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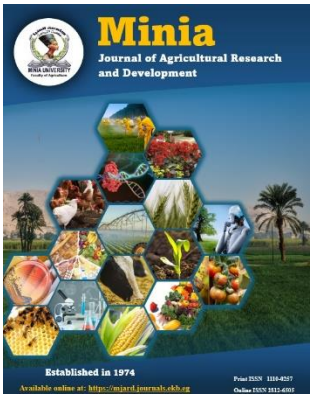

Effect of nano and/or normal fertilizers on growth and productivity of some potato cultivars grown in the Middle Egypt

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ABSTRACT

Nano fertilizers are the talk of recent years in agriculture as farmers are asking for the impact of these fertilizers on production and quality of the products of several crops. In this research we studied the effect of NPK, zinc and boron in the nano and/or normal forms on growth and yield of three cooking and processing potato cultivars (Burren, Cara and Lady Rosetta) under the Middle Egypt (Minia) growing conditions in two successive winter seasons of 2023 and 2024. Results revealed that there were significant differences among the three used cultivars and mixes of nano and/or normal forms of macro and micro elements showed several effects of potato plants growth and tubers productivity. When combinations of different fertilizers and mixes were used the potato plants growth and yield were improved but the best mixes were the combination of 50% or 75 % of the recommended normal-NPK dose + Nano-NPK (foliar application) + Nano-micronutrients (Zn and B) which gave all high values of the desirable characteristics e.g., plant fresh and dry weights, single tuber fresh weight and yield of tubers / feddan. These mixes could be recommended to potato farmers of the Middle Egypt and similar growing conditions to increase their income from potato plantation and reduce potato cultivation costs.

Keywords: Potato, cultivars, Nano fertilizers, NPK, Zinc, Boron, growth, productivity

INTRODUCTION

As the third or fourth most economically important and most consumed tuber crop in the Solanaceae family, potatoes (*Solanum tuberosum* L.) are among the most marketable vegetable plants (Manea *et al.*, 2019). It is grown on all continents except Antarctica and is the most important food crop in the world. Since production in developing countries

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has increased over the past 20 years and is currently higher than in the industrialized world, it is evident how important potatoes are as a staple food crop to meet the demands of expanding human populations. Potato is a major source of starch as well and it has evolved to thrive in a range of environments, and with so many genetic resources available, there is a lot of potential to further exploit its innate biodiversity. It is a nutrient-dense vegetable that contains 15–29% dry matter, 10–25% starch, 1% protein, and 1% mineral salts (Sati *et al.*, 2017). A good variety offers a high yield of high quality, and the genetic component of variety influences potato yields, so studying the behavior of different cultivars under a specific growing environment is very crucial. In addition to the quantity and quality of their yield, different potato varieties also differ in how they develop and mature (Hassan, 2003; Al-Taey *et al.*, 2019; Al-Bayati *et al.*, 2023). Elwan *et al.* (2018) state that potato is one of Egypt's most important vegetable crops for both export and home consumption. With 439,328 fed. acres under cultivation, Egypt produced about 5 million tons in 2016 (an average of 11.5 tons / fed.). About 135,000 tons of tuber seeds were imported from European countries in 2016 to be used in Egypt's summer plantings. The seed tubers cost about 62.1 million pounds a year. Baddour and Masoud (2022) concluded from their research that the type and range of fertilizers used can significantly affect the potato crop's yield and tuber quality.

Consequently, nanotechnology-based fertilizer production is becoming sufficiently affordable to promote broader participation in the global agriculture sector (Yadav *et al.*, 2023). Nanofertilizers (NFs), also referred to as smart fertilizers, have garnered increased attention in recent years due to their potential to increase agricultural yields while reducing their adverse environmental effects. Conventional fertilizers are supplemented with nanomaterials to boost agricultural productivity. By effectively and efficiently delivering these nutrients to the plant, nanoscale particles—which are frequently smaller than 100 nanometers—are intended to improve plant absorption and utilization (Dimkpa and Bindraban, 2017 and Yadav *et al.*, 2023). Commercializing NFs has several benefits, including lower production costs, higher crop yields, more resilience, and better nutrient uptake. enhanced water use efficiency, decreased environmental impact, enhanced agricultural sustainability, enhanced product quality, and decreased nutrient loss (Sati *et al.*, 2017; Yadav *et al.*, 2023; Alobaidi and Ibraheem, 2024). Therefore, our study aimed to ascertain how nano and /or normal NPK and some micro elements affect the growth and productivity of three potato cultivars (cooking and processing cultivars) under the Middle Egypt growing conditions.

MATERIALS AND METHODS

During two successive growing seasons of 2023 and 2024 at a private farm in Manqateen village, Samalout, Minia Governorate, Egypt, field ex/iments were conducted to investigate the impact of NPK fertilizers (either in normal or nano-forms), and Zn and B (either in chelated or nano-form) on horticultural /formance and yield of three potato cultivars namely, Burren, Cara and Lady Rosetta.

Plant materials

Seed-tubers of the three cultivars were obtained from a private farm planting potatoes. Twenty days before cultivation in the field, green germination was conducted on these potato seed-tubers. The tubers were prepared and treated with fungicide (Mancozeb 80%) and were sown in prepared soil on 15th September in both seasons.

Layout of the ex/iments

The ex/iments were arranged in a complete randomized block design (CRBD) with three replicates as split plot design. The treatments included three potato cultivars (in main plots) and six fertilization treatments (in sub plots). So, the total number of the ex/imental units was 54 (3 cultivars X 6 fertilization treatments X 3 replicates). The ex/imental unit (plot) was 3.5 x 3.0 m, equal 10.5 m^2 (1/400 feddan) and contained 4 ridges, 20 cm apart to count 72 plants (4 ridges X 18 plants). The physical and chemical pro/ties of the used soil are listed in table 1. During preparing the soil for potato cultivation in both seasons, chicken manure (analysis of its contents is described in table 2) at a rate of 12 m^3, 500 kg Ca-su/ phosphate (15.5% P_2O_5), 15 kg potassium sulfate (48% K_2O), and 10 kg magnesium sulfate (16% MgO) and 50 kg agricultural sulfur/feddan were added. This pre-planting preparation of the soil matched the instructions of the Egyptian Ministry of Agriculture and Soil Reclamation.

