Effect of spraying with normal and Nano NPK fertilizers and their interference in growth indicators of strawberry seedlings Fragaria *ananassa* Duch. Ruby gem cultivar

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Abstract

This field study was carried out in the plastic canopy of the Dept. of Horticulture and Landscape, College of Agriculture / University of Kerbala on 2019 (during spring season). The design of the experiment was a Randomized Complete Block Design (RCBD) with three replications. The experiment included nine treatments resulting from the combinations among three concentrations of the regular NPK fertilizer (0, 3, and 6) g. l^{-1} with NPK nano-fertilizer (0, 1.5, and 3) g. l^{-1} in order to investigate the impact of foliar addition with these single and combined treatments on strawberry plants cultivar Ruby gem. The results showed that the spraying of the NPK nano fertilizer in combination with the regular fertilizer NPK (at different combinations) had a significant effect on the leaf area and the content of leaves from chlorophyll (985 cm^2, 44.27 SPAD) respectively, which was reflected on the fruit yield and quality represented by the size, length, diameter and weight of the fruit (17.67 cm^3, 37.87 mm, 32.92 mm, 15.13g) respectively in addition to the content of the fruits of total soluble solids and lycopene pigment (17.00%, 0.1890 mg/100 ml) respectively. It could be concluded that it is possible to rely on the use of modern nano-fertilizer technology combined with normal fertilizer in low quantities of recommendations to reach the optimal production of various agricultural crops and reduce the environmental impact by severe usage of the fertilizer's recommendations.

Keyword: Nano-fertilizer, NPK, Ruby gem, lycopene pigment

Introduction

The strawberry plant, *Fragaria X ananassa* Duch. belongs to the Rosaceae family and its name is derived from the Latin word (fragrant, fragrance). Strawberry is a perennial herbaceous plant that adapts to a wide range of temperatures and grows as a wild and cultivated plant. It is considered one of the small fruits spread in the world due to its nutritional and therapeutic value, as it is an important source of vitamins, minerals and antioxidants that are related to human health [1,2]. Strawberry is grown in many countries, where the United States of America and China leading the global production of this crop [3]. Strawberry reproduces vegetatively by dividing the crown, especially in varieties that do not produce runners. It also propagates vegetatively by the runners, which are creeping stems with long and thin internode that originate from the axillary buds, which are able to give roots when they are in contact with the soil and on the upper side forming a rosette that is a group of leaves [4]. Each plant can produce about 7-10 runners, but if conditions are appropriate for the plant, it can reach 15 per plant. The runners produce roots in each node (usually beginning with the third node) and from these nodes a new plant is formed.

The necessary nutrients could enhance growth and production of crops, as they participate or assist in the metabolic processes in the plant, and their deficiency causes a physiological deterioration as a result of the nutritional imbalance. In recent years, modern science has tended to use smart fertilizers or nano fertilizers that are added to the soil either by mixing or with irrigation water or spraying on the plant in order to nourish the plants and improve production and soil properties, as adding them activates carbon metabolism and increases the effectiveness of antioxidant enzymes, which leads to direct Impact on quantitative and qualitative production [5]. Nanotechnology is the latest technology used in this field, which is concerned with studying the basic principles of molecules and compounds whose dimensions range between (1-100) nanometers and their uses in various fields of life, including the agricultural field. Studies indicate that the use of nano-fertilizers increases the efficiency of nutrient application and reduces potential negative effects when added in the conventional form [6]. Nano-fertilizers can be considered as the best alternative to conventional fertilizers because they help to sustain the environment and increase the surface of absorption, thus boosting the photosynthesis process which improve the availability of the active substances in the plant [7]. Nano-fertilization could increase yield quality of strawberry by increasing phenolic content and aroma [8] as well as the nano- fertilizers could produce tolerated plants to stresses [9].

The study aimed to demonstrate the effect of conventional and nano-chemical fertilizer on the nutritional balance of the plant and its reflection on the growth and productivity of strawberry and to create an integrated fertilization program (chemical, nanoscale) for strawberry plants for the purpose of encouraging and enhancing the indicators of vegetative growth and improving the quality of fruits.

