

## Effect of NPK chemical and nano fertilizer on growth and yield of three potato cultivars *Solanum tuberosum* L.

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### Abstract

The experiment was conducted in the vegetable field of the Department of Horticulture and Landscaping / College of Agriculture and Forestry / University of Mosul in the spring season 2021. To study the effect of three potato cultivars (Arizona, Montreal, Florice) and five levels of the fertilizer combination (NPK 15-15-15, 75% chemical + 25% nano, 50% chemical + 50% nano, 25% chemical + 75% nano, Chemical Zero + 100% Nano). The experiment was designed in the split-plot system using The Randomized Complete Block Design (RCBD) and with three replicates, where the cultivars were placed in the main plots and the fertilizer combination treatments in the split plots. The results can be summarized as follows: Arizona cultivar gave the highest significant values in plant height 60.36 cm, number of aerial stems per plant 5.62 stem.plant<sup>-1</sup>, number of tubers per plant, plant yield, total yield of tubers and marketing yield of tubers reached 13.82 tubers.plant<sup>-1</sup>, 874.26 g and 46.627 tons ha<sup>-1</sup> and 41,791 tons ha<sup>-1</sup>, respectively. The Montreal cultivar gave the highest significant value in the average tuber weight of 70.80 g. For the fertilizer mixture, 50% chemical + 50% nano treatment gave the highest significant values in plant height, number of aerial stems per plant, leaf area of plant, content of chlorophyll a and chlorophyll b in leaves and number of tubers. The average tuber weight, plant yield, total yield of tubers, marketing yield of tubers 62.40 cm, 6.00 stems. plant<sup>-1</sup>, 6887 cm<sup>2</sup> plant<sup>-1</sup>, 1.84 g.g<sup>-1</sup> fresh weight, 1.57 g.g<sup>-1</sup> fresh weight, 13.01 tubers.plant<sup>-1</sup>, 72.66 g and 939.61 g and 50,112 ton.ha<sup>-1</sup> and 45.210 ton.ha<sup>-1</sup>, respectively. The interaction of Florice cultivar with the fertilizer combination 50% chemical + 50% nano gave the highest significant values in plant height. The treatment of Arizona cultivar with the fertilizer combination 50% chemical + 50% nano, gave the highest significant values in the number of aerial stems of the plant, the number of tubers per plant and the yield of the plant. The Montreal cultivar with the fertilizer combination 50% chemical + 50% nano gave the highest significant value in the leaf area of the plant, the content of chlorophyll a and b in the leaves, the total yield of the tubers and the marketing yield of the tubers.

**Keywords:** potatoes, nano fertilizer, cultivars

### Introduction

Potato (*Solanum tuberosum* L.) is one of the most important vegetable crops in the world. It belongs to the Solanaceae family. It is native to South America (Wanted et al. 1989). Tuberous crops top the list of important vegetable crops that humans can consume in relatively large quantities because they constitute an important source of many nutrients and come in fourth place among the most cultivated crops after wheat, rice and maize (Daniels-Lake, 2013). The growth and productivity of the potato crop are affected by

many factors, the most important of which is the quality of the planted seeds, which must be of high grades, which import these seeds from outside Iraq, especially European countries, and on multiple factors, including the cultivar and production area. Hassan et al. (2017) observed the Arizona cultivar excelled in plant height, number of aerial stems and number of tubers per plant compared to Riviera and Volar cultivars. Al-Mohammadi and Al-Jumaili (2019) found that the Arizona cultivar was significantly excelled on the Riviera cultivar in the number of aerial stems of the plant and the number of tubers per

