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Evaluating the Effect of NPKMg Nonofertilizers on the Productivity of Zaghloul Date Palm

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ABSTRACT

Throughout 2021 and 2022 seasons, Zaghlul date palm was fertilized with NPKMg via nano-technology system versus traditional fertilizers. Three doses of both, NPKMg nano-fertilizers and through - conventional mineral NPKMg fertilizers were added to each palm/ year. All nutrients were added via fertigation except Mg used via foliage spraying. The target was examining the effect of using NPKMg fertilizers versus normal ones on the fruiting of Zaghloul date palm. Treating Zaghloul date palm with NPKMg via nano fertilizers regardless to the levels was measurably superior to using these fertilizers, via traditional methods in enhancing yield and fruit quality. Varying NPKMg levels applied via a nano-system from 100 to 200, 50 to 100, 50 to 100, and 20 to 40 g/ palm/year, respectively had negligible promotion on all the studied parameters. Supplying Zaghloul date palm grown under sandy soil with NPKMg via nano-technology system at 100, 50, 50, and 20 g/palm/year, respectively succeeded in improving yield and fruit traits.

Keywords: *Nanofertilizer, phoenix dactylifera, Zaghloul variety, growth, yield, fruit characteristics*

1. INTRODUCTION

Zaghloul date palm cultivar represent a vital assortment of soft date cultivars in Egypt which have effectively thrived in Minia, governorate. It is highly anticipated that the Egyptian Zaghloul date palm fruits will spearhead the exportation of Egyptian produce to European and Arab markets. Numerous obstacles were encountered by the agricultural sector in the past, such as decreased crop yield, inefficient use of fertilizers, loss of nutrients, climate change, and limited water availability, which led to restriction in the sustainability of agricultural practices. Along with all of those difficulties, farmers are using large amounts of fertilizers and the cost of conventional fertilizers (CFs) has increased significantly. On the other hand, excessive fertilizers usage has been linked to a number of environmental issues, such as groundwater contamination, degraded soil, and toxicity to useful organisms in the soil. (Tan *et al.*, 2005, Brunner, *et al.*, 2006 and Laghar *et al.*, 2010).

Furthermore, depending on the characteristics of the soil, a significant quantity of most conventional fertilizers (CFs) might be lost to the environment during irrigation when using traditional techniques. About 40 to 70 % of N, between 80 to 90 % of P, and 50 to seventy 70 % of K are lost or being inaccessible to plants for absorption. (Ombódi and Saigusa, 2000 and Duhan *et al.*, 2017). In

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the meanwhile, by 2050, it is expected that consumption of macronutrients will reach 263 million tons. This is rather hard to reach (Alexandratos and Bruinsma, 2012).

In order to preserve food security and plug sustainability gaps, people are resorting to nove l strategies (Wang *et al.*, 2021). These initiatives aim to enhance the effectiveness of fertilizer usage in agricultural systems as well as synchronize nutrient availability without worsening the surrounding environment (Moulick *et al.*, 2020).

Nanotechnology provides the potential to c reate novel fertilizer types, like nano-fertilizers (NFs) (Seleiman *et al.*, 2020). NFs are characterized as necessary or helpful nutrient nanomaterials or nanoparticles that may be applied to crops at the nanoscale (1–100 nm) to promote plant development and enhance yield (Liu, and Lal, 2015; Chhipa, 2017). Compared to conventional fertilizers, novel fertilizers possess distinct attributes that render them more effective, owing to their favorable influences on crop productivity and nutritional value. This is attributed to the rapid assimilation by plant roots, infiltration into cells, movement and distribution within plant tissues when administered through foliar or soil application. (Ali and Al-Juthery, 2017, Morales-Díaz *et al.*, 2017and Singh *et al.*, 2017). However, because of their tiny particle size, large surface area, and excellent solubility in water, NFs are thought to enhance the accessibility of nutrients to plants while enhancing the efficiency of nutrient usage by 20% when applied to the soil (Chhipa, 2017; Ditta and Arshad 2016 and Siddiq and Husen, 2017).