Materials and Methods

The study was applied in the plastic canopy of the Dept. of Horticulture and Landscape / College of Agriculture / University of Kerbala on 2019 (during spring season) to examine the impact of spraying with three concentrations of normal NPK fertilizer (0, 3, and 6) g. l^{-1} and NPK nano-fertilizer (0, 1.5, and 3) g. l^{-1} on the growth of seedlings of strawberry Ruby gem cultivar. A 3 * 3 factorial experiment was carried out with two factors, namely, conventional chemical fertilizer (NPK) and nano-composition (NPK) with three concentrations of each with three replicates in a randomized complete block design (RCBD). 90 seedlings strawberry of consistent size and growth were selected Ruby gem variety (Turkish origin), which is one of the neutral plants in response to light (10 plants for each unit treatment). The plants were sprayed with the above treatments as the experiment included three sprays, starting from (31/01/2019) for the first spray and the second spray was (21/02/2019) after three Weeks after the first spray while the third spray was (13/3/2019), three weeks after the second spray. The spraying was carried out in the early morning for the nanoparticle treatments and in the evening of the same day for the compound chemical fertilizer according to the above dates after the seedlings were irrigated one day before the date of the treatment. The seedlings were left for one month after the third spray in order to stabilize the mineral elements inside the seedling tissues. All agricultural operations, including irrigation, weeding and cultivation, were carried out regularly throughout the experiment period. The statistical analysis of collected data were performed by (GenStat 12) program, and the least significant difference test, L.S.D, at a probability level (0.05) was used to compare the means. Five plants were chosen randomly at each experimental units on 13/4/2019 and the following traits were measured:

1- leaf area (cm^2) was measured according to the [10] using 5 leaves per treatment by Well-defined area borer according to the following equation: leaf area (cm^2) = Weight of dry leaf (g) × The known leaf area (for cut discs cm^2) / Dry weight of known leaf area (for cut discs).

2- Chlorophyll content: The chlorophyll content was measured using the 502-SPAD device by taking the reading of 5 leaves for each seedling in the treatment unit and then taking the averages [11] and the was expressed in SPAD units according to the method by [12].

3- Fruit size measured by the volumetric method (displaced water) cm^3.

4- Fruit length measured using a foot (mm).

5- Fruit diameter measured using a foot (mm).

6- Fruit weight (g) measured using the sensitive balance (GM). A group of fruits were weighed for each repeat and the rate was extracted for each treatment.

7- The total of soluble solids T.S.S% A random sample of 10 fruits from each experimental unit at full ripe stage was taken to determine the percentage of soluble solids content by using hand refractometer as mentioned by [13].

8- Lycopene content was measured using Kimura's method and Lycopene content was expressed as mg/100 ml as mentioned by [14].

Results and Discussion

Leaves area (cm^2)

It is shown at Table (1) that the treatment with the usual compound chemical fertilizer NPK did not have a significant effect on the average leaf area throughout the research period, while the treatment with nano-NPK fertilizer led to a significant impact in this property, where the concentration of 1.5 g. l^{-1} exceeded the other combined treatments and gave the highest rate of 804 cm^2

The interaction between the treatments showed a significant effect among them, but the treatment (3 g. l^{-1} normal NPK fertilizer + 1.5 g. l^{-1} nano NPK) was the best among them, as it recorded the highest rate of 985 cm^2 compared to the other combined treatments (Table 1).

