et al.,* (2005) reported that the use of nano fertilizers enhanced the fresh and dry weights of the plants. Significant improvements in plant fresh and dry weights, as well as the number of branches, were observed. These enhancements might be attributed to the increases in plant physiological processes such as photosynthesis, since the chlorophyll content of tomato plants rose following Nano fertilizer treatments.

Effect of Nano and Inorganic fertilizer rates on macronutrient uptake (mg pot^{-1}) of Faba bean straw and seeds grown in sandy soil.

Effect of Nano and Inorganic fertilizer rats on N uptake (mg pot^{-1}) in straw and seeds by faba bean plant.

Obtained data at Table (5) showed that adding of Nano fertilizers led to increases in the average values of N uptake of faba bean plant than those obtained for the traditional fertilizers treatments. It has been found that the treatments of the single, di, tri-Nano NPK fertilizers have a significant effect on the percentage of N uptake of faba bean plant compared with control treatment (100%) of ordinary fertilizers.

In respect of the single application of Nano fertilizers rates, the data in Table (5) showed that the highest values for N uptake in straw and seeds as (2510.28 mg pot^{-1}) and (2603.34 mg pot^{-1}) respectively were recorded with the single application of Nano fertilizers at 15 % P from the recommended doses (RD), also the highest values of N uptake in straw and seeds as (2294.10 mg pot^{-1}) and (2418.44 mg pot^{-1}) respectively was recorded under traditional fertilizers at (75% P) from the recommended doses (RD).

On the other hand, the lowest value was recorded in the application of NZF at (75% K) from R.D. treatment as (995.94 mg pot^{-1}) and the lowest value for N uptake in seeds was recorded application of NZFs at (75% K) from R.D. treatment as (1040.27 mg pot^{-1}) while the lowest value for N uptake in straw and seeds were recorded traditional fertilizers at (15% N) from R.D. treatment as (842.68 mg pot^{-1}) and (925.16 mg pot^{-1}) respectively compared with control treatment. These results are consistent with what has been achieved by Lal, (2008). It has been reported that Nano fertilizers may be used to manage the slow release of nutrients from fertilizer granules, improving nutrient usage effectiveness (NUE) and keeping nutrient ions from being fixed or lost in the medium, Nano fertilizers have ahigh usage effectiveness and can be used repeatedly. Slow-release and super-sorbent nitrogenous and phosphatic fertilizers are available, and certain new-generation fertilizers have long-term crop productivity uses.

Regarding the effect of application of dual Nano fertilizers on N uptake, the data showed that the highest values for N uptake in straw and seeds were recorded with the dual application of Nano fertilizers at (15 % N +P) from R.D. treatment as (3099.74 mg pot^{-1}) and (3189.98 mg pot^{-1}) respectively, as well as the highest values for N uptake in straw and seeds were recorded with traditional fertilizers at (75% N+ P) from R.D. treatment as (1479.75 mg pot^{-1}) and (1568.96 mg pot^{-1}).

On the other hand, the lowest values were recorded with application of Nano fertilizers at (75% N+ K) from R.D. treatment as (1314.86 mg pot^{-1} straw) and (1362.49 mg pot^{-1} seeds), while the lowest values were recorded with traditional fertilizers at (15% N+ P) from R.D. treatment as (661.47 mg pot^{-1}) in straw and (730.57 mg pot^{-1}) in seeds compared with control treatment.

In this concern, the effect of mixture application of Nano fertilizers on N uptake found that the highest values for N uptake in straw and seeds were recorded with the mixture of Nano-fertilizers (NPK) at (25 % N P K) from R.D treatment as (6440.49 mg pot^{-1}) and (6542.83 mg pot^{-1}) respectively, as well as the highest value for N uptake in straw and seeds were recorded with traditional fertilizers at (75% N P K) from R.D. treatment as (2031.01mg pot^{-1}) and (2154.10 mg pot^{-1}).