Table 1: Physical and chemical analysis of the ex/imental soil before plantation of the two seasons of 2023 and 2024

Soil character	Values		Soil character	Values	
	2023	2024		2023	2024
Physical pro/ties			**Soluble nutrients**		
Sand (%)	24.56	23.85	Ca^{++} (mg/100 g soil)	2.42	2.33
Silt (%)	28.23	27.11	Mg^{++} (mg/100 g soil)	1.14	1.11
Clay (%)	47.21	49.04	Na^{+} (mg/100 g soil)	1.71	1.62
Soil type	Clay	Clay	K^{+} (mg/100 g soil)	0.89	0.81
Chemical pro/ties			**DTPA-Extractable nutrients**		
pH (1:2.5)	7.91	7.92	Fe (ppm)	3.41	3.42
E.C. (dS/m)	1.24	1.26	Cu (ppm)	1.29	1.26
O.M.	1.35	1.29	Zn (ppm)	1.94	1.93
$CaCO_3$	2.12	2.17	Mn (ppm)	3.21	3.25

Thirty-five days after sowing potato seed-tubers of the three cultivars and after complete emergence, the first dose of nitrogen was added as urea (46% N). Three weeks later, the second dose was added as ammonium nitrate (33.5% N). When potato plants reached 55 days, potassium nitrate was applied.

Table 2: Chemical analysis of the used chicken manure in both seasons of 2023 and 2024

Pro/ties	Value	Pro/ties	Value
Organic carbon (%)	21.12	Total N (%)	5.52
Humidity (%)	39.73	K^+ (ppm)	538
Protein	34.5	Na^+ (ppm)	93
C/N ratio	3.83	Ca^{++} (ppm)	1635
pH (1:2.5)	6.1	Mg^{++} (ppm)	103

Treatments

Potato cultivars: three potato cultivars, namely, Burren, Cara and Lady Rosetta were used in this research.

Fertilization treatments

1. 100% of the recommended normal-NPK (100 kg/fed.).
2. 50% of recommended normal-NPK (50 kg/fed.).
3. 75% of the recommended normal-NPK *(100 kg/fed.)* + Nitrolef (foliar application) + micronutrients (Zn and B).
4. 50% of the recommended normal-NPK + Nitrolef + micronutrients (Zn and B).
5. 75% recommended normal-NPK *(100 kg/fed.)* + Nano-NPK (foliar application) + Nano-micronutrients (Zn and B).
6. 50% of the recommended normal-NPK + Nano-NPK (foliar application) + Nano-micronutrients (Zn and B).

The NPK-fertilization treatments started 70 days after sowing the potato tuber-seeds. Foliar application of all normal NPK (urea, 46% N and ammonium nitrate, 33.5% N), Nitrolef (20:20:20 NPK) and Nano-NPK (12:6:8 NPK) were applied twice (70 and 85 days after sowing the potato tuber-seeds). Similarly, microelements; Zn and B were sprayed two times, Granora cleated zinc (13% ZnO) and boron (11.5% BO_3) and Nano forms of these microelements (6% Zn) and (14% BO_3), respectively were foliar sprayed on plants two days after NPK application in both seasons. All nano fertilizers were purchased from Faculty of Agriculture, Cairo University, Egypt, which locates in El Dokki districts, Giza Governorate, Egypt.

Recorded data

Vegetative growth parameters:

Seven days before potato harvest, the vegetative growth characters were recorded as follows:

1. Plant length (cm) was measured 2 times (at 70 days as average of 5 plants, 70 days after plantation of potato seed tubers) and after harvesting (as average of 3 plants).
2. Number of branches / plant was counted 2 times in the same manner as plant length.
3. Plant fresh weight / plant (g).
4. Plant dry weight / plant (g).

Yield and its components

Yield measurements were obtained from each treatment after 100 days of planting:

1. Single tuber fresh weight (g) as average of 3 plants.
2. Single tuber dry weight (g) as average of 3 plants.
3. Number of tubers / plant.
4. Tuber yield / plot in kg.
5. Tuber yield / feddan in ton.

Statistical analysis

All obtained data were subjected to the analysis of variance and means were compared using the LSD test at 5% using the **MSTAT–C software Ver. 4** according to **Gomez and Gomez (1986)**.

RESULTS AND DISCUSSION

Our data concerning the effect of NPK fertilization either in normal or nano form and (Zn and B) either in cleated or nano form on growth, productivity and some quality parameters of three potato cultivars (Lady Rosetta, Cara and Burren) will be presented and discussed under the following three main subjects:

Effect of nano and/or normal fertilizers on vegetative growth of potato plants

Plant length (cm)

The effect of fertilization forms (NPK, Zn and B) on plant length of three potato cultivars (Lady Rosetta, Cara and Burren) at 70 days after planting and at harvest through the two growing seasons was listed in tables (3 and 4). It is obvious from the presented tables that there were significant differences between Cara and Lady Rosetta cultivars in plant length throughout the two seasons at 70 days after planting. However, Burren cultivar recorded insignificant intermediate values. On contrast, cultivars did not show significant differences for this characteristic. In all cases, Cara produced the tallest plants (60.74 and 65.70 cm), followed by Burren (59.32 and 61.21 cm), then Lady Rosetta (56.68 and 55.88 cm) in both seasons at 70 days after planting. The same observation was noticed at harvest. Fertilization form was not only important but also one of the most effective parameters in increasing plant growth. All used fertilization treatments positively affected the length of potato plants in both tested times during the two ex/imental seasons. As could be seen from the above-mentioned tables, at 70 days after planting, the treatment of [75% of the recommended traditional-NPK *(100 kg/fed.)* + Nano-NPK (foliar application) + Nano-micronutrients (Zn and B)] markedly recorded the tallest plant comparing to the other fertilization treatments in the two seasons. Likewise, at harvest, this su/ior treatment was in the same line of significance as the treatment of [75% of recommended traditional-NPK (75 kg/fed.) + Nitrolef (foliar application) + Chelated (Zn and B)] and they were notably differed to the other fertilization treatments. Therefore, the tallest plants (64.93 and 68.93 cm, at 70 days after planting) and (79.19 and 78.89 cm at harvest) in the first and second seasons, respectively were produced from the treatment [75% of the recommended traditional-NPK (75 kg/fed.) + Nano-NPK (foliar application) + Nano-micronutrients (Zn and B)].