plant. Al- Bayati and Al- Quraishi (2019) mentioned that the plants of the Arizona cultivar gave the highest significant values in plant height, number of aerial stems per plant, leaf area of the plant, number of tubers per plant, average tuber weight, yield of one plant and total yield of tubers compared to Agria and Riviera cultivars. Al-Ajili (2021) noticed that the cultivar Arizona was significantly excelled in the number of tubers per plant, the yield of one plant and the marketing yield per unit area compared to the cultivar Florice. Al-Zibari (2021) found that the Montreal cultivar gave the highest significant value in the average tuber weight, total and marketing yield of tubers compared to Laperla, Florice and Arizona cultivars. In recent years, the world has turned to study several modern technologies in the agricultural field, including studying the possibility of using nanotechnology to improve the efficiency of fertilizer use towards the design and development of the so-called nano-fertilizers (NF) (Rastogi et al., 2017 and (Elemike et al , 2019). Nano-fertilizers have several properties and advantages, including that they work to increase the efficiency of the use of nutrients .It also affects the yield in terms of its increase, and it is of better quality and is safer for the environment in that it reduces the process of soil pollution, as well as the possible negative effects that occur when adding traditional mineral fertilizers (Liu and Lal, 2016) and (Singh et al., 2017). Nano-fertilizers (NF) are more efficient and effective than conventional fertilizers because of their positive effects on the quality of food crops and reducing the stresses that occur to the plant. Botanicals (Ali and Al-Juthery, 2017). Janmohammadi et al. (2016) indicated when using fertilizer combinations (B nano + Ca nano) and the complete nano fertilizer containing 11 macro and micro elements for potato plants, that the complete fertilizer combination caused a significant increase in plant height, leaf area of the plant, average tuber weight and number of tubers per plant The yield of a single plant. Abbas and Allawi (2018) mentioned that the addition of

chemical fertilizer 15-15-15 with the full recommendation of 600 kg ha<sup>-1</sup> with the spraying of nano-fertilizer 2 g.L<sup>-1</sup> caused a significant increase in the leaf area of the plant, the number of tubers per plant, the average tuber weight and the total yield of tubers. Al-Khafaji (2019) observed that the use of NPK 15-15-15 fertilizer combinations with nano-fertilizer at a concentration of 2 g.L<sup>-1</sup> for Arizona potato plants caused a significant increase in plant height, number of aerial stems of the plant, leaf area of the plant, number of tubers per plant, average tuber weight and yield per plant And the total and marketing yield of tubers. Abd El-Azeim et al. (2020) explained that adding 50% chemical fertilizer recommended with nano-fertilizer spraying for potato plants caused a significant increase in vegetative growth traits and yield components. Al-Zebari et al. (2021) found that the addition of chemical fertilizer NPK 20-20-20 with nano fertilizer spraying at a concentration of 2 g.L<sup>-1</sup> to plants of four cultivars of potato caused a significant increase in the number of tubers per plant, the average tuber weight, the yield per plant and the total and marketing yield of tubers per unit area.

the study aim: The study aims at the possibility of reducing the addition of traditional chemical fertilizer to the soil and replacing it with nano-fertilizer for potato plants.

### Materials and methods

The experiment was conducted during the spring agricultural season of 2021, in the vegetable field of the Department of Horticulture and Landscaping, College of Agriculture and Forestry, University of Mosul. Samples were taken from the field soil from the surface layer down to a depth of 30 cm in order to conduct a laboratory examination to know the physical and chemical properties of the field soil before planting and Table No. (1) shows the most important physical and chemical properties of the measured soil.

**Table (1) shows some physical and chemical properties of the soil of the experimental field before cultivation**

traits	values
PH	7.2
Electrical conductivity EC (m-1/dc)	0.3
% organic matter	1.3
Availability Nutrients Content	
Nitrogen mg kg <sup>-1</sup>	27.2
Phosphorous mg kg <sup>-1</sup>	6.5
Potassium mg kg <sup>-1</sup>	100
Physical soil components g kg <sup>-1</sup>	
sand gram kg <sup>-1</sup>	420.5
silt Gram kg <sup>-1</sup>	340
Clay kg kg <sup>-1</sup>	239.5
texture	Loam