On the other hand, the lowest values for N uptake in straw and seeds were recorded with the mixture of Nano-fertilizers (NPK) at (75 % N P K) from R.D treatment as (1329.12 mg pot^{-1}) and (1363.30 mg pot^{-1}), In contrast, the lowest values were recorded with traditional fertilizers at (15% N P K) from R.D. treatment as (428.10 mg pot^{-1}) and (475.18 mg pot^{-1}) compared with control treatment. This result agreed with (Al-Amin and Jayasuriya, 2007, Sultan *et al.*, 2009) Nano-fertilizers may release their contents in a regulated (slow or fast) way in response to various signals, such as heat, moisture, and so on. Crops, on the other hand, release carbonaceous molecules into the rhizosphere in response to nutrient constraint, allowing biotic mineralization of N and/or P from soil organic matter, as well as P linked with soil inorganic colloids. These root exudates can be used to make Nano biosensors that will be included in new Nano fertilizers since they can be regarded as environmental signals.

Effect of Nano and inorganic fertilizer rats on P uptake (mg pot^{-1}) in straw by faba bean plant grown in sandy soil.

The presented data in Table (6) showed that adding Nano fertilizers led to greater average values of P uptake by faba bean plants than those obtained for the traditional fertilizers treatments. It has been found that the treatments of the single, di, and tri Nano NPK fertilizers have a significant effect on the percentage of P uptake of faba bean plants compared with the control treatment (100%).

In respect of the single application of Nano fertilizers rates, the data in Table (6) showed that the highest values for P uptake in straw and seeds as (446.27 mg pot^{-1}) and (582.96 mg pot^{-1}) were recorded with the single application of Nano fertilizers at 15 % P from the recommended doses (RD), also the highest values for P uptake in straw and (278.78 mg pot^{-1}) and (308.53 mg pot^{-1}) respectively were recorded under traditional fertilizers at (75% N) from the recommended doses (RD).

On the other hand, the lowest values for P uptake in straw and seeds were recorded application of NZFs at (75% k) from R.D. treatment as (66.40 mg pot^{-1}) and (125.37 mg pot^{-1}), while the lowest values recorded traditional fertilizers at (15% P) from R.D. treatment as (105.61 mg pot^{-1}) and (137.62 mg pot^{-1}) compared with control treatment. These results are consistent with what has been achieved by Sadik *et al.*, (2009) who reported that Nano fertilizers have been shown to boost nutrient usage efficiency (NUE) by three times and provide strain tolerance. Nano technology increases bio-source utilisation and is eco-friendly in nature.

Regarding the effect of dual application of Nano fertilizers on P uptake, the data showed that the highest values of P uptake in straw and seeds were recorded with the dual application of Nano fertilizers at (15 % N +P) from R.D. treatment as (419.62 mg pot^{-1}) and (538.80 mg pot^{-1}) respectively, as well as the highest values of P uptake in straw and seeds were recorded with traditional fertilizers at (75% N+ K) from R.D. treatment as (207.78 mg pot^{-1}) and (229.96 mg pot^{-1}).

On the other hand, the lowest values were recorded with application of Nano fertilizers at (75% N+ K) from R.D. treatment as (85.75 mg pot^{-1}) and (155.76 mg pot^{-1}) respectively, while the lowest values were recorded with traditional fertilizers at (15% N+ P) from R.D. treatment as (80.22 mg pot^{-1} straw) and (100.77 mg pot^{-1} seeds) compared with control treatment.

In this concern, the effect of mixture application of Nano fertilizers on P uptake found that the highest values of P uptake in straw and seeds were recorded with the mixture application of Nano-fertilizers (NPK) at (25 % N P K) from R.D treatment as (817.84 mg pot^{-1}) and (995.11 mg pot^{-1}) respectively, as well as the highest values of P uptake in straw and seeds were recorded with traditional fertilizers (75% N P K) from R.D. treatment as (217.22 mg pot^{-1}) and (199.07 mg pot^{-1}) respectively.

Meanwhile, the lowest values were recorded with the mixture of Nano-fertilizers (NPK) at (75 % N P K) from R.D treatment as (95.42 mg pot^{-1}) and (121.50 mg pot^{-1}), In contrast, the lowest values were recorded with traditional fertilizers at (15% N P K) from R.D. treatment as (51.37 mg pot^{-1}) and (65.62 mg pot^{-1}), compared with control treatment. This result agreed with (Mikhak *et al.,* 2017) who found that Nano fertilizer is a Nano-sized fertilizer that contains nanoparticles and nutrient encapsulation to slowrelease micro and macronutrients to specific locations in plants. Nanostructured elements in Nano fertilizers are commonly incorporated into a carrier complex. Nano fertilizer carriers have previously been characterized as chitosan, polyacrylic acid, clay, and zeolite.