Table (3): Effect of normal and/or nano fertilizers on plant length (cm) at 70 days after planting of three potato cultivars grown in two successive winter seasons of 2023 and 2024

Fertilization treatments (B)	Cultivars (A)			Mean (B)
	Lady Rosetta	Cara	Burren	
First season (2023)				
1	57.90 C-E	56.57 C-E	58.30 B-E	**57.59 BC**
2	54.40 E	55.93 DE	55.73 DE	**55.36 C**
3	55.20 E	63.20 BC	64.67 AB	**61.02 B**
4	54.67 E	60.73 B-E	60.53 B-E	**58.64 BC**
5	62.07 B-D	70.60 A	62.13 B-D	**64.93 A**
6	55.87 DE	57.40 CDE	54.53 E	**55.93 C**
Mean (A)	**56.68 B**	**60.74 A**	**59.32 AB**	
L.S.D. (5%)	**A: 3.44**	**B: 4.68**	**AB: 6.04**	
Second season (2024)				
1	56.70 F-J	67.27 BC	61.43 DE	**61.80 B**
2	53.27 JK	60.53 D-F	57.60 E-I	**57.13 CD**
3	56.13 G-IJ	71.40 A	64.13 CD	**63.89 B**
4	49.73 K	58.93 E-H	54.60 IJ	**54.42 D**
5	64.53 CD	72.00 A	70.27 AB	**68.93 A**
6	54.93 H-J	64.07 CD	59.23 E-G	**59.41 BC**
Mean (A)	**55.88 B**	**65.70 A**	**61.21 AB**	
L.S.D. (5%)	**A: 5.45**	**B: 4.45**	**AB: 3.76**	

Where:
1: 100% normal-NPK (100 kg/fed.).
2: 50% normal-NPK (50 kg/fed.).
3: 75% normal-NPK + Nitrolef + Chelated (Zn and B).
4: 50% normal-NPK + Nitrolef + Chelated (Zn and B).
5: 75% normal-NPK + Nano-NPK + Nano (Zn and B).
6: 50% normal-NPK + Nano-NPK + Nano (Zn and B).

Many authors emphasized the positive influence of Nano-fertilizers on increasing potato plant length such as Janmohammadi *et al.*(2016), Singh *et al.*(2018), Elshamy *et al.*(2019), Al-Abdali *et al.*(2021), Kumar *et al.*(2022), Abdulkadhum *et al.*(2023), Chauhan *et al.*(2023) and Mahmood *et al.*(2025a) for NPK fertilization and Al-Yasari and Al-Hilli (2018), Rahman *et al.*(2018), Mahmoud *et al.*(2020), Marzouk *et al.*(2022), Al-Sharifi and Al-Zubaidi (2023), Rashwan *et al.*(2023), Salama and Haggag (2024), Dhiman *et al.*(2024), Alobaidi and Ibraheem (2024) and Monika *et al.*(2024) for Zn and B fertilization. The effect of interaction between the three potato cultivars and fertilization forms was significant for plant length in the two seasons during both examined times. In most cases, the three cultivars treated with (75% normal-NPK + Nano-NPK + Nano Zn and B) exhibited the best values in both seasons. The tallest plants overall in both seasons were recorded with Cara cultivar fertilized with this mix of fertilizers except in the first season at harvest which were recorded with Burren treated with the same fertilizer's combination.

Table (4): Effect of normal and/or nano fertilizers on plant length (cm) at harvest of three potato cultivars grown in two successive winter seasons of 2023 and 2024

Fertilization treatments (B)	Cultivars (A)			Mean (B)
	Lady Rosetta	Cara	Burren	
First season (2023)				
1	72.56 B-D	71.33 B-E	77.22 AB	**73.70 B**
2	60.56 C	61.00 FG	59.00 G	**60.19 D**
3	73.33 B-D	74.56 A-C	78.22 AB	**75.37 AB**
4	62.11 FG	62.78 FG	64.00 E-G	**62.96 CD**
5	77.44 AB	78.11 AB	82.00 A	**79.19 A**
6	68.44 C-F	64.44 E-G	66.11 D-G	**66.33 C**
Mean (A)	**69.07 A**	**68.70 A**	**71.09 A**	
L.S.D. (5%)	**A: 3.30**	**B: 4.16**	**AB:7.10**	
Second season (2024)				
1	70.89C-F	72.78 B-E	74.11 B-E	**72.59 BC**
2	60.00 H	64.56 F-H	67.67 EFG	**64.07 D**
3	72.79 B-E	74.22 B-E	75.11 B-D	**74.04 AB**
4	63.00 GH	63.00 GH	65.78 F-H	**63.93 D**
5	76.78 A-C	82.00 A	77.89 AB	**78.89 A**
6	65.89 F-H	71.00 C-F	68.33 D-G	**68.41 CD**
Mean (A)	**68.22 A**	**71.26 A**	**71.48 A**	
L.S.D. (5%)	**A: 5.24**	**B: 5.02**	**AB: 6.20**	

Where:
1: 100% normal-NPK (100 kg/fed.).
2: 50% normal-NPK (50 kg/fed.).
3: 75% normal-NPK + Nitrolef + Chelated (Zn and B).
4: 50% normal-NPK + Nitrolef + Chelated (Zn and B).
5: 75% normal-NPK + Nano-NPK + Nano (Zn and B).
6: 50% normal-NPK + Nano-NPK + Nano (Zn and B).

Number of branches / plant

The effect of fertilization form (NPK, Zn and B) on number of branches / plant of three potato cultivars (Lady Rosetta, Cara and Burren) at 70 days after planting and at harvest through both growing seasons listed in tables (5 and 6) showed that the obtained values differed significantly throughout the two seasons for the two testing times (at 70 days after planting and at harvest). At 70 days after planting, Burren gave significantly higher values than the other two cultivars in the first season only. In the second season, Burren and Cara were markedly greater than Lady Rosetta 70 days after planting. Also, at harvest in both seasons, Burren and Cara cultivars were markedly greater than Lady Rosetta. In all cases, Burren recorded the highest number of branches / plant (4.96 and 5.04 branches), followed by Cara (4.46 and 4.78 branches), then Lady Rosetta (3.50 and 3.56 branches) in both seasons at harvest. The same behavior was observed at the age of 70 days after planting (tables 5 and 6).

As denoted in tables 3 and 4, number of branches / plant increased due to all used fertilization treatments in both tested times during the two ex/imental seasons. Interestingly, the treatment of [70% NPK *(100 kg/fed.)* + Nano-NPK (foliar application) + Nano-micronutrients (Zn and B)] resulted in the highest number of branches / plant in both seasons at 70 days after planting and at harvest. The increase over the

control was 18.34 and 20.44% in the 1st and 2nd seasons at 70 days after planting, and 45.58 and 64.89% in the 1st and 2nd seasons at harvest, respectively. The improving impact of Nano-fertilizers on number of branches / potato plant was mentioned by Janmohammadi *et al.*(2016), Elshamy *et al.*(2019), Abdulkadhum *et al.*(2023), Al-Hayani and Sallume (2023) and Chauhan *et al.*(2023) for NPK fertilization and Al-Yasari and Al-Hilli (2018), Rahman *et al.*(2018), Mahmoud *et al.*(2020), Marzouk *et al.*(2022), Rashwan *et al.*(2023) and Salama and Haggag (2024) for Zn and B fertilization.