The land was prepared for cultivation by tillage with a triple Moldboard plow and two perpendicular plows, and the smoothing and leveling of the soil was conducted. The chemical fertilizer NPK 15:15:15 was added according to the treatments and mixed with the soil. The experimental field was divided into three sectors, and each sector was divided into 15 experimental units with a length of 2 M and then work the troughs at an average of three troughs for the experimental unit and extend the drip irrigation pipes. The seeds were planted on February 13, 2021, for the cultivars Arizona, Montreal, and Florice, rank E, The experimental unit included three furrows with a length of 2 m, a width of 2.25 m, and the distance between one meadow and another is 75 cm. The area of the experimental unit was 4.5 m<sup>2</sup> and 8 tubers were planted in each furrows . The number of tubers in the experimental unit was 24, and they were planted at a depth of 15 cm. The method was drip irrigation. The agricultural service operations were conducted as is the case in the commercial fields of the potato

crop in the same methods for all the experimental units, from weeding and weeding (twice during the growing season), exporting the soil for plants (once during the growing season) and controlling diseases and insects.

Two factors were studied in the experiment:

The first factor: Three types of seed grade E:

- 1- Arizona
- 2- Montreal
- 3- Florice

The second factor: Fertilizer combination treatments:

1. Chemical fertilizer NPK 15: 15: 15 full recommendation 400 kg ha<sup>-1</sup> (Al Fadli, 2006).
2. 75% of the recommended chemical fertilizer NPK 15:15:15 + 25% nano-fertilizer NPK 20:20:20

(300 kg NPK + 0.25 g L<sup>-1</sup>).

3. 50% of the recommended chemical fertilizer NPK 15:15:15 + 50% nano-fertilizer NPK 20:20:20

(200 kg NPK + 1 g L<sup>-1</sup>).

4. 25% of the recommended NPK chemical fertilizer 15:15:15 + 75% NPK nano-fertilizer 20:20:20

(100 kg NPK + 1.5 g L<sup>-1</sup>).

5. NPK 20:20:20 Nano Fertilizer only (2g.L<sup>-1</sup>).

The chemical fertilizer was added 15:15:15 before planting, and the nano-fertilizer was sprayed three times during the growing season, the first spraying a week after the tuber germination was completed, the second 20 days after the first and the third spray 20 days after the second spray.

#### Studied traits:

plant height (cm)

Number of aerial stems (stem.plant<sup>-1</sup>)

The leaf area of the plant (cm<sup>2</sup>.plant<sup>-1</sup>)

Chlorophyll a and b content in leaves (mg g<sup>-1</sup> fresh wight)

Number of tubers (tuber.plant<sup>-1</sup>)

Tuber weight average(g)

**Table (2): Effect of cultivar and fertilizer combination on vegetative growth traits of potato crop.**

Treatments	plant height cm	Number of aerial stems (stem.plant <sup>-1</sup> )	Leaf area (cm <sup>2</sup> plants <sup>-1</sup> )	Chlorophyll l A (mg g <sup>-1</sup> fresh weight)	Chlorophyll l B (mg g <sup>-1</sup> fresh weight)
Arizona	60.36 a	5.62 a	6092 a	1.56 a	1.38 a
Montreal	49.22 b	5.02 b	6466 a	1.57 a	1.44 a
Florice	60.29 a	4.25 c	6136 a	1.46 a	1.38 a
Fertilizer combination					
V1	56.32 b	4.23 c	6201 ab	1.36 d	1.32 d
V2	56.43 b	4.83 b	5917 b	1.54 c	1.40 c
V3	62.40 a	6.00 a	6887 a	1.84 a	1.57 a
V4	60.69 ab	5.62 a	6313 ab	1.71 b	1.47 b
V5	47.28 c	4.13 c	5843 b	1.21 e	1.24 e

yield per plant (g)

Marketing yield of tubers (tons. ha<sup>-1</sup>)

Total yield of tubers (ton ha<sup>-1</sup>)

After recording the data, it was statistically analyzed according to the SAS (2001) system, according to the split-plot system, using the R.C.B.D. complete block design, with three replicates. Where the cultivars were placed in the main plots and the fertilizer combination coefficients were placed in the split plots according to Duncan's polynomial test and under the probability level of 0.05 (Al-Rawi and Khalaf Allah, 2000).

