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Response of Growth and Quantity Yield of Two Potato Cultivars *Solanum tuberosum* to Spraying with Nano-NPK Fertilizer and Amino Acid *(Tecamin Max)*

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ABSTRACT

Two successive field experiments were conducted during the spring seasons of 2024 and 2025 at Dinaran village, located in Bardarash district, Duhok Governate, Kurdistan Region-Iraq. The objective was to inspect the growth and quantity yield response of two potato cultivars namely, (Harry and Lucinda) to foliar spraying with three concentrations of nano NPK fertilizer (0, 2 and 4g.L-1) and three concentrations of amino acid (0,3 and 6ml.L-1) in Bardarsh district due to it is considered as a famous region for potato production. The experimental treatments were organized within a split-split plot design following a randomized complete block design (R.C.B.D) with three replicates. The statistical analysis revealed that the Harry cultivar exhibited the highest significant values across most growth and yield parameters in both spring growing seasons, including leaf area (cm2), dry matter of growth (g plant-1), number of marketable tubers (tuber plant-1), marketable tuber weight (g tuber-1), marketable plant yield (kg plant-1) and overall marketable tuber yield (t ha-1). Conversely, the Lucinda cultivar showed a significant advantage in plant height (cm). The treatment with a concentration of 4g.L-1 of nano NPK fertilizer resulted in the most significant improvements across most of the studied catachrestic. Application of amino acids at both dosage 3 and 6ml.L-1 led to significant increase in all parameters compared to the control treatments in both seasons. Furthermore, the combination of treatments involving both nano NPK fertilizer and amino acids, as well as the interaction among cultivars, yielded the heights values for the studied parameters of potato plants.

***Keywords*:** Potato, Cultivars, Nano NPK, Amino acid, Growth, yield.

INTRODUCTION

The potato (*Solanum tuberosum* L.) is an essential tuber crop belonging to the Solanaceae family. It is widely cultivated in Iraq and around the world due to its high economic value and strategic importance as a staple food crop. In Iraq, the mass production of the potatoes is approximately 270,591 tons, cultivated over an area of 12645 hectares devoted for its planting and a maximum harvest income of 21399.2 kg ha^{-1} **[1].**

Potato cultivars play a crucial role in determining the productivity and resilience of potato crops. Selecting the appropriate cultivar for a specific region can significantly enhance crop performance and yield quality. In Iraq, where multiple potato cultivars are cultivated, choosing the best suited cultivars is essential to optimize production and ensure sustainable agriculture practices. **[2]** reported that the Rivera cultivar had the highest chlorophyll content. The Bureen cultivar exhibited the greatest number of branches per plant and dry weight, whereas the Arizona cultivar demonstrated the tallest plant height. **[3]** indicated that the Sefra cultivar demonstrated superior moral traits related to overall productivity, such as total yield per plant and total tuber yield. Conversely, the Bada cultivar exhibited advantages in traits associated with marketability, including marketable yield per plant and marketable tuber yield. Given the global significance of the potato crop and the challenges posed by low productivity and population growth in Iraq, it is essential to adopt advanced methods and techniques to enhance production and improve crop quality. Among these methods, nano fertilizers represent a valuable complement to traditional fertilizers. It was observed that increasing crop productivity through the adoption of new applications, including nanotechnology and nanomaterials, positively affects plant growth and development, with nano-fertilizer particles playing a beneficial role **[4, 5].**

Nano fertilizer improves nutrient use efficiency, minimize fertilizer wastage and reduce cultivation cost. Due to their nanoscale size this fertilizer offers a larger surface area which facilitates more efficient metabolic reactions within the plant. This increased activity boosts the rate of photosynthesis leading to higher production of dry matter and greater crop yields **[6,7, 8].** The study by **[9]** demonstrated that foliar application of nano NP fertilizer on potato plant led to a significant enhanced in vegetative growth, including plant height, chlorophyll leaf content (SPAD), aerial stems count, dry matter of the vegetative growth, leaf area, as well as overall total yield and marketable yield.

Amino acid is essential organic compound which enhancing metabolic balance and boosting resistance to environmental stresses **[10, 11].** Additionally, amino acids help regulate physiological process **[12]** including photosynthesis, respiration and nutrient absorption. By enhancing the metabolic balance within the plant, amino acids contribute to improved growth rates and enhanced stress tolerance **[13, 14]** conducted an experiment on potato plants (Arizona cultivar) by spraying them with an organic acid (Ticamin Max) at a concentration of 6 ml.L^{-1} led to significant increase in total number of marketable tubers, tuber firmness and (TSS%) in tuber. [13] demonstrated that foliar spray treatment with amino acids significantly outperformed the control group across all measured parameters. These parameters included the number of marketable tubers, main stem length, tuber number per plant, tuber length, tuber diameter, tuber weight, and total tuber yield per plant. The objective of this study was to evaluate the effect of foliar application of nano-NPK fertilizer and amino acid on the vegetative growth and quantity yield of two potato cultivars under the climatic conditions of Duhok province, Kurdistan region, Iraq.

Materials and Method

The experiment was conducted in an open field at Dinaran village, Bardarash district, Duhok province, Kurdistan region, Iraq, during the consecutive spring seasons of 2024 and 2025. The study aimed to evaluate the effects of nano NPK fertilizer at three concentrations (0, 2 and 4 g.L^{-1}) and amino acid at three concentrations (0, 3 and 6 ml.L^{-1}) as foliar application on the growth and quantity of the yield of two potato cultivars, Harry and Lucinda, under the climatic conditions of Baradarch district. The experimental soil was silty clay with a pH of (7.3). The soil fields were prepared by plowing, softened and levelling. The area was divided into three replicates. Each replicate included (18) experimental units, each unit measured 3.6 m in length and 75 cm in width, with two ridges representing each experimental unit with an area of 5.4 m^2.

Experimental studied factors:

The experiments included the following factors:

The first factors: cultivars:

- Lucinda [Dutch cultivar from HZPC company, registered by the Iraqi Ministry of agriculture, tuber size: 35/55 mm, class: E]
- Harry [France cultivar from Agrico company, registered by the Iraqi Ministry of agriculture, tuber size: 35/60 mm, class: E].

The second factors: Nano-NPK fertilizer:

- [Khazra Nano chelated NPK contain 12% nitrogen, 12% phosphorus, 36% potassium, produced by Sodour Ahrar Shargh, Iran country].