The effect of interaction impact of the three potato cultivars and fertilization forms was significant for number of branches / plant in the two seasons at both examined times. The three potato cultivars treated with [75% normal-NPK + Nano-NPK + Nano (Zn and B)] showed the highest values in both seasons at the two tested times. The highest values of number of branches / plant (4.20 and 4.60 at 70 days after planting in the first and second seasons) and (8.22 and 8.44 at harvest in the first and second seasons) were produced from Burren cultivar fertilized with [75% normal-NPK + Nano-NPK + Nano (Zn and B)] followed with Cara cultivar with the same fertilization mix in both seasons (tables 3 and 4).

Plant fresh and dry weights / plant (g)

The plant weight is a function of plant length and number of shoots / plant. The plant weights, either fresh or dry, were markedly influenced by potato cultivars in the second season only (tables 7 and 8). Burren cultivar produced higher values of plant fresh weight than Lady Rosetta and higher values of dry weight than the other cultivars in the second season. So, the Burren cultivar recorded the heaviest weights (234.42 and 250.18 g fresh weight), followed by Cara (238.97 and 175.92 g fresh weight), then Lady Rosetta (232.05 and 161.07 g fresh weight) in both seasons at harvest. The same trends were obtained with the dry weight. Data presented in Tables (5 and 6) showed that all used fertilization treatments positively affected the plant weights of potato plant in both ex/imental seasons. As could be expected from the afore-mentioned Tables for plant length and number of branches / plant, the treatment of [75% of the recommended traditional-NPK *(100 kg/fed.)* + Nano-NPK (foliar application) + Nano-micronutrients (Zn and B)] recorded the heaviest weights (fresh and dry) in both seasons at harvest. This su/ior treatment increased plant fresh weight over control by 16.19 and 63.80% in the first and second seasons, and plant dry weight by 12.03 and 48.46% in both seasons, respectively. Nano-fertilizers enhanced plant weight of potato as reported by Mijweil and Abboud (2018), Elshamy *et al.* (2019), Al-Abdali *eet al. (*021), Al-Hayani and Sallume (2023) and Mahmood *et al.*(2025a) for NPK fertilization and Al-Yasari and Al-Hilli (2018), Rahman *et al.* (2018), Mahmoud *et al.* (2020), Marzouk *et al.* (2022), Rashwan *et al.* (2023) and Monika *et al.* (2024) for Zn and B fertilization. The interaction effect between the three potato cultivars and fertilization forms was significant for plant fresh and dry weight / plant characteristics at harvest time in both seasons. All the three cultivars fertilized with [75% of normal-NPK + Nano-NPK + Nano (Zn and B)] produced the heaviest weights in both seasons. Under this combination of fertilizers, Burren cultivar recorded the heaviest weights overall, followed by Cara cultivar, then Lady Rosetta in both seasons.

Table (5): Effect of normal and/or nano fertilizers on No of branches / plant at 70 days after planting of three potato cultivars grown in two successive winter seasons of 2023 and 2024

Fertilization treatments (B)	Cultivars (A)			Mean (B)
	Lady Rosetta	Cara	Burren	
First season (2023)				
1	2.33 CD	2.67 CD	3.67 AB	**2.89 BC**
2	2.13 D	2.47 CD	2.27 CD	**2.29 D**
3	2.80 CD	2.80 CD	4.00 A	**3.20 AB**
4	2.67 CD	2.80 CD	2.40 CD	**2.62 CD**
5	3.00 BC	3.07 BC	4.20 A	**3.42 A**
6	2.73 CD	2.80 CD	3.67 AB	**3.07 AB**
Mean (A)	**2.61 B**	**2.77 B**	**3.37 A**	
L.S.D. (5%)	**A: 0.44**	**B: 0.42**	**AB: 0.74**	
Second season (2024)				
1	2.73 EF	3.67 B-D	4.47 AB	**3.62 AB**
2	2.13 F	3.33 C-E	3.20 C-E	**2.89 B**
3	3.27 C-E	3.80 A-C	4.33 AB	**3.80 A**
4	2.87 D-F	4.00 A-C	3.80 A-C	**3.56 AB**
5	3.93 A-C	4.53 AB	4.60 A	**4.36 A**
6	3.13 C-E	4.27 AB	3.93 A-C	**3.78 A**
Mean (A)	**3.01 B**	**3.93 A**	**4.06 A**	
L.S.D. (5%)	**A: 0.30**	**B: 0.82**	**AB: 0.81**	

Where:
1: 100% normal-NPK (100 kg/fed.).
2: 50% normal-NPK (50 kg/fed.).
3: 75% normal-NPK + Nitrolef + Chelated (Zn and B).
4: 50% normal-NPK + Nitrolef + Chelated (Zn and B).
5: 75% normal-NPK + Nano-NPK + Nano (Zn and B).
6: 50% normal-NPK + Nano-NPK + Nano (Zn and B).

Table (6): Effect of normal and/or nano fertilizers on No of branches / plant at harvest of three potato cultivars grown in two successive winter seasons of 2023 and 2024

Fertilization treatments (B)	Cultivars (A)			Mean (B)
	Lady Rosetta	Cara	Burren	
First season (2023)				
1	3.33 HI	4.89 CD	4.67 C-F	**4.30 BC**
2	3.00 I	4.11 D-H	3.78 F-I	**3.63 D**
3	4.11 D-H	5.11 C	4.78 C-E	**4.67 B**
4	3.00 I	3.11 I	3.89 E-I	**3.33 D**
5	4.56 C-F	6.00 B	8.22 A	**6.26 A**
6	3.00 I	3.56 G-I	4.44 C-G	**3.67 CD**
Mean (A)	**3.50 B**	**4.46 A**	**4.96 A**	
L.S.D. (5%)	**A: 0.94**	**B: 0.64**	**AB: 0.86**	
Second season (2024)				
1	3.33 F-H	4.22C-G	4.22C-G	**3.93 B**
2	2.89 H	4.11C-G	4.22 C-G	**3.74 B**
3	3.56 E-H	4.67 C-E	4.89 CD	**4.37 B**
4	3.67 A-H	4.67 C-E	3.11 GH	**3.82 B**
5	4.33 C-F	6.67 B	8.44 A	**6.48 A**
6	3.56 E-H	4.33 C-F	5.33 C	**4.41 B**
Mean (A)	**3.56 B**	**4.78 A**	**5.04 A**	
L.S.D. (5%)	**A: 0.92**	**B: 0.72**	**AB: 1.04**	

Where:
1: 100% normal-NPK (100 kg/fed.).
2: 50% normal-NPK (50 kg/fed.).
3: 75% normal-NPK + Nitrolef + Chelated (Zn and B).
4: 50% normal-NPK + Nitrolef + Chelated (Zn and B).
5: 75% normal-NPK + Nano-NPK + Nano (Zn and B).
6: 50% normal-NPK + Nano-NPK + Nano (Zn and B).