Table (1): Influence of (normal and nano) NPK fertilizers and interaction between them in leaf area (cm^2)

Normal- NPK g. l^{-1} / **Nano-NPK g. l^{-1}**	**0**	**3**	**6**	**The Average**
0	443	564	898	632
1.5	749	985	677	804
3	506	360	507	457
The Average	566	636	694	
L.S.D. 0.05	Normal-NPK n. s.	Nano-NPK 278.700	Interaction 482.700	

Chlorophyll pigment

The results showed that the treatment with the normal NPK fertilizer had a significant impact on the values of chlorophyll content, where at concentration of 6 g. l^{-1} was superior to the rest of the treatments by recording the highest rate of 43.320 SPAD relating to the other treatments, while spraying with nano-NPK did not significantly affect this trait throughout the duration of the experiment (Table 2). The interaction between the treatments led to a significant effect among them, as treatment of (6 g. l^{-1} of regular NPK & 3 g. l^{-1} of nano-NPK) was the best among the interaction treatments, as it recorded the highest rate of 44.270 SPAD (Table 2).

Table (2): Influence of (normal and nano) NPK fertilizers and interaction between them in Chlorophyll content

Normal- NPK g. l^{-1} / **Nano-NPK g. l^{-1}**	**0**	**3**	**6**	**The Average**
0	43.100	38.530	42.150	41.260
1.5	43.250	38.920	43.550	41.910
3	39.620	40.620	44.270	41.500
The Average	41.990	39.360	43.320	
L.S.D. 0.05	Normal-NPK 1.546	Nano-NPK n. s.	Interaction 2.678	

Fruit size (cm^3)

It is noticed from the data of Table (3) that there was a significant impact in relation to the treatment with the normal NPK fertilizer on the average fruit size, as the treatment of 3 g. l^{-1} was superior to other treatments by giving it the highest rate of 15.670 cm^3 compared with the control treatment that gave an average 12.830 cm^3. It is also noticed from the table below that the treatment with nano-NPK had a remarkable impact on the values of this characteristic and at concentration of 3g. l^{-1} these values exceeded the other applied treatments, and it gave a rate of 16.170 cm^3 compared to 12.780 cm^3, which was recorded in the comparison treatment. The interaction between the treatments led to a significant effect among them, which reached a maximum when the treatment was 6 g. l^{-1} normal-NPK with 3g. l^{-1} nano-NPK fertilizer, which amounted to 17.670 cm^3 related to the control treatment, which produced the lowest rate (11.330 cm^3).

Table (3): Influence of (normal and nano) NPK fertilizers and interaction between them in the average of fruit size (cm^3)

Normal- NPK g. l^{-1} / **Nano-NPK g. l^{-1}**	**0**	**3**	**6**	**The Average**
0	11.330	14.50	12.500	12.780
1.5	11.830	15.830	017.50	15.050
3	14.170	16.670	17.670	16.170
The Average	12.830	15.670	15.500	
L.S.D. 0.05	Normal-NPK 1.954	Nano-NPK 1.954	Interaction 3.384	

Fruit length (mm)

The data of Table (4) show that there was no noticeable impact in relation to the spraying with normal NPK fertilizers in relation to the average length of the fruit. It is also noted from the same table that the treatment with nano-NPK also did not significantly affect the rate of this trait throughout the research period, while the interaction between the treatments led to a significant effect among them, which reached a maximum when the treatment was 3 g. l^{-1} normal NPK and 1.5 g. l^{-1} nano fertilizer, which amounted to 37.870 mm compared to the comparison treatment, which gave 33.390 mm.

Table (4): Influence of (normal and nano) NPK fertilizers and interaction between them in the average of fruit length (mm)

Normal- NPK g. l^{-1} / Nano-NPK g. l^{-1}	0	3	6	The Average
0	33.390	35.810	37.290	35.500
1.5	35.820	37.870	32.970	35.550
3	33.560	35.710	36.190	35.150
The Average	34.260	36.470	35.480	
L.S.D. 0.05	Normal-NPK n. s.	Nano-NPK n. s.	Interaction 3.957	

Fruit diameter (mm)

The outcomes at Table (5) reveal that there was no remarkable impact for the application with regular NPK fertilizer on the average diameter of the fruit, while the treatment with nano-NPK led to a prominent impact on the values of this property, where at concentration 1.5 g. l^{-1} the value of fruit diameter was superior related to the other sprayed applications and gave high mean (30.08 mm) in comparison to the other concentrations. Combined treatments also led to a significant effect among the treatments, whereby the treatment (3 g. l^{-1} normal fertilizer and 1.5 g. l^{-1} nano-NPK) outperformed the other interacted treatments by recording high rate (32.920 mm) compared to the control treatment, which gave less value (25.270 mm).