Effect of Nano and inorganic fertilizer rates on K uptake (mg pot^{-1}) in straw by faba bean plant grown in sandy soil.

The results presented in Table (7) showed that the application of NPK Nano fertilizers at comparable or lower rates than recommended doses of NPK chemical fertilizers (traditional fertilizers) had a favorable impact compared to (traditional chemical fertilizers). In general, Nano fertilizers had a considerable influence on faba bean plant K absorption when compared to traditional fertilizer treatments.

In respect of the single application of Nano fertilizers rates, the data in Table (7) showed that the highest values for K uptake in straw and seeds as (2844.98 mg pot^{-1}) and (2961.22 mg pot^{-1}) were recorded with the single application of Nano fertilizers at 15 % P from the recommended doses (RD), also the highest values of K uptake of in straw and seeds as (1862.22 mg pot^{-1}) and (1921.73 mg pot^{-1}) were recorded under traditional fertilizers at (75% N) from the recommended doses (RD).

On the other hand, the lowest values recorded application of NZF at (75% P) from R.D. treatment as (944.64 mg pot^{-1}) and (996.75 mg pot^{-1}), while the lowest values recorded traditional fertilizers at (15% N) from R.D. treatment as (904.53 mg pot^{-1} straw) and (940.63 mg pot^{-1}seeds), compared with control treatment. These results are in harmony with those obtained by (Rameshaiah *et al.,* 2015) who discovered that Nano fertilizers are important instruments in agriculture for enhancing crop growth, yield, and quality characteristics by improving K uptake efficiency, decreasing the amount of fertilizers waste, and lowering cultivation costs. Higher concentrations of Nano fertilizers boost crop growth at optimal concentrations, but higher concentrations can hinder crop development owing to nutrient toxicity.

Regarding the effect of dual application of Nano fertilizers on K uptake, the data showed that the highest values of K uptake in straw and seeds were recorded with the dual application of Nano fertilizers at (15 % P +K) from R.D. treatment as (3210.18 mg pot^{-1}) and (3311.93 mg pot^{-1}), as well as the highest values of K uptake were recorded with traditional fertilizers at (75% N+ P) from R.D. treatment as (1054.71 mg pot^{-1}) and (1096.67 mg pot^{-1}).

On the other hand, the lowest values were recorded with application of Nano fertilizers at (75% N + P) from R.D. treatment as (1044.66 mg pot^{-1}) and (1107.05 mg pot^{-1}), while the lowest value was recorded with traditional fertilizers at (15% P+ K) from R.D. treatment as (752.69 mg pot^{-1}) and the lowest value was recorded with traditional fertilizers at (15% N+

K) from R.D. treatment as (750.63 mg pot^{-1}), compared with control treatment. These results are consistent with what has been achieved by (Jhanzab *et al.,* 2015) who developed Nano fertilizers to increase nutrient usage efficiency by utilizing unique nanoscale features such as quick and full nutrient uptake by plants, hence reducing fertilizer use and reducing environmental concerns.

In this concern, the effect of mixture application of Nano fertilizers on K uptake found that the highest values of K uptake in straw and seeds were recorded with the mixture of Nano-fertilizers (NPK) at (25 % N P K) from R.D treatment as (6256.48 mg pot^{-1}) and (6420.18 mg pot^{-1}), as well as the highest values of K uptake were recorded with traditional fertilizers at (75% N P K) from R.D. treatment as (1325.04 mg pot^{-1}) and (1379.32mg pot^{-1}).

On the other hand, the lowest values were recorded with the mixture of Nano fertilizers (NPK) at (75 % N P K) from R.D treatment as (1308.67 mg pot^{-1}) and (1363.27 mg pot^{-1}), in contrast, the lowest values were recorded with traditional fertilizers at (15% N P K) from R.D. treatment as (440.94 mg pot^{-1}) and (331.08 mg pot^{-1}), compared with control treatment. This result agreed with (According to Abdall *et al.,* 2018), Nano fertilizers have a higher function in increasing cotton crop output, which will lower fertilizer costs and lessen environmental risks. Furthermore, in the majority of the tested parameters, Nano 50% RFD was statistically comparable to the control treatment (conventional 100% RFD), while Nano 12.5% RFD was statistically comparable to Nano 25% RFD. This implies that employing nano-fertilizers at the correct times, with the proper procedures, and at the right rates can enhance cotton growth and yield.