#### Results and discussion:

The results in Table (2) indicate that the cultivar Arizona gave the highest significant values in plant height and number of aerial stems of the plant, which were 60.36 cm and 5.62 stems.plant<sup>-1</sup>. While no significant differences were observed between the cultivars in the leaf area of the plant and the content of leaves from chlorophyll a and b. As for the fertilizer mixture, the treatment of V3 gave the highest significant values in plant height, number of aerial stems, leaf area of the plant, and chlorophyll a and b content in leaves, which were 62.40 cm and 6.00 plant stems<sup>-1</sup>, 6887 cm<sup>2</sup> plant<sup>-1</sup>, 1.84 mg gm<sup>-1</sup> fresh weight and 1.57 g.g-1 fresh weight respectively.

The averages with the same letter or letters within the same column and the interaction treatments do not differ between them significantly according to Duncan's polynomial test under the 0.05 probability level. V1 = chemical only V2 = chemical 75% + 25% nano V3 = chemical 50% + 50% nano V4 = Chemical 25% + 75% NaN V5 = Chemical 0% + 100% NaN

The results in Table (3) in the interaction between the cultivar and the fertilizer combination indicate that the highest significant value in plant height was obtained in plants of the cultivar Florice with the fertilizer combination V3 and it reached 68.47 cm and the lowest values for this trait reached 45.63 cm in the treatment of the Montreal cultivar with the fertilizer combination V5. As for the number of aerial stems, the Arizona

cultivar was observed with the V3 fertilizer combination, which gave the highest significant value in the number of aerial stems, which amounted to 6.74 stems.plant<sup>-1</sup>, and the lowest value for this trait was 3.45 stems.plant<sup>-1</sup> in the treatment of Florice with the fertilizer combination V5 and the highest significant value for leaf area and chlorophyll a and b content in leaves was 7816 cm<sup>2</sup> plant<sup>-1</sup>, 1.90 and 1.60 mg g<sup>-1</sup> fresh weight in Montreal cultivar with V3 fertilizer combination. The lowest value of leaf area was 4974 cm<sup>2</sup> plant<sup>-1</sup> in the treatment of Arizona cultivar with the fertilizer combination V2, and the lowest values for chlorophyll a and b were 1.14 and 1.20 mg g<sup>-1</sup> fresh weight, respectively, in the treatment of the cultivar Florice with the fertilizer combination V5.

**Table (3): The effect of the interaction between the cultivar and the fertilizer combination on the vegetative growth traits of the potato crop.**

Treatments	Fertilizer combination	plant height cm	Number of aerial stems (stem.plant <sup>-1</sup> )	Leaf area (cm <sup>2</sup> plants <sup>-1</sup> )	Chlorophyll A (mg g <sup>-1</sup> fresh weight)	Chlorophyll B (mg g <sup>-1</sup> fresh weight)
Arizona	V1	62.56 ab	4.54 efg	6326 abc	1.46 ef	1.29 de
	V2	58.89 abc	5.49 cd	4974 c	1.55 def	1.36 cd
	V3	66.07 ab	6.74 a	6869 ab	1.85 ab	1.56 ab
	V4	64.43 ab	6.40 ab	6316 abc	1.69 bcd	1.44 bc
	V5	49.84 cd	4.89 de	5975 bc	1.24 gh	1.26 de
Montreal	V1	47.89 d	4.19 e-h	6011 bc	1.37 fg	1.37 cd
	V2	48.35 d	4.81 def	6038 bc	1.59 cde	1.46 bc
	V3	52.63 cd	6.35 ab	7816 a	1.90 a	1.60 a
	V4	51.55 cd	5.69 bc	7083 ab	1.77 abc	1.50 ab
	V5	45.63 d	4.03 fgh	5381 bc	1.24 gh	1.26 de
Florice	V1	58.49 bc	3.94 gh	6266 abc	1.24 gh	1.30 de
	V2	62.02 ab	4.19 e-h	6740 abc	1.48 ef	1.37 cd
	V3	68.47 a	4.91de	5976 bc	1.77 abc	1.55 ab
	V4	66.08 ab	4.76 def	5541 bc	1.67 bcd	1.47 bc
	V5	46.36 d	3.45 h	6172 abc	1.14 h	1.20 e