Table (5): Influence of (normal and nano) NPK fertilizers and interaction between them in the average of fruit diameter (mm).

Normal- NPK g. l^{-1} / Nano-NPK g. l^{-1}	0	3	6	The Average
0	25.270	29.450	29.960	28.230
1.5	29.640	32.920	27.680	30.080
3	28.710	25.680	28.150	27.520
The Average	27.880	29.350	28.600	
L.S.D. 0.05	Normal-NPK n. s.	Nano-NPK 1.635	Interaction 2.831	

Fruit weight (g)

By observing the results of Table (6), it is evident that the average of fruit weight was affected by the normal NPK treatments for the duration of the research, where the spraying with 3 g. l^{-1} was superior by registering the highest rate of 14.500 g in comparison with the rest of the treatments. The same table shows that the treatment with nano-NPK reflected a remarkable influence on the values of this property, as spraying with 3 g. l^{-1} recorded the highest value (14.760 g) in comparison with the less recorded rate in the control plants, which amounted to 11.480 g. The interaction between the treatments also produced a considerable influence on this trait, as the application with (3 g. l^{-1} ordinary NPK fertilizer + 1.5 g. l^{-1} nano fertilizer) recorded the highest average fruit weight of 15.130 g compared to the lowest rate recorded in the application with 6 g. l^{-1} of the normal NPK with 0 g. l^{-1} of nano fertilizer which recorded 9.420 g (Table 6).

Table (6): Influence of (normal and nano) NPK fertilizers and interaction between them in fruit weight (g)

Normal- NPK g. l^{-1} / Nano-NPK g. l^{-1}	0	3	6	The Average
0	10.870	14.160	9.420	11.480
1.5	13.130	15.130	11.100	13.120
3	15.110	14.220	14.950	14.760
The Average	13.040	14.500	11.830	
L.S.D. 0.05	Normal-NPK 3.025	Nano-NPK 3.025	Interaction 5.239	

Total Soluble Solids Ratio (T.S.S) (%)

The outcomes at Table (7) confirmed the clear impact (significant) of spraying with normal NPK fertilizer in the percentage of total soluble solids, where the treatment excelled with 3 g. l^{-1} by registering the highest rate of 15.390% related to the control plants, which produced less value (13.170%). It also appears from the same table that the treatment with nano-NPK also had a considerable influence on the value of this trait, as the spraying with 3 g. l^{-1} recorded the highest results compared to the rest of the treatments, which amounted to 15.170%. The interaction between the treatments led to a significant effect among them, which reached a maximum when the treatment was 3 g. l^{-1} of ordinary NPK and 3 gm. l^{-1} of nano-NPK, which amounted to 17.000% compared to the control treatment, which gave 13.170% (Table 7).

Table (7): Influence of (normal and nano) NPK fertilizers in Total Soluble Solids Ratio (T.S.S) (%)

Normal- NPK $g.\ l^{-1}$ / Nano-NPK $g.\ l^{-1}$	0	3	6	The Average
0	13.170	14.830	12.670	13.560
1.5	12.500	14.330	13.920	13.580
3	13.830	17.000	14.670	15.170
The Average	13.170	15.390	13.750	
L.S.D. 0.05	Normal-NPK 1.083	Nano-NPK 1.083	Interaction 1.876	

Lycopene content (mg/100 ml)

It was noticed from the results revealed in Table (8) that there was a considerable influence in relation to the treatment with the normal NPK fertilizer on the rate of lycopene pigment throughout the research period, where the spraying with 3 $g.\ l^{-1}$ was superior by registering the highest rate of 0.149 mg/100 ml related to the control plots, which recorded less value (0.087 mg/100 ml).It also appears from the same table that the treatment with nano-NPK also resulted in remarkable impact on the value of this trait, as spraying treatment with 3 $g.\ l^{-1}$ recorded high value in relation to the other applied single treatments of nano-NPK, which amounted 0.154 mg/100 ml. It is noted from the same table that the interaction between the treatments also had a noticeable impact on this parameter, as the spraying with 3 $g.\ l^{-1}$ of ordinary NPK fertilizer and 3g. l^{-1} of nano-NPK recorded the highest rate of 0.189 compared to the comparison treatment, which recorded 0.067 mg/100 ml.