The third factors: Amino acid (Ticamin Max):

- Ticamin Max consist of [w/w]: 14.4% total amino acid, 12% free amino acid, 3.5% total nitrogen, 20% organic compound, pH:6.6, produced by Agri-Tecno, Espain.

The imported potato cultivars Harry and Lucinda were sprouted for (15) days at room temperature before planting. After seed tuber sprouted, they are planted on 1st March at distance of 30 cm between of them and a depth of 15 cm in both spring seasons. Twelve tubers were planted in each ridge (24 tubers for the experimental unit). The potato plants were sprayed three times with nano NPK fertilizers and amino acids, the first application occurred when the plants reached 3-4 true leaves, the second was applied 20 days after the first, and the third was 20 days after the second with three days interval between the spraying of nano NPK fertilizer and amino acids. Sprinkler irrigation system of the field was performed prior to planting. Other agricultural practices were similarly carried out as followed by farmers in the area like irrigation, weed control and controlling pest and diseases. Harvesting was conducted 120 days after planting in both seasons.

Experimental Treatments

The treatments were arranged using a Split-Split plot design with three replicates. The cultivars served as the main plots, while the sub plots consisted of amino acid treatments, and the sub-sub plot included the nano $N_{12}P_{12}K_{36}$ fertilizer. The experiment involved (18) treatments arranged according to a Randomized Complete Block Design (RCBD) with three replicates. The parameters measured included: plant height (cm), leaf area (cm^2), vegetative dry matter (g), number of marketable tuber (tuber plant^{-1}), marketable tuber weight (g plant^{-1}), marketable plant yield (kg plant^{-1}) and marketable yield of tubers (t ha^{-1}). Data were statistically analyzed using the (SAS) program **[15]** and means were compared using Duncans multiple rang test at a 0.05 significance level.

Results

Plant height (cm):

The data presented in Table (1) indicate that there was a significant difference between the cultivars regarding plant heigh, the Lucinda cultivar excessed the highest values measuring (62.94 and 116.30 cm) in both seasons respectively. In contrast, the Harry cultivar which recorded lower heights, with values of (60.70 and 104.27 cm) respectively. According the effect of nano NPK fertilizer, both concentrations of 2 and 4g.L^{-1} resulted a significant increase in potato plant heigh compared to the control treatment. Conversely, the tallest plant was observed in treatments where plants received both concentration 3ml.L^{-1} and 6ml.L^{-1} of amino acid in the two seasons while the shortest plant observed with control treatments which matched at value of (59.86 and 105.31 cm) respectively. In the case of binary interactions, the Lucinda cultivar treated with 2g.L^{-1} of nano NPK produced the excellent plant heigh (64.31 and 124.24 cm) respectively, compared to other interactions. On the other side, the Lucinda cultivar treated with 3ml.L^{-1} of amino acid exhibited the greatest plant heigh, reaching (64.93 and 123.07 cm), while the Harry cultivar under control conditions recorded the lowest plant high (59.53 and 99.76 cm) respectively.The combination of nano NPK and amino acids, showed the maximum plant heigh (65.67 and 123.07 cm) respectively occurred as a result of addition 2g.L^{-1} nano NPK and 3ml.L^{-1} of amino acid compared to the control of both factors in the two spring seasons. The triple interactions among the three studied factors, Lucinda cultivar with using 2g.L^{-1} of nano NPK and 3ml.L^{-1} of amino acid produced the peak value of plant heigh, measuring (66.07 and 131.60 cm) respectively, compared to other treatment interactions.

Table (1): Effect of cultivars, nano-NPK fertilizers and amino acid on the plant height (cm).

First Spring Season of (2024)						
Cultivars	Nano-NPK (g L^{-1})	Amino Acid (ml L^{-1}) 0	3	6	Cultivars * Nano-NPK	Cultivars Effects
Harry cv.	0	56.60 ^{fg}	60.87 $^{c-f}$	59.53 $^{d-f}$	59.00 ^{d}	60.70 ^{b}
	2	60.27 $^{d-f}$	65.27 $^{a-c}$	62.13 $^{a-e}$	62.56 $^{a-c}$	
	4	61.73 $^{a-e}$	60.73 $^{c-f}$	59.20 ^{ef}	60.56 ^{cd}	
Lucinda cv.	0	54.93 ^{g}	62.73 $^{a-e}$	65.73 ^{ab}	61.13 $^{b-d}$	62.94 ^{a}
	2	62.73 $^{a-e}$	66.07 ^{a}	64.13 $^{a-d}$	64.31 ^{a}	
	4	62.87 $^{a-e}$	66.00 ^{a}	61.27 $^{b-e}$	63.38 ^{ab}	
Amino Acid Effects		59.86 ^{b}	63.61 ^{a}	62.00 ^{a}		
Cultivars * Amino Acid	Harry cv.	59.53 ^{d}	62.29 ^{bc}	60.29 ^{cd}	Nano-NPK Effects	
	Lucinda cv.	60.18 ^{cd}	64.93 ^{a}	63.71 ^{ab}		
Nano-NPK * Amino acid	0	55.77 ^{c}	61.80 ^{b}	62.63 ^{ab}	60.07 ^{b}	
	2	61.50 ^{b}	65.67 ^{a}	63.13 ^{ab}	63.43 ^{a}	
	4	62.30 ^{b}	63.37 ^{ab}	60.23 ^{b}	61.97 ^{a}	
Second Spring Season of (2025)						
Harry cv.	0	90.40 ^{h}	97.60 $^{f-h}$	106.47 $^{d-g}$	98.16 ^{c}	104.27 ^{b}
	2	105.07 $^{d-g}$	114.53 $^{b-e}$	110.07 $^{c-g}$	109.89 ^{b}	
	4	103.80 $^{d-h}$	103.07 $^{e-h}$	107.40 $^{d-g}$	104.76 ^{bc}	

Lucinda cv.	0	96.20 ^{gh}	109.20 $^{c-g}$	110.53 $^{c-g}$	105.31 ^{bc}	116.30 ^{a}
	2	118.67 $^{a-d}$	131.60 ^{a}	122.47 $^{a-c}$	124.24 ^{a}	
	4	117.73 $^{a-e}$	128.40 ^{ab}	111.87 $^{c-f}$	119.33 ^{a}	
Amino Acid Effects		105.31 ^{b}	114.07 ^{a}	111.47 ^{a}		
Cultivars * Amino Acid	Harry cv.	99.76 ^{d}	105.07 ^{cd}	107.98 ^{bc}	Nano-NPK Effects	
	Lucinda cv.	110.87 ^{bc}	123.07 ^{a}	114.96 ^{b}		
Nano-NPK * Amino acid	0	93.30 ^{d}	103.40 ^{c}	108.50 ^{bc}	101.73 ^{b}	
	2	111.87 ^{bc}	123.07 ^{a}	116.27 ^{ab}	117.07 ^{a}	
	4	110.77 ^{bc}	115.73 ^{ab}	109.63 ^{bc}	112.04 ^{a}	

The columns, rows and their interactions, which share the same letters, are not significantly different from each other according to Duncan's multiple range test at the significant level (α=0.05).

