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Impact of Foliar Application of Nano Organic (Optimus Plus) on Quantitative and Qualitative Traits of Two Potato (*Solanum tuberosum* L.) Cultivars

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Abstract. *College of Agriculture and Forestry, located within the university campus. The study involved two factors: the first was the application of an organic nutrient)Optimus Plus) at three concentrations (0, 2, and 4 ml L $^{-1}$), and the second included two imported potato cultivars, Lady Rosetta and Hermes. To promote growth, fertilizers were applied in three split doses: the first, 15 days after planting, included the full dose of phosphorus fertilizer; the second, at emergence, included half of the nitrogen and the full dose of potassium; and the third, one month after the second. Data were statistically analyzed using the SAS(2017) software package [1] according to the experimental design, and treatment means were compared using Duncan's Multiple Range Test at a significance level of ≤0.05.*
Keywords. *Potato, Nutrient, Organic, Taxonomy, Yield, Quantitative, Protein*

INTRODUCTION

Potato (*Solanum tuberosum* L.) is a member of the Solanaceae family and is considered one of the world's four most important food crops after wheat, maize, and rice. It is rich in easily digestible nutrients, with a dry matter content ranging from 15% to 29%, starch content between 10% and 24%, proteins between 1% and 2%, carbohydrates around 17.5%, and mineral salts up to 1%, primarily composed of potassium, phosphorus, calcium, and magnesium (Hassan, 1999). Potatoes are regarded as the most promising alternative to cereal crops for solving global food insecurity (Aldoury et al., 2019).

Organic fertilization, derived from various sources such as animal waste or extracts of wild and marine plants, is considered a fundamental pillar in enhancing soil fertility and reducing environmental pollution caused by excessive use of chemical fertilizers. Organic nutrients have a significant impact on the physical, chemical, and biological properties of soils (Al-Salmani & Abbas, 2003).In this regard, a study conducted by by Tyasmoro et al. (2024) in Indonesia demonstrated that applying liquid organic fertilizer (molasses) at a concentration of 10 ml/L to potato plants resulted in significant improvements in plant height, number of leaves, leaf dry matter percentage, an leaf area, compared to the untreated control.Similarly, Martirosyan et al. (2024) in the Republic of Armenia reported that foliar application of Biohums at a concentration of 0.2% in potato cultivation led to significant increases in dry matter and starch content in the tubers, as well as an overall yield increase per unit area, compared to the control treatment.

There are hundreds of potato cultivars cultivated across various regions of the world, with most of the varieties grown in Arab countries originating from European sources. These cultivars can be distinguished based on a range of morphological characteristics, including growth habit (prostrate or erect), vigor, stem length, and aerial stem features such as degree of branching, number, and thickness. Additionally, classification can be made based on leaf traits, stolon (underground stem) characteristics, and tuber features such as shape, skin color, and internal flesh color (Hassan, 2011). Olaniyi et al. (2010) indicated that differences in growth and yield among cultivars are primarily influenced by physiological processes governed by the interaction between genetic and environmental factors. This diversity is attributed to the genetic adaptability of the cultivars, their morphological traits, and physiological functions during the growth stages of the potato crop.In a study conducted. Haile et al. (2015) in Ethiopia to compare three potato cultivars—Jallene, Guidene, and Local—the results revealed that the Jallene cultivar significantly outperformed the others in terms of the number of tubers, average tuber weight, total yield, and marketable yield.Similarly, Jasim and Merhij (2018), in a study comparing three potato varieties (Riviera, Arizona, and Burren), observed that the Arizona cultivar achieved the highest dry matter percentage in tubers compared to the other two varieties.

Objectives

- To compare the effects of different concentrations of nano-formulated organic nutrient (Optimus Plus) to identify the most effective concentration for enhancing growth, yield, and quality traits in potato plants.
- To evaluate the performance of two potato cultivars (Hermes and Lady Rosetta), commonly used in the chip industry, in terms of vegetative, yield, and quality traits.
- To determine the best interaction between nutrient concentrations and potato cultivars.

MATERIALS AND METHODS

The experiment were conducted in the spring season of 2024 at location in Nineveh Governorate, Iraq. was the vegetable field within the College of Agriculture and Forestry, University of Mosul, irrigated using municipal water.

The experiment studied the foliar application of the nano-organic nutrient (Optimus Plus) at three concentrations (0, 2, and 4 ml L^{-1}) on two potato cultivars (Hermes and Lady Rosetta). Applications were performed at three growth stages: 10 days after full emergence, and then at 20-day intervals.

The field experiment was laid out in a factorial arrangement using a randomized complete block design (RCBD) (AL-Rawi and Khalaf Alla,2000) with three replications [11], Each experimental unit included three rows (2.10 m long, 75 cm between rows), totaling 4.725 m^2 per plot. Tubers were manually planted at 30 cm spacing, with 21 plants per plot (63 plants per treatment).

Data were analyzed using [1], and treatment means were compared using Duncan's Multiple Range Test at the 0.05 significance level.