Table (8): Influence of (normal and nano) NPK fertilizers and interaction between them in Lycopene content (mg/100 ml)

Normal- NPK $g.\ l^{-1}$ / Nano-NPK $g.\ l^{-1}$	0	3	6	The Average
0	0.067	0.139	0.077	0.094
1.5	0.068	0.119	0.113	0.100
3	0.127	0.189	0.148	0.154
The Average	0.087	0.149	0.113	
L.S.D. 0.05	Normal-NPK 0.012	Nano-NPK 0.012	Interaction 0.012	

It is noted from the results of the above tables that the interaction between the added fertilizers is superior. The reason for the superiority of the treatment of the interaction of the nano-NPK fertilizer (3 g. l^{-1}) with the regular fertilizer is that the nano fertilizer has distinctive properties resulting from the high surface area and the smallness of the particles, which leads to its absorption, spread and then availability to plants, and this leads to stimulating plant growth, provided that they are added in low concentrations [15].

The growth enhancement could be attributed to the impact nutrients included in the nano-fertilizer, which includes nitrogen, phosphorous and potassium, as these elements affect meristematic growth, and encourage the fixation of CO_2 gas, and then increase the capacity of the photosynthesis process and the role of its products in building the vegetative system as well as The role of potassium in the absorption of nutrients, increasing its concentration in the leaves, activating the starch synthetase enzyme, which increases starch synthesis, increasing the efficiency of the photosynthesis process and increasing its outputs [16]. In addition to that, the vital role played by these elements in building chlorophyll and stimulating the enzymes of the photosynthesis process [17]. In light of these functions and participation between the three elements, it led to an improvement in the characteristics of the vegetative growth of seedlings, including an increase in the leaf area, and this could reflect on the process of photosynthesis and eventually the nutrients accumulation, which appeared in all the studied characteristics in the research.

The reason for this increase in chlorophyll pigment is due to the role of spraying with NPK nano fertilizer in increasing the elements and its role in stimulating vital processes, including the construction of chlorophyll pigment, especially the nitrogen element, which has a direct and important role in building chlorophyll pigment, as nitrogen participates in the installation of the four Porphyrins groups (a group of pigments and iron) included in the composition of chlorophyll [18] which leads to an increase in the content of chlorophyll in leaves. These results are in agreement with what was stated by [19, 20] in olives and [21] in figs in terms of increasing the leaf area of seedlings treated with NPK nano fertilizer.

Conclusion

This study indicated the possibility of field use of nano-fertilizers to reduce the excessive use of the required quantities of regular fertilizers for agricultural production, as it is possible to rely on low concentrations of nano-fertilizers to reach the desired results.

This study recommends conducting future experiments to test different types and quantities of nano-fertilizers individually or in combination and on different horticultural crops, in addition to testing the qualities of the yield to determine the fertilizer recommendations of these fertilizers, which will certainly be less than what is recommended of ordinary fertilizers to maintain the ecosystem.