Leaf area (cm^2):

Table (2) shows Harry cultivar produced larger expansion leaves, with values of (146.35 and 204.84 cm^2) respectively, compared to the Lucinda cultivar showed lower leaf expansion with values of (113.91 and 187.26 cm^2) respectively. Spraying nano NPK fertilizers at a high concentration of 4g.L^{-1} notably enhanced leaf area at a value (143.24 and 205.47 cm^2) respectively as compared to the control treatments at value (119.76 and 181.98cm^2) respectively. Additionally. the leaves area of potato plants showed a positive response to foliar feeding with amino acids and plants dosed with 6 ml.L^{-1} of amino acid owned the greatest leaves area (137.78 and 207.54cm^2) respectively relative to control (119.01 and 181.83 cm^2) at both seasons.

Meanwhile, providing the Harry cultivar receiving 4g.L^{-1} of nano NPK recorded the peak leaf area (154.49 and 215.65 cm^2) respectively relative to the other interaction. The statistical analysis indicated that both cultivars type and amino acid treatment significantly increase leaves area, the largest value reached (154.70 and 216.21 cm^2) respectively for the Harry cultivar interacted with 6ml.L^{-1} of amino acid, whereas the smallest value (105.58 and 172.99 cm^2) respectively was enumerated for the Lucinda cultivar interacted with control of amino acid.

The study on dual interactions, revealed that the maximum average leaves area was achieved with 4g.L^{-1} of nano NPK and 6ml.L^{-1} of amino acid during both spring seasons, with values (155.18 and 215.41 cm^2) respectively compared to other interactions. The effect of triple interactions, illustrated that the Harry cultivar which interacted with 4g.L^{-1} of nano NPK and 6ml.L^{-1} of amino acid produced the highest leaves area of (163.21 and 222.03 cm^2) respectively when compared with the lowest value (98.61 and 160.76 cm^2) being accounted for Lucinda cultivar with non-treated of nano NPK and amino acid in the dual seasons.

Table (2): Effect of cultivars, nano-NPK fertilizers and amino acid on the leaf area (cm^2).

First Spring Season of (2024)						
Cultivars	Nano-NPK (g L^{-1})	Amino Acid (ml L^{-1})			Cultivars * Nano-NPK	Cultivars Effects
		0	3	6		
Harry cv.	0	112.76 $^{b-e}$	148.54 $^{a-c}$	155.59 ^{ab}	138.96 ^{a}	146.35 ^{a}
	2	137.83 $^{a-e}$	153.65 ^{ab}	145.31 $^{a-e}$	145.60 ^{a}	
	4	146.73 $^{a-d}$	153.53 ^{ab}	163.21 ^{a}	154.49 ^{a}	
Lucinda cv.	0	98.61 ^{e}	100.68 ^{de}	102.36 $^{c-e}$	100.55 ^{c}	113.91 ^{b}
	2	101.91 $^{c-e}$	112.59 $^{b-e}$	113.08 $^{b-e}$	109.20 ^{bc}	
	4	116.22 $^{b-e}$	132.60 $^{a-e}$	147.14 $^{a-d}$	131.99 ^{ab}	
Amino Acid Effects		119.01 ^{b}	133.60 ^{ab}	137.78 ^{a}	Nano-NPK Effects	

Cultivars * Amino Acid	Harry cv.	132.44 ^{ab}	151.91 ^{a}	154.70 ^{a}		
	Lucinda cv.	105.58 ^{c}	115.29 ^{bc}	120.86 ^{bc}		
Nano-NPK * Amino acid	0	105.69 ^{c}	124.61 $^{a-c}$	128.97 $^{a-c}$	119.76 ^{b}	
	2	119.87 ^{bc}	133.12 $^{a-c}$	129.20 $^{a-c}$	127.40 ^{ab}	
	4	131.48 $^{a-c}$	143.07 ^{ab}	155.18 ^{a}	143.24 ^{a}	
Second Spring Season of (2025)						
Harry cv.	0	163.37 ^{cd}	192.10 $^{a-d}$	210.45 ^{ab}	188.64 ^{bc}	
	2	202.23 $^{a-d}$	212.35 ^{ab}	216.14 ^{ab}	210.24 ^{ab}	204.84 ^{a}
	4	206.43 $^{a-c}$	218.48 ^{a}	222.03 ^{a}	215.65 ^{a}	
Lucinda cv.	0	160.76 ^{d}	178.91 $^{a-d}$	186.29 $^{a-d}$	175.32 ^{c}	
	2	174.05 $^{b-d}$	197.87 $^{a-d}$	201.54 $^{a-d}$	191.16 ^{bc}	187.26 ^{b}
	4	184.14 $^{a-d}$	192.94 $^{a-d}$	208.79 ^{ab}	195.29 $^{a-c}$	
Amino Acid Effects		181.83 ^{b}	198.78 ^{a}	207.54 ^{a}		
Cultivars * Amino Acid	Harry cv.	190.68 ^{bc}	207.64 ^{ab}	216.21 ^{a}	Nano-NPK Effects	
	Lucinda cv.	172.99 ^{c}	189.91 ^{bc}	198.87 ^{ab}		
Nano-NPK * Amino acid	0	162.07 ^{c}	185.51 ^{bc}	198.37 ^{ab}	181.98 ^{b}	
	2	188.14 $^{a-c}$	205.11 ^{ab}	208.84 ^{ab}	200.70 ^{a}	
	4	195.29 ^{ab}	205.71 ^{ab}	215.41 ^{a}	205.47 ^{a}	

The columns, rows and their interactions, which share the same letters, are not significantly different from each other according to Duncan's multiple range test at the significant level (α=0.05).