CONCLUSION

Application of Nano fertilizers has a major role in boosting faba bean growth and nutrient uptake, lowering fertilizer costs and reducing pollution risks. In this regard the most suitable treatment was 25%(NPK) Nano fertilizers from RD., which gave the highest values of all aforementioned traits, it can be concluded that Nano fertilizers are ideal alternatives to soluble conventional fertilizers that release nutrients at slower rates, allowing plants to absorb nutrients before they are lost.

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Table 1: Some physical and chemical properties of investigated soil

Particle size distribution			Texture	pH (1:2.5)	EC(dS/m)	O.M %	$CaCO_3$ %	Cations (mq L^{-1})				Anions (mq L^{-1})				Total soluble (mg kg^{-1})		
Sand (%)	Silt (%)	Clay (%)						Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	SO_4^{--}	Cl^{-}	N	P	K
63.55	20.18	16.27	sandy Loam	7.58	0.49	0.5 8	2.11	0.59	0.86	2.23	1.24	0.0	1.18	1.83	1.91	88.44	46.23	52.68

Table 2: Some chemical characteristics of (C K M) manure (as organic fertilizer)

chemical characteristics							
O.M %	C/N Ratio	pH (1:2.5)	EC d S m^{-1}	N %	P %	K %	O.C %
64.47	21:1	7.8	3.44	1.68	0.99	0.84	37.42

Table 3: experimental Design

Treatment						
addition forms						
Element	Nano-fertilizers			Mineral fertilizers		
	N	P	K	N	P	K
N	15- 25- 50- 75- ◆	*	*	15- 25- 50- 75- ◆	*	*
P	*	15- 25- 50- 75- ◆	*	*	15- 25- 50- 75- ◆	*
K	*	*	15- 25- 50- 75- ◆	*	*	15- 25- 50- 75- ◆
N + P	15- 25- 50- 75- ◆	15- 25- 50- 75- ◆	*	15- 25- 50- 75- ◆	15- 25- 50- 75- ◆	*
N + K	15- 25- 50- 75- ◆	*	15- 25- 50- 75- ◆	15- 25- 50- 75- ◆	*	15- 25- 50- 75- ◆
P + K	*	15- 25- 50- 75- ◆	15- 25- 50- 75- ◆	*	15- 25- 50- 75- ◆	15- 25- 50- 75- ◆
N + P + K	15- 25- 50- 75- ◆	15- 25- 50- 75- ◆	15- 25- 50- 75- ◆	15- 25- 50- 75- ◆	15- 25- 50- 75- ◆	15- 25- 50- 75- ◆
Control treatment	-					
Mineral fertilization	*					

(-) No addition (Control). (*) R.D. (◆) 15, 25, 50, and 75 %rate of R.D

Table (4) Effect of Nano and Inorganic fertilizer rates on shoot dry weight (g.pot^{-1}) and seeds yield (per pot^{-1}) of Faba bean (Vicia faba) plants grown in sandy soil.