Effect of nano and/or fertilizers on tuber production:

Average tuber fresh and dry weights (g)

The effect of fertilization form (NPK, Zn and B) on mean tuber fresh and dry weights (g) of three potato cultivars (Lady Rosetta, Cara and Burren) at harvest through both growing seasons was listed in tables (7 and 8). Mean tuber dry weight (g) was insignificantly affected as a result to potato cultivars, except Lady Rosetta in the first season, which produced the lightest significant single tuber weight (Table 7). It is reflected the comparable tuber size of the three potato cultivars.

Table (7): Effect of normal and/or nano fertilizers on plant fresh weight (g) at harvest of three potato cultivars grown in two successive winter seasons of 2023 and 2024

Fertilization treatments (B)	Cultivars (A)			Mean (B)
	Lady Rosetta	Cara	Burren	
First season (2023)				
1	254.77 ABC	247.74 BC	231.89 CD	**244.80 B**
2	212.33 CDE	243.77 BC	209.77 CDE	**221.96 BC**
3	187.00 DE	186.44 DE	231.55 CD	**201.66 C**
4	177.33 E	220.00 CDE	217.44 CDE	**204.92 C**
5	278.22 AB	280.33 AB	294.77 A	**284.44 A**
6	282.66 AB	255.55 ABC	221.11 CDE	**253.11 AB**
Mean (A)	**232.05 A**	**238.97 A**	**234.42 A**	
L.S.D. (5%)	**A: 26.84**	**B: 32.37**	**AB: 41.18**	
Second season (2024)				
1	134.33 F	174.55 DEF	195.11CDEF	**168.00 CD**
2	149.55 F	172.00 DEF	144.00 F	**155.18 D**
3	165.00 DEF	147.33 F	265.22 B	**192. 52 BC**
4	131.44 F	153.55 F	260.66 BC	**181. 89BCD**
5	226.44BCDE	234.33 BCD	364.78 A	**275.18 A**
6	159.66 EF	173.78 DEF	271.33 B	**201. 59 B**
Mean (A)	**161.07 B**	**175.92 B**	**250.18 A**	
L.S.D. (5%)	**A: 62.90**	**B: 28.10**	**AB: 62.76**	

Where:
1: 100% normal-NPK (100 kg/fed.).
2: 50% normal-NPK (50 kg/fed.).
3: 75% normal-NPK + Nitrolef + Chelated (Zn and B).
4: 50% normal-NPK + Nitrolef + Chelated (Zn and B).
5: 75% normal-NPK + Nano-NPK + Nano (Zn and B).
6: 50% normal-NPK + Nano-NPK + Nano (Zn and B).

In all cases, the Burren cultivar recorded the heaviest mean tuber weight (141.41 and 104.03 g), followed by Cara (122.67 and 96.94 g), then Lady Rosetta (100.88 and 90.35 g) in both seasons.

Regarding the single (g), it could be seen from table (9) that Lady Rosetta significantly increased tuber dry weight than either Cara or Burren in both seasons. However, there were no significant differences detected between Cara and

Burren cultivars in both seasons. Data presented in table (7) mentioned that mean tuber weight was affected as a result to all used fertilization treatments in both seasons. Nano-fertilizers produced the heaviest tuber weight. So, the treatment of [75 % of recommended traditional-NPK (100 kg/fed.) + Nano-NPK (foliar application) + Nano-micronutrients (Zn and B)] recorded the heaviest tuber weight in both seasons. On contrast, the lightest significant mean of tuber weight was obtained from the treatment of [50% of the recommended traditional-NPK (50 kg/fed.) + Nitrolef (foliar application) + Chelated (Zn and B).

Table (8): Effect of normal and/or nano fertilizers on plant dry weight (g) at harvest of three potato cultivars grown in two successive winter seasons of 2023 and 2024

Fertilization treatments (B)	Cultivars (A)			Mean (B)
	Lady Rosetta	Cara	Burren	
First season (2023)				
1	59.11 AB	53.44 B	61.00 AB	**57.85 AB**
2	53.89 B	53.00 B	54.67 B	**53.85 B**
3	59.67 AB	54.89 B	61.44 AB	**58.67 AB**
4	54.78 B	54.44 B	58.11 AB	**55.78 AB**
5	72.33 A	59.78 AB	62.33 AB	**64.81 A**
6	56.67 AB	55.78 B	61.11 AB	**57.85 AB**
Mean (A)	**59.41 A**	**55.22 A**	**59.78 A**	
L.S.D. (5%)	**A: 17.78**	**B: 9.017**	**AB: 14.31**	
Second season (2024)				
1	41.78 EFG	44.56DEFG	52.33 CDEF	**46.22 CD**
2	36.22 C	40.67 FG	40.11 FG	**39.00 D**
3	43.33 EFG	57.44 BCD	66.56 B	**55.78 B**
4	41.67 EFG	45.44DEFG	63.78 BC	**50.30 BC**
5	55.33 BCDE	62.00 BC	87.44 A	**68.26 A**
6	42.11 EFG	47.33DEFG	67.11 B	**52.19 BC**
Mean (A)	**43.41 C**	**49.57 B**	**62.89 A**	
L.S.D. (5%)	**A: 2.306**	**B: 7.744**	**AB: 12.31**	

Where:
1: 100% normal-NPK (100 kg/fed.).
2: 50% normal-NPK (50 kg/fed.).
3: 75% normal-NPK + Nitrolef + Chelated (Zn and B).
4: 50% normal-NPK + Nitrolef + Chelated (Zn and B).
5: 75% normal-NPK + Nano-NPK + Nano (Zn and B).
6: 50% normal-NPK + Nano-NPK + Nano (Zn and B).