The dry matter (%) of vegetative growth (g):

Table (3) demonstrates that Harry cultivar gave the most significant value in the (%) vegetative dry matter which amounted to (12.45 and 12.01 g) respectively compared to the Lucinda cultivar, which gave (11.71 and 11.34 g) respectively in two spring seasons. As concerning to the concentrations of nano NPK, it is observed that high levels was significantly superior in the (%) of vegetative dry matter except control treatments which produced low percentage of dry matter at value (11.26 and 10.90 g) respectively in both planting seasons. In status of amino acid effect, indicated that application amino acid at both levels 3ml.L^{-1} and 6ml.L^{-1} significantly increased the (%) of vegetative dry matter comparing to the control which recorded least value (11.65 and 10.86 g) respectively during two seasons In case of binary interactions, the maximum percentage of vegetative dry matter (13.10 and 12.66 g) in both seasons was counted in Harry cultivar treated with nano NPK at 4g.L^{-1} as comparison to the other dual interactions. Treatment of the cultivar Harry with a level of 6ml.L^{-1} of amino acid gave the superior values (12.81 and 12.52 g) respectively in the percentage of vegetative dry matter as compared to the Lucinda cultivar which gave the lowest value (11.27 and 10.53 g) respectively. Foliar application of both studied factors caused a significant difference on the percentages of vegetative dry matter, the heights value (13.16 and 13.03 g) respectively as resulted of 4g.L^{-1} of nano NPK and 6ml.L^{-1} of amino acid as compared to the other interaction treatments in both seasons.The triple interactions among the three studied factors indicated that, Harry cultivar received 4g.L^{-1} of nano NPK fertilizer and 6ml.L^{-1} of amino acid gave the biggest value of this parameter (13.52 and 13.32 g) respectively as comparing with the lowest value (10.31 and 9.68 g) respectively was estimated for Lucinda cultivar in combination with non-treatment for both nano NPK fertilizers and amino acid.

Table (3): Effect of cultivars, nano-NPK fertilizers and amino acid on the dry matter (%) in vegetative growth (g).

Cultivars	Nano-NPK (g L^{-1})	Amino Acid (ml L^{-1}) 0	3	6	Cultivars * Nano-NPK	Cultivars Effects
First Spring Season of (2024)						
Harry cv.	0	10.99 fg	11.84 c-f	11.66 d-f	11.50 de	12.45 a
	2	12.21 b-f	12.76 a-e	13.26 ab	12.74 ab	
	4	12.90 a-c	12.89 a-c	13.52 a	13.10 a	
Lucinda cv.	0	10.31 g	11.18 fg	11.59 d-f	11.02 e	11.71 b
	2	11.94 c-f	11.78 c-f	12.06 b-f	11.93 cd	
	4	11.55 ef	12.15 b-f	12.79 a-d	12.16 bc	
Amino Acid Effects		11.65 b	12.10 a	12.48 a		
Cultivars * Amino Acid	Harry cv.	12.03 bc	12.50 ab	12.81 a	Nano-NPK Effects	
	Lucinda cv.	11.27 d	11.70 cd	12.15 bc		
Nano-NPK * Amino acid	0	10.65 d	11.51 c	11.62 c	11.26 b	
	2	12.08 bc	12.27 bc	12.66 ab	12.33 a	
	4	12.23 bc	12.52 ab	13.16 a	12.63 a	
Second Spring Season of (2025)						
Harry cv.	0	10.35 ef	11.61 b-e	11.66 b-e	11.21 cd	12.01 a
	2	11.35 b-e	12.59 a-c	12.57 a-c	12.17 ab	
	4	11.90 a-d	12.75 ab	13.32 a	12.66 a	
Lucinda cv.	0	9.68 f	10.85 d-f	11.25 c-e	10.60 d	11.34 b
	2	11.34 b-e	11.93 a-d	11.09 de	11.45 bc	
	4	10.56 d-f	12.59 a-c	12.74 ab	11.96 a-c	
Amino Acid Effects		10.86 b	12.05 a	12.11 a		
Cultivars * Amino Acid	Harry cv.	11.20 cd	12.32 ab	12.52 a	Nano-NPK Effects	
	Lucinda cv.	10.53 d	11.79 a-c	11.69 bc		
Nano-NPK * Amino acid	0	10.02 e	11.23 d	11.46 cd	10.90 b	
	2	11.35 cd	12.26 a-c	11.83 b-d	11.81 a	
	4	11.23 d	12.67 ab	13.03 a	12.31 a	

The columns, rows and their interactions, which share the same letters, are not significantly different from each other according to Duncan's multiple range test at the significant level (α=0.05).

Number of marketable tubers (tuber plant^{-1})

Table (4) illustrated that Harry cultivar gave the topmost number of the marketable tubers in both spring seasons which reached (8.58 and 11.20) tuber respectively as compared to the Lucinda cultivar which produced the low number of marketable tubers (8.07 and 9.79) tuber respectively. According to the impact of individual effect of nano NPK fertilizer, which was significant on the number of marketable tubers and the topmost values (8.76 and 11.23) tuber respectively recorded under application of 4g.L^{-1} of nano NPK as compared to the other levels.Additionally, the different concentration of amino acid caused significant increase on the number marketable of tubers, the heights value (8.66 and 10.89) tuber respectively belonged to the level 6ml.L^{-1} of amino acid as compared to the other concentrations in dual spring seasons respectively. The result in Table (5) displayed the positive impact of interference between cultivars and nano NPK on the number of marketable tubers, the peak value (9.04 and 12.16) tuber respectively showed with Harry cultivars when dosed with 4g.L^{-1} of nano NPK fertilizer as matched with the other interactions. Moreover, the greatest number of marketable tubers (9.04 and 11.44) tuber respectively was created from applying 6ml.L^{-1} of amino acid on Harry cultivar as compared to the other treatments. The heights dosage of 4g.L^{-1} nano NPK and 6ml.L^{-1} of amino acid on potato plants, caused significant increase on the number of marketable tubers which reached (9.13 and 11.73) tuber respectively as compared to the control treatments which remarked the lowest value (7.37 and 8.90) tuber respectively in both seasons of 2024 and 2025. Regarding the effect triple combination, the highest ever value (9.53 and 12.53) tuber respectively was observed with Harry cultivar plants sprayed with 4g.L^{-1} of nano NPK and 6ml.L^{-1} amino acid as compared to the least value (7.20 and 8.40) tuber respectively showed with Lucinda cultivar at control of both foliar treatments.