1.1. Studied Traits

Quantitative and qualitative yield traits:

- Average tuber weight (g $tuber^{-1}$)
- Marketable tuber weight (g $tuber^{-1}$)
- Total yield per plant (g $plant^{-1}$)
- Total tuber yield (t ha^{-1})
- Marketable yield per plant (g $plant^{-1}$)
- Tuber firmness (kg cm^{-2}) after harvest
- Dry matter percentage in tubers
- Starch percentage in tubers after harvest
- Specific gravity of tubers
- Protein percentage in tubers

Quantitative traits were measured using all plants in each plot, while qualitative traits were assessed on five randomly selected tubers per plot, with mean values calculated.

RESULTS

As shown in Tables 1, the applied nutrient concentrations did not significantly affect average tuber weight. However, significant differences were found between cultivars. The Hermes cultivar significantly outperformed Lady Rosetta, recording average tuber weights of 67.368 g and 73.359 g, respectively.

Significant interactions between nutrient concentration and cultivar were observed., the interaction between the control (0 ml L^{-1}) and the Hermes cultivar produced the highest average tuber weight (70.301 g), significantly higher than all interactions involving Lady Rosetta.

Table 1. The effect of foliar application of the nano-organic nutrient (Optimus Plus), potato cultivars, and their interaction on the average tuber weight (g $tuber^{-1}$)

Cultivars	Organic Nutrient concentrations ml L^{-1}			Mean effect of Cultivars
	0	2	4	
Lady Roseeta	49.714 b	51.203 b	55.271 b	52.063 b

Hermes	70.301 a	66.801 a	65.001 a	67.368 a
Mean effect of Organic Nutrient	60.008 a	59.002 a	60.136 a	

Means followed by the same lowercase letter within rows or uppercase letter within columns are not significantly different according to Duncan's multiple range test at $P \leq 0.05$.

The data presented in Tables 2, which examine the effect of the studied factors on the average marketable tuber weight, indicate that there were significant differences among the concentrations of the organic nutrient. The application of the 0 ml L^{-1} concentration of Optimus Plus led to a significantly higher average marketable tuber weight, reaching 78.394 g $tuber^{-1}$, compared to the other concentrations.

Regarding the effect of cultivars, the results show that the Hermes cultivar significantly outperformed the Lady Rosetta cultivar in terms of marketable tuber weight, recording a value of 78.458 g $tuber^{-1}$.

As for the interaction effects, the most effective treatment was the combination of 0 ml L^{-1} of the organic nutrient and the Hermes cultivar, which resulted in the highest value of 85.886 g $tuber^{-1}$, showing a significant superiority over all other interaction treatments.

Table 2. Effect of Foliar Application of Organic Nutrient (Optimus Plus), Cultivars, and Their Interaction on Marketable Tuber Weight (g $tuber^{-1}$).

Cultivars	Organic Nutrient concentrations ml L^{-1}			Mean effect of Cultivars
	0	2	4	
Lady Roseeta	70.902 c	67.827 c	72.169 bc	70.299 b
Hermes	85.886 a	78.458 b	71.031 c	78.458 a
Mean effect of Organic Nutrient	78.394 a	73.142 b	71.600 b	

Means followed by the same lowercase letter within rows or uppercase letter within columns are not significantly different according to Duncan's multiple range test at $P \leq 0.05$.

The results presented in Tables 3 show the effects of the studied factors on the total yield per plant., foliar application of the organic nutrient at a concentration of 4 ml L^{-1} significantly outperformed the other concentrations, recording a total yield per plant of 662.91 g $plant^{-1}$ in the superior treatment. Regarding cultivar effects, a significant difference was observed, with Lady Rosetta outperforming the other cultivar, achieving a total yield per plant of 665.84 g $plant^{-1}$.

Data on the interaction effect between the organic nutrient and cultivars indicated a significant superiority for the high concentration (4 ml L^{-1}) combined with Lady Rosetta, achieving the highest total yield per plant of 753.94 g $plant^{-1}$.

Table 3. Effect of Foliar Application of Organic Nutrient (Optimus Plus), Cultivars, and Their Interaction on Total Yield per Plant (g $plant^{-1}$).

Cultivars	Organic Nutrient concentrations ml L^{-1}			Mean effect of Cultivars
	0	2	4	
Lady Roseeta	642.85 b	600.73 bc	753.94 a	665.84 a

Hermes	559.27 c	569.24 c	571.88 c	566.80 b
Mean effect of Organic Nutrient	601.06 b	584.99 b	662.91 a	

Means sharing the same letter within each factor and interaction do not differ significantly according to Duncan's multiple range test at a probability level of ≤ 0.05.

The data from Tables 7 and 8 at both the first and second sites indicate that the three individual factors, along with all their two-way and three-way interactions, exhibited the same pattern of significant effects on the total yield per plant trait as shown in Tables 5 and 6. This similarity is expected because the total tuber yield per hectare (ton ha^{-1}) is fundamentally derived from the total yield per plant. Consequently, all treatments that showed superiority in total tuber yield per hectare correspond to those that were superior in total yield per plant, as previously discussed.