Several researchers found that, in comparison to high levels of conventional chemical fertilizers much smaller quantities of NPK nano-fertilizers (10%) greatly enhanced agro-physiological attributes, biologically active substances, yield quantity, and nutritional value of a variety of crops, including wheat, potato, French beans, and pepper. (Hasaneen *et.al.*, 2016, Abdel-Aziz *et al.*, 2016, Elshamy *et.al.*, 2019, Abd El-Azeim *et.al.*, 2019 and Abdel-Aziz, 2021).

Foregoing study showed that using fertilizers via a nano-system was necessary for improving yield and fruit characteristics of different fruit and crop species (Larson and Frisvold, 1996, Junghua, 2000, Wassel *et al.*, 2017; Ahmed *et al.*, 2018 and 2019, and El-Wany, 2019).

The goal of this study was to assess the use of NPKMg via NFs technology system versus conventional ones to reduce the number of CFs and to compare the effects of applying both NFs and CFs alone on the leaf area, leaf chemical components, and Fruit characteristics of Zaghlul date palm trees grown in sandy soil.

2. MATERIALS AND METHODS

This investigation was carried out during 2021 and 2022 seasons on thirty years old Zaghloul date palm trees. They are characterized by being uniform in vigor and grown in a private orchard situated in West Minia district, Minia Governorate, Egypt. These selected palm trees were grown using vegetatively propagated by offshoot procedures and were spaced 8 by 8 meters apart, as well as characterized by regular bearing. Hand pollination was achieved by inserting five male strands over each female spathe after two days of female spathe breaking day period a 2-of female breaking, using the same source of pollens (Zaghloul date palm males) to avoid residues of meta xenia according to Musa, (1981). The chosen palms attained the standard agricultural and horticultural practices that were recommended by the Ministry of Agriculture of Egypt and being used in the orchard. The number of bunches was adjusted to ten bunches/palm and leaf bunch ratio was maintained at 8:1. Soil texture was sandy (Table 1).

Table (1): Analysis of the tested soil

Parameters	Values
Sand %	75
Silt %	12
Clay %	13
Texture	Sandy
pH (1: 2.5 extract)	8.11
E.C. (1: 2.5 extract) dsm^{-1}	3.13
Calcium carbonate %	2.9
Organic Matter %	0.11
Total N %	0.004
Available P (Olsen, ppm)	2.5
Available K (ppm, ammonium acetate)	96
Available Mg (ppm)	4.0

2.1. Soil Analysis

The analysis of the tested soil was conducted in accordance to the methodology proposed by Wilde *et al.* (1985). The palm trees were irrigated by a ~~to~~ drip irrigation system, using wells water. The salinity level of both the soil and irrigation water 2000 and 1500 ppm, respectively.

2.2. Treatments

Six treatments, were examined in this study:

1-Using NPKMg via traditional fertilizers at 250: 125: 125:50 g /palm.

2- Using NPKMg via traditional fertilizers at 500: 250: 250:100 g /palm.

3- Using NPKMg via traditional fertilizers at 1000: 500: 500:200 g /palm.

4- Using NPKMg via nano-fertilizers at 50: 25: 25:10 g /palm.

5- Using NPKMg via nano-fertilizers at 100: 50: 50:20 g / palm.

6-Using NPKMg via nano-fertilizers at 200: 100: 100:40 g / palm.

Every treatment was replicated 3 times with one palm acting as a separate replicate. Nitrogen, phosphorus, potassium, and magnesium were used in the form of ammonium nitrate (33.5 %N), phosphoric acid (80 % P_2O_5), potassium sulphate (48 % K_2O), and magnesium sulphate (9.6 % Mg), respectively.

2.3. Nano fertilizers

All of the NFs were utilized in accordance with the manufacturer's (Nanotech for Photo Electronics (located in Nanotech, Giza, Egypt) instructions. Fertilizers were applied at the growth start (Middle of Feb.) which N fertilizer was added via fertigation at ten equal batches phosphoric acid applied via fertigation was added at four equal batches. Potassium added via fertigation was used in six equal batches of magnesium and was foliage sprayed once just after fruit setting.