Table (4): Effect of cultivars, nano-NPK fertilizers and amino acid on the number of marketable tubers (tuber plant^{-1}).

Cultivars	Nano-NPK (g L^{-1})	Amino Acid (ml L^{-1}) 0	3	6	Cultivars * Nano-NPK	Cultivars Effects
First Spring Season of (2024)						
Harry cv.	0	7.53 ^{cd}	8.03 $^{a-d}$	8.73 $^{a-d}$	8.10 ^{bc}	8.58 ^{a}
	2	7.80 $^{b-d}$	9.13 ^{ab}	8.87 $^{a-c}$	8.60 ^{ab}	
	4	8.40 $^{a-d}$	9.20 ^{ab}	9.53 ^{a}	9.04 ^{a}	
Lucinda cv.	0	7.20 ^{d}	8.07 $^{a-d}$	7.93 $^{b-d}$	7.73 ^{c}	8.07 ^{b}
	2	7.93 $^{b-d}$	7.97 $^{b-d}$	8.13 $^{a-d}$	8.01 ^{bc}	
	4	7.73 $^{b-d}$	8.93 ^{ab}	8.73 $^{a-d}$	8.47 $^{a-c}$	
Amino Acid Effects		7.77 ^{b}	8.56 ^{a}	8.66 ^{a}		
Cultivars * Amino Acid	Harry cv.	7.91 ^{b}	8.79 ^{a}	9.04 ^{a}	Nano-NPK Effects	
	Lucinda cv.	7.62 ^{b}	8.33 ^{ab}	8.27 ^{ab}		
Nano-NPK * Amino acid	0	7.37 ^{c}	8.05 ^{bc}	8.33 $^{a-c}$	7.92 ^{b}	
	2	7.87 ^{bc}	8.55 ^{ab}	8.50 ^{ab}	8.31 ^{ab}	
	4	8.07 ^{bc}	9.07 ^{a}	9.13 ^{a}	8.76 ^{a}	
Second Spring Season of (2025)						
Harry cv.	0	9.40 $^{f-g}$	10.47 $^{b-g}$	10.07 $^{c-h}$	9.98 ^{bc}	11.20 ^{a}
	2	11.27 $^{a-f}$	11.40 $^{a-e}$	11.73 $^{a-d}$	11.47 ^{a}	
	4	11.87 $^{a-c}$	12.07 ^{ab}	12.53 ^{a}	12.16 ^{a}	
Lucinda cv.	0	8.40 ^{h}	9.27 ^{gh}	9.87 $^{d-h}$	9.18 ^{c}	9.79 ^{b}
	2	9.33 $^{f-h}$	10.07 $^{c-h}$	10.20 $^{b-h}$	9.87 ^{bc}	
	4	9.60 $^{e-h}$	10.40 $^{b-g}$	10.93 $^{a-g}$	10.31 ^{b}	
Amino Acid Effects		9.98 ^{b}	10.61 ^{ab}	10.89 ^{a}	Nano-NPK Effects	

Cultivars * Amino Acid	Harry cv.	10.84 a-c	11.31 ab	11.44 a	
	Lucinda cv.	9.11 d	9.91 cd	10.33 bc	
Nano-NPK * Amino acid	0	8.90 d	9.87 cd	9.97 b-d	9.58 b
	2	10.30 bc	10.73 a-c	10.97 a-c	10.67 a
	4	10.73 a-c	11.23 ab	11.73 a	11.23 a

The columns, rows and their interactions, which share the same letters, are not significantly different from each other according to Duncan's multiple range test at the significant level (α=0.05).

Marketable tuber weight (g tuber^{-1})

Table (5) showed significant differences between the two cultivars in terms of marketable tuber weight, The highest produced marketable tuber weight (130.61 and 137.55 g) respectively belonged to the Harry cultivar, while the lower produced (125.81 and 131.68 g) respectively which remarked with Lucinda cultivar.

Moreover, spraying potato plants with high concentrations 4g.L^{-1} of nano NPK fertilizers caused a significant increase in marketable tuber weight (133.04 and 140.83 g) respectively as compared to the control treatments.

On the other hand, treated plants at 3ml.L^{-1} of amino acid led to significant increase on the marketable tuber weight in both seasons which was (132.92 and 140.04 g) respectively relative to the control treatment which decreased the weight of marketable tuber at value (123.71 and 127.03 g) respectively. Regarding the effects of cultivars and nano NPK, show that spraying Harry cultivar with 4g.L^{-1} of nano NPK had a significant effect on the marketable tuber weight at both spring seasons which recorded (134.74 and 144.50 g) respectively as compared to the other interaction treatments. The dual interaction between Harry cultivar and amino acid at 3ml.L^{-1} granted the highest marketable tuber weight produced at value (135.64 and 144.59 g) respectively relative to the minimum value (121.66 and 125.27 g) determined for Lucinda cultivar with no addition of amino acid. Significant difference was occurred between the interaction of nano NPK fertilizer and amino acid, the level 4g.L^{-1} of nano NPK and 3ml.L^{-1} of amino acid formed premium value (139.73 and 150.32 g) of marketable tuber weight as compared to the other interactions in both seasons.According to the interaction among three studied factors, spraying Harry cultivar with 4g.L^{-1} of nano NPK fertilizers and 3ml.L^{-1} of amino acid had the top value (143.62 and 156.40 g) respectively of marketable tuber weight as compared with the least value (114.46 and 116.64 g) for Lucinda cultivar sprayed with non-addition of nano NPK fertilizers and amino acid.

Table (5): Effect of cultivars, nano-NPK fertilizers and amino acid on the marketable tuber weight (g. tuber^{-1}).