The su/ior treatment increased the average tuber weight over the control by 8.43 and 38.34% in the first and second seasons, respectively. According to table (10), tuber dry weight was differed significantly due to fertilization treatments in the second season only. The heaviest tuber weight (62.71 and 64.93 g) was produced from the treatment of [50% of recommended traditional-NPK (50 kg/fed.)] in both seasons. Improving single tuber weight by NPK- Nano-fertilizers was emphasized by Janmohammadi *et*

al.(2016), Abd El-Azeim *et al.*(2019), Elshamy *et al.*(2019), Abd El-Azeim *et al.*(2020), Al-Abdali *et al.*(2021), Al-Zebari *et al.*(2021), Al-Bayati *et al.*(2023), Al-Sultan *et al.*(2023), Chauhan *et al.*(2023) and Mahmood *et al.*(2025a). Likewise, Nano- Zn and B fertilization enhanced potato tuber weight as stated by Al-Yasari and Al-Hilli (2018), Rahman *et al.* (2018), Al-Juthery *et al.* (2019), Marzouk *et al.* (2022), Al-Sharifi and Al-Zubaidi (2023), Rashwan *et al.* (2023), Alobaidi and Ibraheem (2024) and Salama and Haggag (2024). The interaction effect between the three potato cultivars and fertilization form was significant for mean tuber fresh and dry weights (g) at harvest in both seasons. The heaviest mean tuber fresh weight in the first season was obtained from Burren cultivar fertilized with [75% normal-NPK + Nano-NPK + Nano (Zn and B)] and, in the second season, from Cara cultivar with the same fertilization form. However, Lady Rosetta cultivar produced the heaviest mean tuber dry weight when fertilized with [100% normal-NPK + Nano-NPK + Nano (Zn and B)] in both seasons.

Table (9): Effect of normal and/or nano fertilizers on mean tuber weight (g) at harvest of three potato cultivars grown in two successive winter seasons of 2023 and 2024.

Fertilization treatments (B)	Cultivars (A)			Mean (B)
	Lady Rosetta	Cara	Burren	
First season (2023)				
1	101.27 DE	114.50ABCDE	140.80 ABC	**118.86 A**
2	100.37 DE	119.26ABCDE	137.58ABCD	**119.07 A**
3	102.35 CDE	128.50ABCDE	142.53 AB	**124.46 A**
4	94.01 E	118.77ABCDE	134.87ABCD	**115.88 A**
5	107.38BCDE	129.33ABCDE	150.63 A	**129.11 A**
6	99.92 DE	126.20ABCDE	142.03 AB	**122.72 A**
Mean (A)	**100.88 B**	**122.76 A**	**141.41 A**	
L.S.D. (5%)	**A:1 9.29**	**B: 20.79**	**AB: 35.06**	
Second season (2024)				
1	91.72 AB	89.14 B	101.49 AB	**94.12 B**
2	79.18 B	88.49 B	101.02 AB	**89.56 B**
3	92.61 AB	89.90 B	117.73 AB	**100.08 B**
4	82.45 B	88.59 B	80.86 B	**83.97 B**
5	103.29 AB	135.10 A	123.37 AB	**120.79 A**
6	92.86 AB	90.40 B	99.71 AB	**94.32 B**
Mean (A)	**90.35 A**	**96.94 A**	**104.03 A**	
L.S.D. (5%)	**A: 34.09**	**B: 17.48**	**AB: 39.89**	

Where:
1: 100% normal-NPK (100 kg/fed.).
2: 50% normal-NPK (50 kg/fed.).
3: 75% normal-NPK + Nitrolef + Chelated (Zn and B).
4: 50% normal-NPK + Nitrolef + Chelated (Zn and B).
5: 75% normal-NPK + Nano-NPK + Nano (Zn and B).
6: 50% normal-NPK + Nano-NPK + Nano (Zn and B).

Number of tubers / plant

The effect of fertilization form (NPK, Zn and B) on number of tubers / plant of three potato cultivars (Lady Rosetta, Cara and Burren) at harvest through both growing seasons was listed in table 11. Number of tubers / plant was insignificantly differed due to potato cultivars in both seasons (table 11). This reflects the extent of similarity in the number of tubers / plant for the three studied varieties. In the first season, the greatest number of tubers / plant (6.72) was obtained from Lady Rosetta, followed by (6.68) from Burren, then (6.30) from Cara. However, in the second season, the greatest number of tubers / plant (6.89) was obtained from Cara, followed by (6.67) from Burren, then (4.81) from Lady Rosetta.

Table (10): Effect of normal and/or nano fertilizers on mean tuber dry weight (g) at harvest of three potato cultivars grown in two successive winter seasons of 2023 and 2024

Fertilization treatments (B)	Cultivars (A)			Mean (B)
	Lady Rosetta	Cara	Burren	
First season (2023)				
1	78.73A B	52.00 EF	52.53 EF	**61.09 A**
2	78.53 AB	56.30 D	53.30 E	**62.71 A**
3	76.00 C	50.33 FG	48.97 G	**58.43 A**
4	77.00 BC	52.67 E	51.83 EF	**60.50 A**
5	80.67 A	51.67 EF	52.17 EF	**61.50 A**
6	79.00 AB	53.33 E	52.00 EF	**61.44 A**
Mean (A)	**78.32 A**	**52.72 B**	**51.80 B**	
L.S.D. (5%)	**A: 2.15**	**B: 6.85**	**AB: 2.01**	
Second season (2024)				
1	82.00 A	54.33 D	55.00 D	**63.78 A**
2	80.67 A	57.97 C	56.17 CD	**64.93 A**
3	73.33 B	48.67 GH	46.33 H	**56.11 B**
4	75.33 B	51.50 EF	50.00 FG	**58.94 AB**
5	82.67 A	53.67 DE	54.33 D	**63.56 AB**
6	81.13 A	55.17 D	54.97 D	**63.76 A**
Mean (A)	**79.19 A**	**53.55 B**	**52.80 B**	
L.S.D. (5%)	**A: 3.28**	**B: 7.28**	**AB: 2.61**	

Where:
1: 100% normal-NPK (100 kg/fed.).
2: 50% normal-NPK (50 kg/fed.).
3: 75% normal-NPK + Nitrolef + Chelated (Zn and B).
4: 50% normal-NPK + Nitrolef + Chelated (Zn and B).
5: 75% normal-NPK + Nano-NPK + Nano (Zn and B).
6: 50% normal-NPK + Nano-NPK + Nano (Zn and B).

Data presented in table 11 demonstrated that number of tubers / plant increased as a result to all used fertilization treatments facing control, except the treatment of [50% normal-NPK (50 kg/fed.)] in both seasons. Nano-fertilizers produced the highest values of tubers number / plant. Therefore, the highest tubers number was gained from the treatment of [75% normal-NPK *(100 kg/fed.)* + Nano-NPK (foliar application) + Nano-micronutrients (Zn and B)] in both seasons. This su/ior treatment increased

number of tubers / plant over the control by 12.50 and 23.84% in the first and second seasons, respectively. The enhancement of potato tubers number due to NPK- Nano-fertilizers was stated by many researchers such as Janmohammadi *et al.*(2016), Mijweil and Abboud (2018), Elshamy *et al.*(2019), Abd El-Azeim *et al.*(2020), Al-Abdali *et al.*(2021), Abdulkadhum *et al.*(2023), Al-Bayati *et al.*(2023), Al-Hayani and Sallume (2023), Al-Sultan *et al.*(2023), Chauhan *et al.*(2023), Farrag *et al.*(2024) and Mahmood *et al.*(2025a). Similarly, Nano- Zn and B fertilization enhanced potato tubers number / plant as stated by Al-Yasari and Al-Hilli (2018), Rahman *et al.*(2018), Al-Zebari *et al.*(2021), Marzouk *et al.*(2022), Al-Selwey *et al.*(2023),

Table (11): Effect of normal and/or nano fertilizers on number of tubers / plant at harvest of three potato cultivars grown in two successive winter seasons of 2023 and 2024.