2.4. Measurements

During both seasons, the forming measurements were recorded:

1-Leaf area (cm^2) (Ahmed and Morsy, 1999).

2-Total chlorophylls (mg/ g. F.W.). The fresh pinnae were cut into small pieces and 0.2 g. weight from each sample was taken, homogenized and extracted by 25% acetone in the presence of little amount of Na_2CO_3 and silica quartz, then filtered through central glass funnel G_4. (Von –Wettstein, 1957).

3- Measurements of leaf content of N, P, and K.Accurate plant material (0.2 g) was digested using hydrogen peroxide and sulfuric acid as recommended by (Peach and Tracey, 1968). The digested materials were transferred quantitatively to 50 ml volumetric flask and raised up to the uniformity volume. Then, the following nutrients were determined:

- Nitrogen % was determined by the modified micro kjeldahl method as described by Chapman and Pratt, 1965) and Page *et al*., (1982).
- Phosphorus % was determined by using spekol spectrophotometer (Evenhus and Deward 1980 and Cottenie *et al*., 1982).
- Potassium % was determined by using Flame photometer according to the procedure reported by Jones *et al*. (1991).
- Yield/ palm (kg.) and bunch weight (kg.)
- Fruit characteristics namely weight (g.), height and diameter (cm.) fruit pulp, seed ratio (T.S.S.%) the fruit flesh was well minced with electric blender and poste was squeezed and the total soluble solids % was determined by using a hand refractometer according to (A.O.A.C. 2000). Total and reducing sugars % were determined according to volumetric method outlined in A.O.A.C. (2000). Non-reducing sugars percentage was computed by calculating the differences between total and reducing sugars, total acidity (as g malic acid/ 100 g / pulp), and total soluble tannins % was determined using the Indigo Carmen indicator according to Balbaa *et al.* (1981). Titration was carried out using 0.1 N potassium permanganate solutions. Tannins in fresh weight were calculated (as total tannins percentage) according to the following equation: 1 ml potassium permanganate (0.1 N) = 0.00416 g. tannins. (Lane and Eynon, 1965) and A.O.A.C., 2000).

2.5. Statistical analysis

The experiment was carried out in a randomized complete block design (RCBD), with three replicates. The experimental data were subjected to analysis of variance (ANOVA). Significant differences between treatments ($p \leq 0.05$) were assessed by the means new LSD test (Mead *et al.,* 1993).

3. RESULTS AND DISCUSSION

3.1. Effect of NPKMg fertilization Leaf area

As shown in Table (2), various NPKMg fertilization treatments applied via nano and traditional fertilizers had a significant effect on the leaf area. Supplying the palms with NPKMg via a nano-fertilizers system at 50 to 200, 25 to 100, 25 to 100, and 10 to 40 g/ palm/year had significantly stimulated the leaf area compared with the use of NPKMg via the traditional method at 250 to 1000, 125 to 50, 125 to 500, and 50 to 200 g/palm/year, respectively. There was a gradual and significant promotion in the leaf area by increasing the levels of NPKMg applied via the traditional method fertilizers. However, increasing levels of NPKMg applied via nano-fertilizer ~~on~~ from 100 to 200, 50 to 100, 50 to 100, and 20 to 40 g/palm/year, respectively, failed to show significant promotion on the leaf area. The largest leaf area (1.76, 1.81 m^2) was recorded for the palms that received NPKMg via nanosystem at 200: 100: 100: 40 g/palm/year, for both seasons respectively. The lowest values were recorded ~~on~~ for the palm that fertilized with NPKMg via the traditional fertilizers at 250: 125, 125, and 50g per palm per year, respectively. Throughout both seasons, these outcomes held true.