The averages with the same letter or letters within the same column and the interaction treatment do not differ between them significantly according to Duncan's polynomial test under the 0.05 probability level. V1 = chemical only V2 = chemical 75% + 25% nano V3 = chemical 50% + 50%

nanoV4 = Chemical 25% + 75% NaN V5 = Chemical 0% + 100% NaN

It is noted from the results in Table (4) that the cultivar Arizona gave the highest significant values in the number of tubers per plant, the yield of one plant, the total yield of tubers and the marketing yield of tubers,

which amounted to 13.82 tubers plant<sup>-1</sup>, 874.26 g, 46.627 tons ha<sup>-1</sup> and 41,791 tons ha<sup>-1</sup>, Compared to the other two cultivars, Montreal and Florice. Which gave the lowest values for these traits. As for the average tuber weight, it is noted that the Montreal cultivar gave the highest significant value and reached 70.80 g and the lowest value reached

63.28 g in the Arizona cultivar. As for the fertilizer combination, we note that the fertilizer combination V3 gave the highest significant values in the number of tubers and the average tuber weight. The yield per plant, total and marketing yield of tubers was 13.01 tuber plant<sup>-1</sup>, 72.66 g, 939.61 g, 50,112 tons ha<sup>-1</sup> and 45.210 ton. ha<sup>-1</sup>, respectively.

**Table (4): Effect of cultivar and fertilizer combination on yield traits of potato crop.**

Treatments	Total number of tubers (tuber plant <sup>-1</sup> )	Tuber weight average (g)	Total Plant Yield (g)	The total yield of tubers (tons. ha <sup>-1</sup> )	Marketing yield of tubers (ton ha <sup>-1</sup> )
Arizona	13.82 a	63.28 b	874.26 a	46.627 a	41.791 a
Montreal	11.54 b	70.80 a	812.60 b	43.338 b	39.824 b
Florice	10.82 c	64.07 b	693.13 c	36.966 c	33.094 c
<b>Fertilizer combination</b>					
V1	11.81 b	61.57 c	724.56 d	38.642 d	34.844 d
V2	12.00 b	68.19 b	803.50 c	42.852 c	38.576 c
V3	13.01 a	72.66 a	939.61 a	50.112 a	45.210 a
V4	12.77 a	68.68 b	867.39 b	46.260 b	42.078 b
V5	10.71 c	59.12 c	631.61 e	33.685 d	30.473 e

The averages with the same letter or letters within the same column and the interaction treatments do not differ between them significantly according to Duncan's polynomial test under the 0.05 probability level. V1 = chemical only V2 = chemical 75% + 25% nano V3 = chemical 50% + 50% nano V4 = Chemical 25% + 75% NaN V5 = Chemical 0% + 100% NaN

It is noted from the results of Table (5) that the highest significant values in the number of tubers of the plant were in the treatment of the

Arizona cultivar with the fertilizer combination V3 and it reached 14.58 tuber plant<sup>-1</sup> and in the yield of the seed, the total yield of the tubers and the marketing yield of the tubers in the treatment of the Montreal cultivar with the fertilizer combination V3 They were 988.50 g, 52,719 tones ha<sup>-1</sup> and 48,891 ton. ha<sup>-1</sup>, respectively. The lowest values for these traits were found in the treatment of Florice cultivar with the fertilizer combination V5. And the average weight of the tuber in the treatment of cultivar Montreal with the fertilizer mixture V2 was 78.92 g.

**Table (5): The effect of the interaction between the cultivar and the fertilizer combination on the yield traits of the potato crop**