First Spring Season of (2024)						
Cultivars	Nano-NPK (g L^{-1})	Amino Acid (ml L^{-1})			Cultivars * Nano-NPK	Cultivars Effects
		0	3	6		
Harry cv.	0	119.11 de	126.35 b-e	128.47 a-e	124.64 bc	130.61 a
	2	128.31 a-e	136.93 ab	132.09 a-d	132.44 ab	
	4	129.87 a-e	143.62 a	130.73 a-e	134.74 a	
Lucinda cv.	0	114.46 e	124.15 b-e	120.33 c-e	119.65 c	125.81 b
	2	121.87 b-e	130.64 a-e	126.85 b-e	126.45 a-c	
	4	128.65 a-e	135.83 a-c	129.52 a-e	131.34 ab	
Amino Acid Effects		123.71 b	132.92 a	128.00 ab		
Cultivars * Amino Acid	Harry cv.	125.76 bc	135.64 a	130.43 ab	Nano-NPK Effects	
	Lucinda cv.	121.66 c	130.21 a-c	125.57 bc		
Nano-NPK *	0	116.78 c	125.25 bc	124.40 bc	122.15 b	

Amino acid	2	125.09 ^{bc}	133.79 ^{ab}	129.47 ^{ab}	129.45 ^{a}	
	4	129.26 ^{ab}	139.73 ^{a}	130.13 ^{ab}	133.04 ^{a}	
Second Spring Season of (2025)						
Harry cv.	0	122.57 ^{de}	131.47 $^{b-e}$	134.11 $^{b-e}$	129.38 ^{bc}	137.55 ^{a}
	2	128.96 $^{b-e}$	145.91 ^{ab}	141.47 $^{a-c}$	138.78 ^{ab}	
	4	134.83 $^{b-e}$	156.40 ^{a}	142.27 $^{a-c}$	144.50 ^{a}	
Lucinda cv.	0	116.64 ^{e}	128.55 $^{b-e}$	136.24 $^{b-d}$	127.14 ^{c}	131.68 ^{b}
	2	131.74 $^{b-e}$	133.64 $^{b-e}$	126.89 $^{c-e}$	130.76 ^{bc}	
	4	127.42 $^{b-e}$	144.25 $^{a-c}$	139.80 $^{a-d}$	137.16 ^{ab}	
Amino Acid Effects		127.03 ^{b}	140.04 ^{a}	136.80 ^{a}		
Cultivars * Amino Acid	Harry cv.	128.79 ^{cd}	144.59 ^{a}	139.28 ^{ab}	Nano-NPK Effects	
	Lucinda cv.	125.27 ^{d}	135.48 $^{a-c}$	134.31 $^{b-d}$		
Nano-NPK * Amino acid	0	119.61 ^{c}	130.01 ^{bc}	135.17 ^{b}	128.26 ^{b}	
	2	130.35 ^{bc}	139.78 ^{ab}	134.18 ^{b}	134.77 ^{a}	
	4	131.12 ^{bc}	150.32 ^{a}	141.04 ^{ab}	140.83 ^{a}	

The columns, rows and their interactions, which share the same letters, are not significantly different from each other according to Duncan's multiple range test at the significant level (α=0.05).

Marketable plant yield (kg plant^{-1})

Table (6) presented that Harry cultivar produced the heights marketable plant yield (1.124 and 1.546 kg) respectively than Lucinda cultivar (1.022 and 1.294 kg) respectively in the dual spring seasons. Relating to the single effect of nano NPK fertilizer at concentration 4g.L^{-1} gave the highest average mean of marketable plant yield which reached (1.173 and 1.588 kg) respectively in both seasons as compared to the other two dosage. In case of the amino acid effect, significant increase was noticed, both level 3ml.L^{-1} and 6ml.L^{-1} respectively recorded the greatest mean of marketable plant yield as compared with control which gave the lowest average value (0.962 and 1.273 kg) respectively in two spring seasons. In term of binary interactions, Harry cultivar foliar provided with 4g.L^{-1} of nano NPK produced the marketable plant yield (1.221 and 1.756 kg) respectively surpassing control and other dual doses in both planting seasons. Concerning the interaction between cultivars and amino acid led to significant increase of marketable plant yield at both levels 3ml.L^{-1} and 6ml.L^{-1} of amino acid, while the lowest value (0.928 and 1.147 kg) respectively was observed with Lucinda cultivar and non-addition of amino acid.The dual interaction between 4g.L^{-1} of nano NPK fertilizer and 3ml.L^{-1} of amino acid created the highest value (1.290 and 1.692 kg) respectively of marketable plant yield as in comparison with the lowest value (0.860 and 1.065 kg) respectively was showed with control treatments. In state of triple effect, the biggest average value (1.332 and 1.887 kg) respectively was calculated for Harry cultivar dosed with nano NPK at rate 4g.L^{-1} and amino acid at rate 3ml.L^{-1} against the smallest average value (0.823 and 0.979 kg) respectively being estimated for Lucinda cultivar and without given of both foliar applications.

Table (6): Effect of cultivars, nano-NPK fertilizers and amino acid on the marketable plant yield (kg. plant^{-1}).

First Spring Season of (2024)						
Cultivars	Nano-NPK (g L^{-1})	Amino Acid (ml L^{-1})			Cultivars * Nano-NPK	Cultivars Effects
		0	3	6		
Harry cv.	0	0.897 ^{de}	1.009 $^{b-e}$	1.125 $^{a-d}$	1.010 ^{bc}	1.124 ^{a}
	2	1.001 $^{b-e}$	1.255 ^{ab}	1.170 $^{a-c}$	1.142 ^{ab}	

	4	1.091 $^{a-e}$	1.332 ^{a}	1.241 ^{ab}	1.221 ^{a}	
Lucinda cv.	0	0.823 ^{e}	1.002 $^{b-e}$	0.955 $^{c-e}$	0.927 ^{c}	1.022 ^{b}
	2	0.966 $^{c-e}$	1.042 $^{b-e}$	1.032 $^{b-e}$	1.013 ^{bc}	
	4	0.994 $^{b-e}$	1.248 ^{ab}	1.131 $^{a-d}$	1.124 ^{ab}	
Amino Acid Effects		0.962 ^{b}	1.148 ^{a}	1.109 ^{a}		
Cultivars * Amino Acid	Harry cv.	0.996 ^{bc}	1.198 ^{a}	1.179 ^{a}	Nano-NPK Effects	
	Lucinda cv.	0.928 ^{c}	1.098 ^{ab}	1.039 ^{bc}		
Nano-NPK * Amino acid	0	0.860 ^{d}	1.005 ^{cd}	1.040 ^{bc}	0.968 ^{c}	
	2	0.984 ^{cd}	1.148 $^{a-c}$	1.101 ^{bc}	1.078 ^{b}	
	4	1.042 ^{bc}	1.290 ^{a}	1.186 ^{ab}	1.173 ^{a}	
Second Spring Season of (2025)						
Harry cv.	0	1.151 ^{fg}	1.375 $^{c-f}$	1.351 $^{c-f}$	1.293 ^{cd}	1.546 ^{a}
	2	1.446 $^{c-f}$	1.665 $^{a-c}$	1.660 $^{a-c}$	1.590 ^{b}	
	4	1.598 $^{a-d}$	1.887 ^{a}	1.783 ^{ab}	1.756 ^{a}	
Lucinda cv.	0	0.979 ^{g}	1.198 $^{e-g}$	1.343 $^{c-f}$	1.173 ^{d}	1.294 ^{b}
	2	1.229 $^{e-g}$	1.347 $^{c-f}$	1.294 $^{d-g}$	1.290 ^{cd}	
	4	1.232 $^{e-g}$	1.497 $^{b-e}$	1.528 $^{b-e}$	1.419 ^{c}	
Amino Acid Effects		1.273 ^{b}	1.495 ^{a}	1.493 ^{a}		
Cultivars * Amino Acid	Harry cv.	1.398 ^{b}	1.642 ^{a}	1.598 ^{a}	Nano-NPK Effects	
	Lucinda cv.	1.147 ^{c}	1.347 ^{b}	1.388 ^{b}		
Nano-NPK * Amino acid	0	1.065 ^{c}	1.287 ^{b}	1.347 ^{b}	1.233 ^{c}	
	2	1.337 ^{b}	1.506 ^{ab}	1.477 ^{ab}	1.440 ^{b}	
	4	1.415 ^{b}	1.692 ^{a}	1.656 ^{a}	1.588 ^{a}	