3.2. Effect of NPKMg via nano-fertilizer Leaf chemical components

Data in Table (2) clearly demonstrate that total chlorophylls, as well as percentages of N, P, and K were significantly enhanced in response to supplying the palms with NPKMg via nano-fertilizer, relative to using these fertilizers via traditional methods. There was a gradual and significant promotion of these chemical traits with increasing levels of NPKMg in both methods of application. However, increasing levels of NPKMg applied via-nano-fertilizer from 100 to 200 N, 50 to 100 P, 50 to 100 K, and 20 to 40 g/palm/year failed to show significant promotion of these chemical components. Fertilizing the palms with NPKMg via nanotechnology at 200 to 100: 100: 40 g/palm/year gave the maximum values. The lowest results, 250: 125: 125: 50 g/palm/year, were found on palms fertilized with NPKMg using the traditional method. During the two seasons, these outcomes held true.

3.3. Effect of NPKMg via nano-fertilizer on bunch weight and yield/palm

According to the data in Tables (2 and 3) bunch weight and yield per palm varied significantly among the six NPKMg treatments. Both were significantly boosted by nutrition with NPKMg via nano-systems than when using traditional fertilizers. The promotion of bunch weight and yield per palm was significantly associated with increasing levels of NPKMg, regardless of the applied type. Increasing levels of NPKMg applied via the traditional method from 500 to 1000, 250 to 500, 250 to 500, and 100 to 200 g/palm/year, respectively, signified promotion, while in the case of nanosystems, raising levels of NPKMg from 100 to 200, 500 to 100, 50 to 100, and 20 to 40 g/palm/year had no significant promotion.

Hence, considering the economic perspective, the most optimal approach entailed applying nanotechnology for the fertilization of Zaghloul date palm with NPKMg at the rates of 100, 50, 50 and 20 g/palm/year, respectively.

Under the aforementioned treatment, the productivity achieved per palm was 112 and 111 kg for the first and second seasons, respectively, whereas in the palm trees subjected to the conventional fertilization with NPKMg at rates of 1000 to 500:500, the yield per palm for each season reached 100 and 103 kg, for both seasons respectively. The increase in yield per palm resulting from the aforementioned treatment compared to those treated with higher levels of NPKMg amounted to 12.0 and 9.7% for both seasons, respectively. This implies that the utilization of the nanosystem effectively conserved approximately 90% of NPKMg fertilization, while simultaneously yielding a net profit surpassing that of the conventional method. The lowest yield (90 and 89 kg) was recorded for palms fertilizer with NPKMg at 250, 125, 125 and 50, respectively through the traditional fertilizers. These results were true during both seasons.

Table (2): Effect of using nano NPKMg fertilizers versus traditional methods on the leaf area, total chlorophylls, percentages of N, P, and K in the leaves, and bunch weight of Zaghloul date palms during 2021 and 2022 seasons.

NPKMg treatments (g/palm)	Leaf area (m^2)		Total chlorophylls*		Leaf N %		Leaf P %		Leaf K %		Bunch weight (kg.)	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
Traditional fertilizers at: 250: 125: 125: 50	1.56	1.60	6.1	5.9	1.71	1.74	0.11	0.09	1.26	1.31	9.0	8.9
Traditional fertilizers at: 500: 250: 250: 100	1.59	1.63	6.5	6.6	1.80	1.86	0.14	0.15	1.31	1.36	9.5	9.6
Traditional fertilizers at: 1000: 500: 500: 200	1.64	1.67	7.0	7.1	1.90	1.96	0.17	0.18	1.36	1.41	10.0	10.3
Nano fertilizers at: 50: 25: 25: 10	1.71	1.75	7.9	7.9	1.98	2.03	0.20	0.22	1.41	1.48	10.6	10.8
Nano fertilizers at: 100: 50: 50: 20	1.75	1.80	8.9	9.0	2.05	2.10	0.23	0.25	1.47	1.54	11.2	11.3
Nano fertilizers at: 200: 100:100: 40	1.76	1.81	9.0	9.1	2.06	2.11	0.24	0.26	1.48	1.55	11.3	11.4
New L.S.D. at 5%	0.03	0.04	0.4	0.4	0.06	0.05	0.02	0.02	0.04	0.05	0.5	0.4

- **= (mg/ g F.W.)**

Table (3): Effect of using nano NPKMg fertilizers versus traditional methods on the yield and some physical and chemical characteristics of the fruits of Zaghloul date palms during 2021 and 2022 seasons.