Fertilization treatments (B)	Cultivars (A)			Mean (B)
	Lady Rosetta	Cara	Burren	
First season (2023)				
1	6.78 A	6.22 A	5.94 A	**6.32 A**
2	6.75 A	5.78 A	6.33 A	**6.29 A**
3	6.89 A	6.67 A	6.89 A	**6.81 A**
4	6.44 A	6.33 A	6.44 A	**6.41 A**
5	7.44 A	6.56 A	7.33 A	**7.11 A**
6	6.00 A	6.22 A	7.11 A	**6.44 A**
Mean (A)	**6.72 A**	**6.30 A**	**6.68 A**	
L.S.D. (5%)	**A: 1.20**	**B: 1.94**	**AB: 1.83**	
Second season (2024)				
1	4.83 D	7.33 AB	5.33 BCD	**5.83 AB**
2	4.50 D	5.00 CD	5.17 BCD	**4.89 B**
3	4.83 D	7.33 AB	6.67 BCD	**6.28 AB**
4	4.50 D	7.17 ABC	6.50 BCD	**6.06 AB**
5	5.17 BCD	7.33 AB	9.17 A	**7.22 A**
6	5.00 CD	7.17 ABC	7.17 ABC	**6.44 A**
Mean (A)	**4.81 A**	**6.89 A**	**6.67 A**	
L.S.D. (5%)	**A: 2.64**	**B: 1.34**	**AB: 2.08**	

Where:
1: 100% normal-NPK (100 kg/fed.).
2: 50% normal-NPK (50 kg/fed.).
3: 75% normal-NPK + Nitrolef + Chelated (Zn and B).
4: 50% normal-NPK + Nitrolef + Chelated (Zn and B).
5: 75% normal-NPK + Nano-NPK + Nano (Zn and B).
6: 50% normal-NPK + Nano-NPK + Nano (Zn and B).

Al-Sharifi and Al-Zubaidi (2023), Rashwan *et al.* (2023), Alobaidi and Ibraheem (2024) and Salama and Haggag (2024). The interaction effect between the three potato cultivars and fertilization form was significant for tubers number / plant at harvest in both seasons. The highest tubers number / plant (7.33 and 9.17) were gained from Burren cultivar fertilized with [75% normal-NPK + Nano-NPK + Nano (Zn and B)] in both seasons, respectively. Contrarily, the least number of tubers / plant was recorded from Cara cultivar

fertilized with [50% normal-NPK (50 kg/fed.)] in the first season and from Lady Rosetta cultivar treated with the same fertilization treatment in the second season.

Tuber yield / feddan (ton)

The effect of fertilization form (NPK, Zn and B) on tuber yield / feddan (ton) of three potato cultivars (Lady Rosetta, Cara and Burren) at harvest through both growing seasons was listed in table (12). It is obvious from Table (12) that there was a statistical difference between the potato cultivars (Lady Rosetta, Cara and Burren) in tuber yield / feddan during the second season at harvest. Burren cultivar recorded the heaviest tubers yield (20.611 ton/fed), while Cara cultivar produced the lightest tubers weight (17.506 ton/fed) in both seasons. At the same time, Lady Rosetta cultivar registered nonsignificant intermediate value (19.050 ton/fed). In the first season, there were insignificant differences between tuber yield / feddan was markedly influenced by fertilizing fertilization forms in both seasons. In both seasons, the heaviest tubers yield (24.974 and 23.968 ton/fed) was produced from the treatment of [75% of the recommended traditional-NPK *(100 kg/fed.)* + Nano-NPK (foliar application) + Nano (Zn and B)]. On contrarily, the lightest tubers yield (18.112 and 15.713 ton/fed) was produced from the treatment of [half dose of recommended traditional-NPK (50 kg/fed.)]. These results were expected because of the positive effect of fertilization forms on yield components (tuber weight, number and size), as previously discussed. Our findings are in the line with those obtained by many researchers who emphasized the positive role of Nano-NPK fertilization on tuber yield such as Mijweil and Abboud (2018), Abd El-Azeim *et al.*(2019), Elshamy *et al.*(2019), Abd El-Azeim *et al.*(2020), Al-Abdali *et al.*(2021), Al-Zebari *et al.*(2021), Kumar *et al.*(2022), Abdulkadhum *et al.*(2023), Al-Bayati *et al.*(2023), Al-Hayani and Sallume (2023), Al-Sultan *et al.*(2023), Chauhan *et al.*(2023), Farrag *et al.*(2024) and Mahmood *et al.*(2025a). Also, Nano -Zn and -B fertilization supported the augment of tuber yield Rahman *et al.* (2018), Al-Juthery *et al.* (2019), Mahmoud *et al.* (2020), Marzouk *et al.* (2022), Al-Selwey *et al.* (2023), Al-Sharifi and Al-Zubaidi (2023), Rashwan *et al.* (2023), Alobaidi and Ibraheem (2024) and Salama and Haggag (2024). The effect of interaction between the three potato cultivars and fertilization forms was significant for tuber yield (ton/feddan) in the two seasons. Burren cultivar treated with [75% of the recommended normal-NPK *(100 kg/fed.)* + Nano-NPK (foliar application) + Nano (Zn and B)] recorded the highest tuber yield (28.897 and 32.040 ton/fed in both seasons, respectively). On the other side, the lowest tuber yield (15.677 and 14.437 ton/fed in the first and second seasons, respectively) was produced from Burren cultivar fertilized with [half dose of recommended traditional-NPK (50 kg/fed.)]. Considered one of Egypt's most significant vegetable crops and the second most economically valued vegetable crop after tomatoes, potatoes are used extensively in both industrial and culinary uses (Birch *et al.*, 2012). Egypt ranks 14th in the world for ware potato production and is one of Africa's largest producers and exporters of the crop, with over 20% of its total vegetable production acreage dedicated to potato growing.

Table (12): Effect of normal and/or nano fertilizers on total tuber yield / feddan (ton) at harvest of three potato cultivars grown in two successive winter seasons of 2023 and 2024.