References

1) Morgan, L. (2006). Hydroponic Strawberry production, A technical guide to the hydroponic production of Strawberries. Suntec (NZ) Ltd, Tokomaru, New Zealand.
2) Galli, V.; da Silva Messias; R. Perin; E. C. Borowski; J.M.; Bamberg, A. L. and Rombaldi, C.V. (2016). Mild salt stress improves strawberry fruit quality. LWT, 73: 693-699.
3) FAO. (2018). FAOSTAT Agricultural statistics database. Roma, Italy.
4) Al-Dujaili, J. A. H. (1993). Production of small-fruited fruits, University of Baghdad, Ministry of Higher Education and Scientific Research, Republic of Iraq.
5) Gerdini, F. S. (2016). Effect of nano potassium fertilizer on some parchment Pumpkin (*Cucurbita pepo*) morphological and physiological characteristics under drought conditions. International Journal of Farming and Allied Sciences 5 (5): 367-371.
6) Monreal, C.M.; DeRosa, M.; Mallubhotla, S.C.; Bindraban, P.S. and Dimkpa, C., (2016). Nanotechnologies for increasing the crop use efficiency of fertilizer-micronutrients. Biol. Fertil. 52 (3), pp.423-437.
7) Singh, A; S. Singh and Prasad, S.M. (2016). Scope of nanotechnology in crop science: profit or loss. Research and Reviews: J. Bot.Sci. 5(1): 1-4.
8) Weber, C.N.; Koron, D.; Jakopiˇc, J.; Veberiˇc, R.; Hudina, M.; Baša Cesnik, H. (2021). Influence of nitrogen, calcium and nano-fertilizer on strawberry (*Fragaria* × *ananassa* Duch.) fruit inner and outer quality. Agronomy, 11, 997
9) Mozafari, A.A.; Havas, F.; Ghaderi, N. (2018). Application of iron nanoparticles and salicylic acid in vitro culture of strawberries (*Fragaria* × *ananassa* Duch.) to cope with drought stress. Plant. Cell. Tissue Organ. Cult. (PCTOC), 132, 511–523.
10) Watson, D. j. and A. M. Watson. (1953). Comparative physiological studies on the growth of field crops. III. Effect of infraction with Beet yellow. Ann. Appl. Biol., 40:1
11) Minnotti, P. L.; D. E. Halseth and J. B. Sieczka. (1994). Chlorophyll measurement to assess the nitrogen status of Potato varieties. Hort. Sci. 29 (12): 1497 – 1500.
12) Jemison, J. and M. Williams. (2006). Potato Grain study project Report. Water Quality office. University of Maine Cooperate Extension.

13) Shafshak, N. S.; S. M. Eid; F. A. Abo Sedera and M. H. M. Mohamed. (2011). Improving growth and productivity of strawberry via soil addition and foliar application of some safety growth stimulating compounds. Annals of Agric. Sci. Moshtohor 49(2): 153 –162.

14) Arthanari, M.; and Dhanapalan, S. (2019). Quantification of β-carotene, lycopene, and chlorophyll content in tomato fruits of enrichment of chicken feathers composting. Int. J. Recycl. Org. Waste Agricult. 8: 473–477.

15) Kole, C.; D. S. Kumar and Khodakovskaya, M. V. (2016). Plant Nano-technology:Principles and Practices. Springer International Publishing. Switzerland.

16) Marschner, H., (2011). Marschner's mineral nutrition of higher plants. Academic press.

17) Yassin, B. T. (2001). Fundamentals of plant physiology. College of Science - Qatar University. Qatar.

18) Taiz, L. and Zeiger, E. (2006). Plant Physiology. 4th ed. Sinauer Associates, In C., Publishers.www.Sinauer.Com.

19) Hagagg, L.F.; N. S. Mustafa; E.A.E. Genaidy and El-Hady, E. S. (2018). Effect of spraying nano-NPK on growth performance and nutrients status for (Kalamata cv.) olive seedling. Biosci. Res. 15(2): 1297-1303.

20) Hagagg, L.F.; N. S. Mustafa; E.A.E. Genaidy and El-Hady. E. S. (2018). Impact of nanotechnology application on decreasing used rate of mineral fertilizers and improving vegetative growth of Aggizi olive seedlings. Biosci. Res. 15(2): 1304-1311.

21) Mustafa, N. S.; H. H. Shaarawy; M.F. El-Dahshouri and Mahfouze, S. A. (2018).Impact of nano-fertilizer on different aspects of growth performance, nutrient status and some enzymes activities of (Sultani) fig cultivar. Biosci. Res.15(4):3429-3436.