NPKMg treatments (g/palm)	Yield/ palm (kg.)		Fruit weight		Fruit height (cm)		Fruit diameter(cm)		Flesh / seeds		T.S.S.	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
Traditional fertilizers at: 250: 125: 125: 50	90.0	89.0	15.9	16.0	4.14	4.09	2.11	2.10	5.71	5.69	27.1	26.9
Traditional fertilizers at: 500: 250: 250: 100	95.0	96.0	16.9	17.0	4.15	4.16	2.14	2.20	5.80	5.79	27.6	27.7
Traditional fertilizers at: 1000: 500: 500: 200	100.0	103.0	17.6	17.7	4.20	4.19	2.18	2.25	5.90	5.89	82.2	28.4
Nano fertilizers at: 50: 25: 25: 10	106.0	108.0	18.3	18.4	4.30	4.31	2.21	2.30	6.00	5.99	29.0	28.9
Nano fertilizers at: 100: 50: 50: 20	112.0	113.0	19.0	19.2	4.36	4.40	2.25	2.33	6.10	6.09	29.6	30.0
Nano fertilizers at: 200: 100:100: 40	113.0	114.0	19.1	19.3	4.37	4.41	2.26	1.34	6.11	6.10	29.7	90.1
New L.S.D. at 5%	4.1	4.2	0.6	0.4	0.03	0.03	0.02	0.03	0.08	0.06	0.4	0.4

Table (4): Effect of using nano NPKMg fertilizers versus traditional methods on some chemical characteristics of the fruits of Zaghloul date palms during 2021 and 2022 seasons.

NPKMg treatments per palm	Total sugars %		Reducing sugars %		Non reducing sugars %		Total acidity %		Total crude fiber %		Total soluble tannins %	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
Traditional fertilizers at: 250: 125: 125: 50	18.3	19.0	15.0	14.9	3.3	4.1	0.341	0.338	1.00	0.89	0.82	0.79
Traditional fertilizers at: 500: 250: 250: 100	19.0	19.5	15.5	15.6	3.5	3.9	0.319	0.314	0.95	0.86	0.78	0.74
Traditional fertilizers at: 1000: 500: 500: 200	19.5	20.0	16.0	15.9	3.5	4.1	0.301	0.297	0.89	0.83	0.73	0.69
Nano fertilizers at: 50: 25: 25: 10	20.0	20.6	16.5	16.4	3.5	4.2	0.285	0.81	0.80	0.80	0.67	0.64
Nano fertilizers at: 100: 50: 50: 20	21.0	21.3	17.0	17.0	4.0	4.1	0.275	2.70	0.70	0.66	0.60	0.60
Nano fertilizers at: 200: 100:100: 40	21.1	21.4	17.0	17.1	4.1	4.3	0.273	0.269	0.69	0.65	0.59	0.58
New L.S.D. at 5%	0.4	0.3	0.3	0.3	NS	NS	0.010	0.011	0.04	0.03	0.04	0.03

3.4. Effect of NPKMg via nano-fertilizer on fruit characteristics

It is noticed from the data in Tables (3 and 4) that fertilizing Zaghloul date palm with nano-NPKMg at 50 to 100, 25 to 100, 25 to 100, and 10 to 40 g/palm/year was significantly superior to using traditional NPKMg at 250 to 1000, 125 to 500, 125 to 500, and 50 to 200 g/palm/year, respectively, in improving fruit characteristics in terms of increasing weight diameter and height of fruit, flesh, seeds, and T.S.S.% and decreasing total acidity%, total crude fiber % and total soluble tannins. The increase in NPKMg levels had a considerable impact on the promotion of fruit characteristics, particularly when administered through the conventional method.