Fertilization treatments (B)	Cultivars (A)			Mean (B)
	Lady Rosetta	Cara	Burren	
First season (2023)				
1	21.303 BCD	21.440 BCD	17.880 CD	**20.208 BC**
2	19.907 CD	18.753 CD	15.677 D	**18.112 C**
3	22.080 BC	22.290 BC	19.427 CD	**21.266 B**
4	20.003 CD	22.183 BC	18.290 CD	**20.159 BC**
5	23.243 BC	22.783 BC	28.897 A	**24.974 A**
6	19.963 CD	22.387 BC	26.497 AB	**22.949 AB**
Mean (A)	**21.083 A**	**21.639 A**	**21.111 A**	
L.S.D. (5%)	**A: 3.140**	**B: 2.915**	**AB: 5.190**	
Second season (2024)				
1	18.910 CD	17.487 CD	15.783 CD	**17.393 B**
2	17.530 CD	15.173 CD	14.437 D	**15.713 B**
3	19.323 CD	17.497 CD	18.130 C	**18.317 B**
4	18.440 CD	17.127 CD	17.140 CD	**17.569 B**
5	20.527 C	19.337 CD	32.040 A	**23.968 A**
6	19.570 CD	18.417 CD	26.137 C	**21.374 A**
Mean (A)	**19.050 AB**	**17.506 B**	**20.611 A**	
L.S.D. (5%)	**A: 3.078**	**B: 2.728**	**AB: 5.109**	

Where:
1: 100% normal-NPK (100 kg/fed.).
2: 50% normal-NPK (50 kg/fed.).
3: 75% normal-NPK + Nitrolef + Chelated (Zn and B).
4: 50% normal-NPK + Nitrolef + Chelated (Zn and B).
5: 75% normal-NPK + Nano-NPK + Nano (Zn and B).
6: 50% normal-NPK + Nano-NPK + Nano (Zn and B).

Egypt is a major exporter of potatoes, producing more than 5 million metric tons of potatoes for human consumption. In 2018, Egypt exported around 759,200 MT of potatoes, primarily to the United Arab Emirates (UAE) (53,100 MT or 7%), the Russian Federation (367,000 MT or 48%), and the EU-18 (190,400 MT or 25%) (Abdel-Aziz *et al.*, 2021). Locally available synthetic fertilizers are referred to as conventional fertilizers. These fertilizers' main ingredients are potassium, phosphorus, nitrogen, and other trace elements. Because some fertilizers are compounds, a bag of fertilizers may comprise many substances. Some, like urea, are single elements, though. According to Ullah *et al.* (2008), an eggplant crop's capacity to blossom, develop, and fruit swiftly is severely damaged utilizing traditional fertilizer. They also discovered that the pH of the soil steadily increased when traditional fertilizers were used. Although Savci (2012) noted that there are three ways that nitrogen fertilizers get to water surface flow, leaching, and drainage only 50% of nitrogenous fertilizers that are applied to the soil are used by plants; the remaining 20% are lost through evaporation, 20% react with organic compounds in clay soil, and the

remaining 10% contaminate surface and groundwater. Nizamuddin *et al.* (2003) found that the vegetative stage of potatoes rose with the use of conventional fertilizers, especially nitrogen fertilizer, which supports the previously cited findings.

The use of chemical fertilizers can damage the air, water, and soil (Chandini *et al.*, 2019). Chemical nitrogen fertilizers have the potential to emit harmful greenhouse gases (NH_4, CO_2, CH_4) that could deplete the ozone layer, which would directly harm human health. Excessive chemical fertilizer application can lead to soil pollution by damaging the physical and chemical pro/ties of the soil and producing acidity, which is caused by an imbalance in the utilization of the essential nutrients needed by plants. Crop production thus becomes inefficient. The cost of these chemical fertilizers is also high. Researchers looked at how conventional nanoforms of nitrogen, phosphorus, and potassium affected potato growth and yield. They found that all treatments increased plant height, the number of compound leaves / plant, the number of branches / plant, the number of plants in running meters, and the leaf area index, with the 100% NPK treatment having the highest values (Singh *et al.*, 2018). This is consistent with what we found in this study.

CONCLUSION AND RECOMMENDATIONS

In this research, the impact of fertilization with nitrogen, phosphorus, potassium, zinc, and boron as nano and/or normal forms on potato growth and production was studied. Results revealed that using combination of 75 % of the recommended traditional-NPK dose *(100 kg/fed.)* + Nano-NPK (foliar application) + Nano-micronutrients (Zn and B)] recorded the highest and best values of all desirable characteristics of potato in two successive winter seasons of 2023 and 2024. Thus, this mix is recommended to potato farmers of the Middle Egypt region and similar environments all over the world.

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الملخص العربى

دراسة تأثير التسميد بالأسمدة النانوية أو العادية على نمو وإنتاجية وجودة بعض أصناف البطاطس تحت ظروف مصر الوسطى

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في مزرعة خاصة بقرية منقطن، مركز سمالوط، محافظة المنيا، مصر، أُجريت تجربة حقلية على مدار موسمي نمو متتاليين في عامي 2023 و2024 لدراسة تأثير أسمدة NPK (سواءً التقليدية أو النانوية) والزنك والبوتاسيوم (سواءً المخلبية أو النانوية) على النمو الخضري والمحصول وجودة ثلاثة أصناف من البطاطس هى صنف بيرن، وكارا، وليدي روزيتا. وفيما يتعلق بتأثير الأصناف، أظهرت البيانات المتحصل عليها عن وجود فروق معنوية في جميع صفات النمو الخضري المختبرة (ارتفاع النبات، وعدد الفروع، وأوزان العشب سواء الطازجة أو الجافة)، ومحصول الدرنات ومكوناته (متوسط وزن الدرنات الطازج والجاف، وعدد الدرنات لكل نبات، ومحصول الدرنات للفدان وبالمثل، أدت معاملات التسميد إلى زيادة جميع الصفات المذكورة أعلاه. في معظم الحالات، سجلت معاملة [الجرعة الكاملة الموصى بها من سماد NPK التقليدي (100 كجم/فدان) + سماد NPK النانوي (رش ورقي) + سماد نانوي (زنك وبورون)] أعلى القيم. وتم الحصول على أفضل القيم من معاملة التفاعل من صنف بيرن المُسمد بـ [75% من الجرعة الموصى بها من سماد NPK التقليدي (100 كجم/فدان) + سماد NPK النانوي (رش ورقي) + سماد نانوي (زنك وبورون)].

الكلمات المفتاحية: البطاطس، الأسمدة النيتروجينية النانونية والعادية، النمو، المحصول.