The columns, rows and their interactions, which share the same letters, are not significantly different from each other according to Duncan's multiple range test at the significant level (α=0.05).

Marketable yield of tuber (t ha^{-1})

Based on the data presented in Table (7), it is evident that the Harry cultivar achieved significantly higher marketable tuber yields, with values of (45.31 and 60.48 t ha^{-1}) across the two planting seasons. In comparison, the Lucinda cultivar produced yields of (38.67 and 50.62 t ha^{-1}) in the same seasons. Furthermore, foliar application of nano NPK fertilizers at a concentration of 4g.L^{-1} resulted in notable increase in marketable tuner yield, recording (44.49 and 62.09 t ha^{-1}) in the respective seasons. This dosage was significantly more effective than other fertilization levels tested. The individual application of amino acids at concentration of 3ml.L^{-1} and 6ml.L^{-1} significantly enhanced the marketable tuber yield compared to the control treatments with yields of (37.18 and 49.77 t ha^{-1}) respectively, observed in both seasons. The interactions between the cultivars and nano NPK fertilizers revealed that the Harry cultivar, when sprayed with nano NPK fertilizers at a level of 4g.L^{-1} achieved the highest marketable tuber yield measuring (47.84 and 68.68 t ha^{-1}) respectively, in contrast, with the least value of (35.95 and 45.89 t ha^{-1}) for Lucinda cultivar interacted with 0g.L^{-1} of nano NPK fertilizers. In contrast, the combined effect of the Harry cultivar and foliar application of amino acid at 3ml.L^{-1} significantly increased the marketable tuber yield, reaching (50.52 and 64.23 t ha^{-1}) surpassing all other treatments. Regarding dual treatments, potato plants sprayed with nano NPK and amino acid each at concentrations of 4g.L^{-1} and 3ml.L^{-1} respectively produced marketable tuber yield of (49.90 and 66.18 t ha^{-1}) exceeded those of the control and other combined dosages. Concerning the effect of three factors on the marketable tuber yield, the highest yields (55.32 and 73.80 t ha^{-1}) respectively were observed for the Harry cultivar treated with 4g.L^{-1} of nano NPK fertilizers and 3ml.L^{-1} of amino acid against the lowest average yield (33.43 and 38.31 t ha^{-1}) respectively belonged to the Lucinda cultivar under control treatment of both foliar applications at both seasons.

Table (7): Effect of cultivars, nano-NPK fertilizers and amino acid on marketable yield of tuber (t ha^{-1}).

Cultivars	Nano-NPK (g L^{-1})	Amino Acid (ml L^{-1}) 0	3	6	Cultivars * Nano-NPK	Cultivars Effects
First Spring Season of (2024)						
Harry cv.	0	37.13 ^{de}	43.90 $^{a-e}$	46.27 $^{a-d}$	42.43 $^{a-c}$	45.31 ^{a}
	2	39.74 $^{c-e}$	52.35 ^{ab}	44.88 $^{a-e}$	45.65 ^{ab}	
	4	38.26 $^{c-e}$	55.32 ^{a}	49.95 $^{a-c}$	47.84 ^{a}	
Lucinda cv.	0	33.43 ^{e}	39.44 $^{c-e}$	34.98 ^{de}	35.95 ^{d}	38.67 ^{b}
	2	36.88 ^{de}	40.01 $^{c-e}$	39.87 $^{c-e}$	38.92 ^{cd}	
	4	37.64 ^{de}	44.48 $^{a-e}$	41.29 $^{b-e}$	41.14 $^{b-d}$	
Amino Acid Effects		37.18 ^{b}	45.92 ^{a}	42.87 ^{a}		
Cultivars * Amino Acid	Harry cv.	38.38 ^{c}	50.52 ^{a}	47.03 ^{ab}	Nano-NPK Effects	
	Lucinda cv.	35.98 ^{c}	41.31 ^{bc}	38.72 ^{c}		
Nano-NPK * Amino acid	0	35.28 ^{d}	41.67 $^{b-d}$	40.62 $^{b-d}$	39.19 ^{b}	
	2	38.31 $^{b-d}$	46.18 ^{ab}	42.38 $^{a-d}$	42.29 ^{ab}	
	4	37.95 ^{cd}	49.90 ^{a}	45.62 $^{a-c}$	44.49 ^{a}	
Second Spring Season of (2025)						
Harry cv.	0	45.04 ^{fg}	53.80 $^{c-f}$	52.84 $^{c-f}$	50.56 ^{cd}	60.48 ^{a}
	2	56.56 $^{c-f}$	65.11 $^{a-c}$	64.94 $^{a-c}$	62.20 ^{b}	
	4	62.49 $^{a-d}$	73.80 ^{a}	69.75 ^{ab}	68.68 ^{a}	
Lucinda cv.	0	38.31 ^{g}	46.84 $^{e-g}$	52.53 $^{c-f}$	45.89 ^{d}	50.62 ^{b}
	2	48.05 $^{e-g}$	52.70 $^{c-f}$	50.62 $^{d-g}$	50.46 ^{cd}	
	4	48.18 $^{e-g}$	58.56 $^{b-e}$	59.75 $^{b-e}$	55.50 ^{c}	
Amino Acid Effects		49.77 ^{b}	58.47 ^{a}	58.40 ^{a}		
Cultivars * Amino Acid	Harry cv.	54.69 ^{b}	64.23 ^{a}	62.51 ^{a}	Nano-NPK Effects	
	Lucinda cv.	44.85 ^{c}	52.70 ^{b}	54.30 ^{b}		
Nano-NPK * Amino acid	0	41.67 ^{c}	50.32 ^{b}	52.68 ^{b}	48.22 ^{c}	
	2	52.31 ^{b}	58.90 ^{ab}	57.78 ^{ab}	56.33 ^{b}	
	4	55.33 ^{b}	66.18 ^{a}	64.75 ^{a}	62.09 ^{a}	

The columns, rows and their interactions, which share the same letters, are not significantly different from each other according to Duncan's multiple range test at the significant level (α=0.05).