Treatments	Fertilizer combination	Total number of tubers (tuber plant <sup>-1</sup> )	Tuber weight average (g)	Total Plant Yield (g)	The total yield of tubers (tons. ha <sup>-1</sup> )	Marketing yield of tubers (ton ha <sup>-1</sup> )
Arizona	V1	13.12 b	62.10 de	811.00 d	43.253 d	39.180 ef
	V2	14.56 a	64.04 de	922.83 b	49.217 b	43.587 c
	V3	14.58 a	67.53 cd	982.50 a	52.399 a	45.646 b
	V4	14.58 a	64.44 de	938.50 b	50.053 b	46.391 b
	V5	12.30 bcd	58.28 e	716.50 f	38.213 f	34.154 h
Montreal	V1	11.99 cd	63.28 de	751.33 e	40.070 e	36.503 g
	V2	10.55 fg	78.92 a	819.67 cd	43.715 cd	40.456 de
	V3	12.69 bc	78.18 ab	988.50 a	52.719 a	48.891 a
	V4	11.56 def	73.75 abc	852.17 c	45.448 c	41.549 d
	V5	10.90 efg	59.84 e	651.33 g	34.737 g	31.720 i
Florice	V1	10.31 g	59.33 e	611.33 h	32.604 h	28.850 j
	V2	10.90 efg	61.63 de	668.00 g	35.626 g	31.686 i
	V3	11.77 cde	72.27 bc	847.83 cd	45.217 cd	41.093 de
	V4	12.18 bcd	67.82 cd	811.50 d	43.279 d	38.296 fg
	V5	8.93 h	59.24 e	527.00 i	28.106 i	25.546 k

The averages with the same letter or letters within the same column and the interaction treatments do not differ between them significantly according to Duncan's polynomial test under the 0.05 probability level. V1 = chemical only V2 = chemical 75% + 25% nano V3 = chemical 50% + 50% nano V4 = Chemical 25% + 75% NaN V5 = Chemical 0% + 100% NaN

Through the results, the Arizona cultivar is noted in plant height and number of aerial stems (Table 2). This may be due to the variation of genetic traits between the cultivars used in the study (NIVAA, 2017)

and to the response of the Arizona cultivar to soil factors and conditions, including soil texture, soil PH and soil organic matter. (Table 1). The Arizona cultivar excelled in the number of tubers per plant (Table 4) is due to the excelled of the cultivar in the number of aerial stems of the plant (Table 2), which caused the increase in the number of tubers per plant. ) Which caused giving a small number of tubers to the plant (Table 4) and this led to an increase in the growth and enlargement of the size of the tubers formed. The Arizona cultivar excelled in the yield of one plant, the marketing yield of tubers and the total yield of tubers (Table 4) may be due

to the increase in the number of tubers per plant, which caused an increase in the yield of one plant, which in turn caused an increase in tubers to yield per unit area. It is noted from the results that the fertilizer combination 50% chemical fertilizer + 50% nano fertilizer for all the studied vegetative growth traits represented in the height of the plant, the number of aerial stems of the plant, the leaf area of the plant and the content of chlorophyll a and b in the leaves (Table 2). This may be due to the provision of the three macro elements needed by the plant in high quantities and necessary for the growth of the plant, whether processed by ground addition or sprayed on the leaves (nano), which is complementary to the ground fertilizer for the root zone and its transmission to the vegetative system. Also, nanoparticles enter the leaves of the plant through the stomata very quickly and penetrate more easily and are transferred to the carrier vessels more efficiently (Wilson et al., 2008). and the fertilizer combination 50% chemical + 50% nano excelled in the number of tubers of the plant (Table 4) to its excelled in the number of aerial stems of the plant (Table 2), which caused an increase in the number of tubers formed in the plant and this in turn caused an increase in the yield of the plant and consequently an increase in the marketing and total yield of tubers per unit area as a result. Increasing the number of tubers per plant, the average tuber weight, and the yield of one plant, This is consistent with what was mentioned by (Hassan et al., 2017), (Al-Muhammadi and Al-Jumaili, 2019) and (Al-Bayati and Al-Quraishi, 2019). and (Al-Zebari, 2021) that there are significant differences between potato cultivars in the traits of vegetative growth. It is consistent with what was mentioned (Abbas and Allawi, 2018), (Abd El-Azeim et al., 2020) and (Al-Zebari et al., 2021) that the addition of ground chemical fertilizer with the spraying of nanofertilizer caused an increase in the traits of vegetative growth and yield components of potato plants.

## Conclusions

We conclude from this study the possibility of planting the Arizona cultivar in the spring season under the conditions of Nineveh Governorate and using the fertilizer combination 50% chemical from the fertilizer recommendation + 50% nano spray on the leaves.

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