Treatments										
addition Forms										
Element	Nano-fertilizers						Mineral fertilizers			
	%	Full (RD)	Dry weight of Shoots (g.pot^{-1})	Means	seeds yield (g.pot^{-1})	Means	Dry weight of Shoots (g.pot^{-1})	Means	seeds yield (g.pot^{-1})	Means
N	15 N	P+K	116.36	94.28	44.61	43.61	77.31	93.81	32.53	37.09
	25 N	P+K	105.26		45.74		86.01		36.82	
	50 N	P+K	89.16		42.52		100.41		38.92	
	75 N	P+K	66.36		41.56		111.51		40.08	
P	15 P	N+K	139.46	98.24	46.71	44.76	96.01	105.11	33.98	37.04
	25 P	N+K	115.86		47.59		99.11		36.37	
	50 P	N+K	69.66		43.80		112.31		38.53	
	75 P	N+K	67.96		40.94		113.01		39.27	
K	15 K	N+P	101.06	80.66	41.60	38.76	99.21	106.59	37.00	40.42
	25 K	N+P	99.36		39.83		108.21		39.29	
	50 K	N+P	61.86		38.04		108.41		41.49	
	75 K	N+P	60.36		35.56		110.51		43.89	
N+P	15 N+P	K	135.36	106.99	55.60	52.91	61.71	68.86	29.57	32.54
	25 N+P	K	117.66		53.52		62.61		31.89	
	50 N+P	K	96.96		51.64		72.41		33.68	
	75 N+P	K	77.96		50.87		78.71		35.03	
N+K	15 N+K	P	99.16	86.24	58.24	56.12	63.61	72.99	31.01	33.64
	25 N+K	P	96.66		58.98		66.11		32.58	
	50 N+K	P	77.66		54.68		79.11		34.92	
	75 N+K	P	71.46		52.56		83.11		36.06	
P+K	15 P+K	N	122.06	109.78	57.34	53.49	67.81	76.16	29.23	31.81
	25 P+K	N	120.96		54.69		76.31		30.39	
	50 P+K	N	99.36		51.57		77.21		32.79	
	75 P+K	N	96.76		50.36		83.31		34.84	
N+P +K	15 N+P+K	—	204.16	144.96	65.11	61.06	42.81	77.93	22.49	32.93
	25 N+P+K	—	204.46		66.29		60.61		23.74	
	50 N+P+K	—	103.06		59.01		99.71		41.53	
	75 N+P+K	—	68.16		53.81		108.61		43.94	
Control " treatment 100%RD) dry weight					182.41					
Control " treatment 100%RD) seeds yield					62.86					
L.S.D dry weight 1.04					L.S.D seeds yield 0.974					

Table 5: Effect of Nano and inorganic fertilizer rates on N uptake (mg pot^{-1}) in straw and seeds by faba bean plant.

Treatments										
addition Forms										
Element	Nano-fertilizers						Mineral fertilizers			
	%	Full (RD)	N uptake in straw (mg pot^{-1})	Means	N uptake in seeds (mg pot^{-1})	Means	N uptake in straw (mg pot^{-1})	Means	N uptake in seeds (mg pot^{-1})	Means
N	15 N	P+K	2373.74	1880.93	2494.03	1955.28	842.68	1423.42	925.16	1527.73
	25 N	P+K	2168.36		2238.62		946.11		1040.69	
	50 N	P+K	1720.79		1783.30		1797.34		1911.12	
	75 N	N+K	1260.84		1305.17		2107.54		2233.94	
P	15 P	N+K	2510.28	1763.16	2603.34	1829.81	1046.51	1622.02	1152.09	1738.46
	25 P	N+K	2120.24		2197.53		1159.59		1271.89	
	50 P	N+K	1226.02		1274.81		1987.89		2111.40	
	75 P	N+K	1196.10		1243.56		2294.10		2418.44	
K	15 K	N+P	1879.72	1447.59	1953.87	1505.17	1646.89	1895.70	1752.73	2011.19
	25 K	N+P	1887.84		1954.23		1839.57		1958.57	
	50 K	N+P	1026.88		1072.31		1897.18		2016.45	
	75 K	N+P	995.94		1040.27		2199.15		2317.02	
N+P	15 N+P	K	3099.74	2320.66	3189.98	2393.65	666.47	1012.02	734.57	1087.36
	25 N+P	K	2706.18		2784.69		663.67		730.46	
	50 N+P	K	1987.68		2058.90		1238.21		1315.45	
	75 N+P	K	1489.04		1541.03		1479.75		1568.96	
N+K	15 N+K	P	2201.35	1658.35	2270.84	1717.76	680.63	1027.78	750.59	1109.39
	25 N+K	P	1556.23		1624.95		720.60		793.31	
	50 N+K	P	1560.97		1612.77		1305.32		1394.93	
	75 N+K	P	1314.86		1362.49		1404.56		1498.73	
P+K	15 P+K	N	2844.00	2345.00	2933.50	2422.82	752.69	1069.17	825.00	1151.04
	25 P+K	N	2818.37		2903.09		869.93		953.91	
	50 P+K	N	1927.58		1993.81		1204.48		1286.79	
	75 P+K	N	1790.06		1860.86		1449.59		1538.44	
N+P+K	15 N+P+K	—	6328.96	4057.98	6424.23	4129.70	428.10	1217.25	475.18	1303.36
	25 N+P+K	—	6440.49		6542.83		684.89		749.56	
	50 N+P+K	—	2133.34		2188.42		1724.98		1834.60	
	75 N+P+K	—	1329.12		1363.30		2031.01		2154.10	
Control " treatment (Mineral fertilizers 100%RD) in straw							6326.58			
Control " treatment (Mineral fertilizers 100%RD) in seeds							6823.88			
L.S.D in straw							1.08			
L.S.D in seeds							1.02			

Table 6: Effect of Nano and inorganic fertilizer rates on P uptake (mg pot^{-1}) in straw and seeds by faba bean plant.