There was no noticeable enhancement in fruit characteristics when nano-NPKMg levels were increased from 100 to 200, 50 to 100, 50 to 100, and 20 to 40 g/palm. Therefore, from an economic standpoint, it is recommended to apply nano-NPKMg at 100, 50, 50 and 20 g/palm/year for fertilizing Zaghloul date palm. Conversely, the unsatisfactory promotion of fruit characteristics was attributed to the application of traditional NPKMg at 250, 125, 125, and 50 g/palm/year for palm fertilization. These findings held true for both seasons.

The merits of using fertilizers via nano-fertilizers versus the traditional fertilizers in Zaghloul date palm might be ascribed to the effect of nano fertilizers in enhancing nutrient use efficiency, controlling the release of fertilizers and uptake, preventing the losses of nutrients via soil water, and avoiding the interaction of nutrients with soil, microorganisms, water, and air (Al-Amin-Sadek and Jayasuriya, 2007; Derosa *et al.*, 2010; Rai *et al.*, 2012 and Nongbet *et al.*, 2022)

Thus, one of the most potential substitutes for agricultural systems is the transformation of NPK fertilizers from CFs to NFs. The macronutrients (like N, P, K, and Mg) in NFs are connected either by themselves or in conjunction with nano-adsorbents, which release nutrients gradually, as opposed to CFs. This strategy reduces leaching losses while simultaneously increasing NPK nutrient absorption and utilization efficiency (Abdel-Aziz *et al.*, 2021and Olsen *et al.*, 1954).

Though NFs' benefits are undoubtedly creating new avenues for sustainable agriculture, their drawbacks should also be properly examined before NFs are widely used in agricultural production (Paramo *et al.*, 2020 and Das and Beegum, 2022).

These results are nearly at the same time as those obtained by Jinghua (2004), Wassel *et al.* (2017), Ahmed *et al.* (2018 and 2019) and El-Wany (2019).

Conclusion

Supplying Zaghloul date palm with NPKMG at 100, 50, 50 and 20 g/ palm/ year via nano-technology, respectively gave the best results concerning yield and fruit quality.

Authors' contributions

All authors contributed in conceptualization, methodology, software, validation, formal analysis investigation, resources, data curtain, writing the original draft preparation, writing, review, editing, supervision and funding acquisition. All authors have read and agreed to the published version of the manuscript.

Competing interests

All authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this manuscript.

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تقييم التسميد ب NPKMg النانوية على إنتاجية نخيل بلح زغلول

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ملخص

تم تسميد نخيل بلح زغلول بـ NPKMg النانوية مقارنة بالتسميد بالطرق التقليدية خلال موسمي 2021 و 2022. تمت إضافة NPKMg عند 50-200 ، 25-100 ، 25-100 و 10-40 جم/ نخلة/ سنة عن طريق تقنية النانو و تمت إضافة NPKMg عند 250-1000 ، 125-500، 125-500 و 50- 200 جم/ نخلة/ سنة على التوالي من خلال الطرق التقليدية. تمت إضافة جميع العناصر الغذائية عن طريق التسميد باستثناء الماغنيسيوم الذي يستخدم عن طريق رش الأوراق والسوباطات. كان الهدف دراسة تأثير استخدام الأسمدة NPKMg مقابل الأسمدة العادية على ثمار نخيل الزغلول.

كانت معاملة نخيل بلح الزغلول باستخدام NPKMg عبر تقنية النانو فيما يتعلق بالمستويات أعلى بكثير من استخدام هذه الأسمدة من خلال الطرق التقليدية لتحسين المحصول وجودة الثمار. مستويات NPKMg المتفاوتة المطبقة عبر نظام النانو من 100 إلى 200، 50 إلى 100، 50 إلى 100، 20 إلى 40 جم / نخلة / سنة، على التوالي ، لم يكن لها تأثيرات تذكر على جميع الصفات المدروسة. إمداد نخيل الزغلول المزروع تحت التربة الرملية بـ NPKMg عن طريق تقنية النانو بمعدل 100، 50، 50، 20 جرام / نخلة / سنة، على التوالي قد نجح في تحسين المحصول وخصائص الثمار.

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