Discussion

The results indicated that the different potato cultivars exhibited significant variation across all measured traits of vegetative growth and quantity of yield. The Harry cultivar was superior to Lucinda cultivar in all studied parameters, except for plant height, which was higher in the Lucinda cultivar. The reasons behind this increment may be due to the different genetic traits between the two cultivars. The variation between different genes and environmental factors plays a significant role in improving the vegetative growth and productivity of potato crops, this is agreement with finding from **[16,17, 18].**

The results demonstrated that applying potato plants with 2g.L^{-1} followed by 4g.L^{-1} of nano NPK fertilizers significantly improved all studied characteristics compared to the control treatments. This enhancement may be attributed to the effectiveness of chelated nano fertilizers in supporting various physiological activities, such as increasing chlorophyll content, which is essential for enhancing photosynthesis efficiency and the synthesis of amino acids like tryptophan, crucial for cell enlargement. Furthermor, nano fertilizers are characterized by their small particle size, ranging from 30 to 40 nm, which allows them to hold multiple ions due to their large surface area. This enables a slow and controlled release of nutrients in accordance with the crops needs **[19,20, 21, 22].**

The findings also indicated that applying amino acids at concentrations of 3ml.L^{-1} and 6ml.L^{-1} significantly enhanced vegetative growth and crop yield compared to the control treatments. This is likely because amino acids facilitate the biosynthesis of proteins, phytohormones, and enzymes essential for plant development. They also enhance the uptake of macro- and micro-elements, participate in signaling pathways, and support energy production **[23].** Such beneficial effects may enable amino acids to directly or indirectly influence physiological processes within the plant, including those involved in enzyme activity critical for photosynthesis and overall plant architecture **[24].**

[25] concluded that spraying summer squash with amino acid excelled chlorophyll amount, fruit number per plant, plant yield (kg) per plant and total yield tons per hectare. Based on the study by **[26]** it was observed that foliar application of amino acid to potato plants, significantly increased in tuber weight comparison to untreated controls. Among the various amino acid treatments, the foliar application with arginine acid at a rate of 300 mg^{-1} was particularly effective, producing the largest tubers.

The data analysis of all examined parameters indicates that the second season produced superior results compared to the first. This improvement could be attributed to variations in environmental conditions between the two seasons, particularly temperature. Such environmental factors may have created more favorable conditions for potato growth and productivity during the second season, especially when compared to the first. Optimal plant development and crop yields are generally influenced by environmental factors such as temperature, light intensity, rainfall distribution, atmospheric humidity, and the plant's capacity to adapt its physiological processes to changing conditions **[27].**

Conclusion

It can be concluded from this study that the cultivars differed in parameter of foliage and quantity of yield with the supremacy for Harry cultivar in comparison with Lucinda cultivars. Moreover, treating potato plants with nano NPK fertilizer at rate of 4g.L^{-1} importantly improved all parameters relative to control. On the other side, the foliar application both dosages 3ml.L^{-1} and 6ml.L^{-1} of amino acid gave the maximum results in the all investigated traits with further researches should be done with different concentrations either on potato or on other horticultural crops.

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أستجابة النمو و كمية الحاصل للصنفين من البطاطس *Solanum tuberosum* للرش بسماد النانو NPK و الحامض الاميني *Ticamin Max*

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[2]قسم البستنة، كلية علوم الهندسة الزراعية، جامعة دهوك، أقليم كوردستان العراق

الخلاصة

أُجريت تجربتان حقليتان متتاليتان خلال موسمين الربيعي لعامي 2024 و2025 في قرية ديناران، قضاء بردرش، محافظة دهوك، إقليم كردستان العراق، لدراسة استجابة نمو وإنتاجية صنفين من البطاطس (هاري ولوسيندا) للرش الورقي بثلاثة تراكيز من سماد النانو ***NPK*** **(0**، 2، و4 غ/لتر) وثلاثة تراكيز من الأحماض الأمينية (0، 3، و6 مل/لتر). نُظمت المعاملات بتصميم القطع المنشقة وفق تصميم القطاعات الكاملة العشوائية (***RCBD)***بثلاث مكررات. كشف التحليل الإحصائي أن صنف هاري أظهر أعلى القيم المعنوية في معايير النمو والعائد، بما في ذلك مساحة الورقة (سم^{2})، والمادة الجافة للنموخضري (جم نبات$^{-1}$)، وعدد الدرنات القابلة للتسويق (درنة نبات$^{-1}$)، ووزن الدرنة القابلة للتسويق (جم درنة$^{-1}$)، والعائد التسويقي لكل نبات (كجم نبات$^{-1}$)، وإجمالي عائد الدرنات القابلة للتسويق (طن هكتار$^{-1}$). وعلى العكس من ذلك، أظهر صنف لوسيندا تحسنًا ملحوظًا في ارتفاع النبات (سم). أسفرت المعاملة بـ 4 جم / لتر من سماد النانو ***NPK*** عن أهم التحسينات في معظم نباتات البطاطس المدروسة. أدى تطبيق الرش الأحماض الأمينية بجرعات 3 و 6 مل / لتر إلى زيادة كبيرة في جميع المعايير مقارنة بمعاملة الكنترول في كلا موسمي النمو. علاوة على ذلك، أسفرت المعاملات المزدوجة والثلاثية للأصناف وسماد النانو ***NPK*** والأحماض الأمينية عن أعلى القيم لهذه المعايير المدروسة في نباتات البطاطس.

الكلمات المفتاحية: البطاطس، الاصناف، سماد النانو NPK، الأحماض الأمينية، الرش الورقي، النمو، الحاصل.