Treatments										
addition Forms										
Element	Nano-fertilizers						Mineral fertilizers			
	%	Full (RD)	P uptake in straw (mg pot^{-1})	Means	P uptake in seeds (mg pot^{-1})	Means	P uptake in straw (mg pot^{-1})	Means	P uptake in seeds (mg pot^{-})	Means
N	15 N	P+K	314.17	246.39	485.94	365.64	115.97	190.10	141.74	217.25
	25 N	P+K	315.78		449.78		154.82		177.75	
	50 N	P+K	222.90		336.30		210.86		240.99	
	75 N	N+K	132.72		190.53		278.78		308.53	
P	15 P	N+K	446.27	256.58	582.96	346.30	105.61	143.46	137.62	178.49
	25 P	N+K	359.17		460.80		118.93		151.95	
	50 P	N+K	139.32		200.10		168.47		205.88	
	75 P	N+K	81.55		141.33		180.82		218.49	
K	15 K	N+P	161.70	126.81	261.04	204.29	178.58	224.68	211.63	256.55
	25 K	N+P	198.72		296.10		216.42		248.86	
	50 K	N+P	80.42		134.64		238.50		271.03	
	75 K	N+P	66.40		125.37		265.22		294.69	
N +P	15 N+P	K	419.62	252.90	538.80	347.14	80.22	113.10	100.77	133.66
	25 N+P	K	352.98		456.30		100.18		118.93	
	50 N+P	K	145.44		231.12		130.34		149.66	
	75 N+P	K	93.55		162.33		141.68		165.29	
N + K	15 N+K	P	237.98	176.29	325.05	256.18	133.58	169.17	154.74	190.79
	25 N+K	P	241.65		336.00		145.44		167.49	
	50 N+K	P	139.79		207.90		189.86		210.95	
	75 N+K	P	85.75		155.76		207.78		229.96	
P+ K	15 P+K	N	329.56	225.96	424.90	311.96	101.72	138.27	122.03	163.07
	25 P+K	N	338.69		433.08		129.73		155.14	
	50 P+K	N	129.17		207.27		146.70		172.42	
	75 P+K	N	106.44		182.59		174.95		202.70	
N +P + K	15 N+P+K	—	796.22	473.75	987.15	592.54	51.37	134.75	65.62	134.58
	25 N+P+K	—	817.84		995.11		90.92		107.06	
	50 N+P+K	—	185.51		266.24		179.48		166.57	
	75 N+P+K	—	95.42		121.50		217.22		199.07	
Control " treatment (Mineral fertilizers 100%RD) in straw						795.13				
Control " treatment (Mineral fertilizers 100%RD) in seeds						799.72				
L.S.D in straw						1.61				
L.S.D in seeds						1.31				

Table 7: Effect of Nano and inorganic fertilizer rates on K uptake (mg pot-1) in straw by faba bean plant.

Element	%	Full (RD)	Nano-fertilizers: K uptake in straw (mg pot-1)	Means	Nano-fertilizers: K uptake in seeds (mg pot-1)	Means	Mineral fertilizers: K uptake in straw (mg pot-1)	Means	Mineral fertilizers: K uptake in seeds (mg pot-)	Means
N	15 N	P+K	2466.83	1848.40	2559.96	1924.64	904.53	1324.45	940.63	1372.37
	25 N	P+K	2189.41		2273.65		1075.13		1121.01	
	50 N	P+K	1595.96		1670.37		1455.95		1506.12	
	75 N	N+K	1141.39		1194.57		1862.22		1921.73	
P	15 P	N+K	2844.98	1804.76	2961.22	1883.40	1200.13	1408.00	1244.92	1459.76
	25 P	N+K	2328.79		2421.58		1288.43		1338.02	
	50 P	N+K	1100.63		1154.04		1527.42		1583.54	
	75 P	N+K	944.64		996.75		1616.04		1672.57	
K	15 K	N+P	2132.37	1596.48	2213.29	1661.07	1091.31	1273.80	1140.88	1327.10
	25 K	N+P	2046.82		2126.41		1222.77		1280.46	
	50 K	N+P	1144.41		1193.96		1333.44		1384.08	
	75 K	N+P	1062.34		1110.62		1447.68		1502.96	
N+P	15 N+P	K	3004.99	2065.22	3113.32	2151.76	759.03	888.05	791.95	924.23
	25 N+P	K	2553.22		2650.99		782.63		813.90	
	50 N+P	K	1658.02		1735.68		955.81		994.41	
	75 N+P	K	1044.66		1107.05		1054.71		1096.67	
N+K	15 N+K	P	2488.92	1964.24	2573.01	2034.43	718.79	876.48	750.63	914.18
	25 N+K	P	2561.49		2638.78		766.88		802.11	
	50 N+K	P	1498.84		1561.00		973.05		1015.22	
	75 N+K	P	1307.72		1364.92		1047.19		1088.77	
P+K	15 P+K	N	3210.18	2347.78	3311.93	2436.48	752.69	887.85	784.32	925.34
	25 P+K	N	3108.67		3201.52		862.30		900.43	
	50 P+K	N	1669.25		1748.73		903.36		941.94	
	75 P+K	N	1403.02		1483.75		1033.04		1074.67	
N+P+K	15 N+P+K	—	6165.63	3955.72	6329.10	4072.64	440.94	907.84	331.08	913.14
	25 N+P+K	—	6256.48		6420.18		678.83		709.13	
	50 N+P+K	—	2092.12		2178.02		1186.55		1233.01	
	75 N+P+K	—	1308.67		1363.27		1325.04		1379.32	
Control " treatment (Mineral fertilizers 100%RD) in straw			6173.54							
Control " treatment (Mineral fertilizers 100%RD) in seeds			6374.09							
L.S.D in straw			2.01							
L.S.D in seeds			1.92							

تأثير الأسمدة النانوية والأسمدة الكيماوية على نمو النبات ومحتوى العناصر لنبات الفول البلدي.

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الملخص العربي

تهدف التجربة إلى دراسة تأثير الأسمدة النانوية NPK المطبقة بمعدلات مكافئة أو أقل يمكن أن تحل محل المستويات الموصى بها من الأسمدة الكيماوية ((NPK دون آثار رجعية على نمو النبات وإنتاجية المحصول ومحتوى العناصر. تم تصميم تجربة أصص ذات قطاعات كاملة العشوائية في ثلاث مكررات في الصوبة الزراعة بقسم الأراضي والمياه، كلية الزراعة، جامعة الأزهر (مدينة نصر، القاهرة، مصر)، خلال الموسم الشتوي 2019. تمت إضافة الأسمدة النانوية بمعدلات (15٪ ، 25٪ ، 50٪ و 75٪) من الجرعات الموصى بها من K , P , N وتفاعلاتها مقارنة بالأسمدة الكيماوية (الكنترول) على نمو وإنتاجية المحصول ومحتوى العناصر لنبات الفول (Vicia) faba L.) النامي في التربة الرملية الطميية . اشتملت التجربة على 7 معاملات التسميد الفردي نانو (P،N، (Kثنائي النانو (N + P) ، (N + K)، (P + K)، ثلاثي النانو (N + P + K) مقارنة مع معاملة 100% من الموصي به من الأسمدة الكيماوية . زرعت ستة بذور فول في كل أصيص. أظهرت النتائج أن استخدام الأسمدة النانوية NPK بمعدلات منخفضة من المستويات الموصى بها من الأسمدة غير النانوية NPK (الأسمدة الكيماوية). أدى إلى زيادة الوزن الجاف وإنتاجية المحصول ومحتوى العناصر مقارنة باستخدام الأسمدة التقليدية. وفي هذا الصدد، كانت المعاملة الأنسب هي 25٪ (NPK)من الأسمدة النانوية منRD ، التي أعطت أعلى قيم لجميع الصفات المذكورة أعلاه.

الكلمات الاسترشادية: أسمدة النانو، الأسمدة الكيماوية، الفول البلدي