Table 4. Effect of Foliar Spray with Organic Nutrient Optimus Plus, Cultivars, and Their Interaction on Total Tuber Yield (ton ha^{-1})

Cultivars	Organic Nutrient concentrations ml L^{-1}			Mean effect of Cultivars
	0	2	4	
Lady Roseeta	28.5709 b	26.6993 bc	33.5087 a	29.5930 a
Hermes	24.8566 c	25.2995 c	25.4168 c	25.1909 b
Mean effect of Organic Nutrient	26.7137 b	25.9994 b	29.4627 a	

Means sharing the same letter within each factor and interaction do not differ significantly according to Duncan's multiple range test at a significance level of ≤ 0.05.

The results of Tables indicate that foliar spraying with the organic nutrient had a significant effect on the marketable yield per plant, with the concentration of 4 ml L^{-1} outperforming other concentrations, reaching a value of 594.01 g plant^{-1} for this trait. Regarding cultivar effects, Lady Rosetta showed a significant superiority in marketable yield per plant compared to the other cultivar, achieving the highest value for this trait (606.95 g plant^{-1})

Table 5. Effect of Foliar Spray with Organic Nutrient Optimus Plus, Cultivars, and Their Interaction on Marketable Yield per Plant (g plant^{1})

Cultivars	Organic Nutrient concentrations ml L^{-1}			Mean effect of Cultivars
	0	2	4	
Lady Roseeta	571.45 bc	580.65 b	668.75 a	606.95 a
Hermes	525.90 d	534.00 cd	519.26 d	526.39 b
Mean effect of Organic Nutrient	548.67 b	557.33 b	594.01 a	

Means sharing the same letter within each factor and interaction do not differ significantly according to Duncan's multiple range test at a significance level of ≤ 0.05.

The results of Tables (6) show the effect of the studied factors on tuber firmness after harvest., foliar spraying with the organic nutrient at a concentration of 4 ml L^{-1} significantly outperformed other concentrations in this trait, recording values of 10.7292 kg/cm². Regarding cultivar effects, significant differences in tuber firmness after harvest were observed between the cultivars Lady Rosetta and Hermes. The Lady Rosetta cultivar significantly surpassed Hermes, with tuber firmness reaching 9.4905 kg/cm². Concerning the interaction between foliar spray and cultivars, results showed a significant superiority when spraying with the highest concentration of the organic nutrient combined with the Hermes cultivar, yielding the highest tuber firmness after harvest at 10.7292 .

Table 6. Effect of Foliar Spray with Organic Nutrient Optimus Plus, Cultivars, and Their Interaction on Tuber Firmness After Harvest (kg/cm²).

Cultivars	Organic Nutrient concentrations ml L^{-1}			Mean effect of Cultivars
	0	2	4	
Lady Roseeta	7.4997 d	10.2777 b	10.6942 a	9.4905 a
Hermes	7.0290 e	9.4650 c	10.7642 a	9.0861 b
Mean effect of Organic Nutrient	7.2643 c	9.8713 b	10.7292 a	

Means sharing the same letter within each factor and interaction do not differ significantly according to Duncan's multiple range test at a significance level of ≤ 0.05.

The results presented in Tables () indicate significant differences among the organic nutrient concentrations in the three studied traits. It is noted from the results that the foliar spray treatment with 4 ml L^{-1} of the organic nutrient showed a significant superiority over other treatments in the percentage of dry matter and starch content in tubers after harvest, as well as tuber specific gravity. The values of these traits reached 21.3311%, 15.01449%, 1.0852912.

Plants of the Lady Rosetta cultivar showed significant superiority over the Hermes cultivar for the percentage of dry matter, starch content in tubers after harvest, and tuber specific gravity. The values for these traits in the superior cultivar were 20.44259%, 14.22371%, 1.0810810.

The interaction treatment of foliar spray with 4 ml L^{-1} organic nutrient and Lady Rosetta cultivar gave the highest values for the percentage of dry matter, starch content in tubers after harvest, and tuber specific gravity, reaching 22.396715.9628%, 15.4763%, 1.0903403, respectively. These values were significantly higher than all other interaction treatments.

Table 7. Effect of Foliar Spray with Organic Nutrient Optimus Plus, Boron, Cultivars, and Their Interaction on the Percentage of Dry Matter in Tubers

Cultivars	Organic Nutrient concentrations ml L^{-1}			Mean effect of Cultivars
	0	2	4	
Lady Roseeta	18.8600 c	20.0711 b	22.3967 a	20.44259 a
Hermes	15.2289 e	16.4333 d	20.2656 b	17.30926 b
Mean effect of Organic Nutrient	17.0444 c	18.2522 b	21.3311 a	

Means sharing the same letter within each factor and interaction do not differ significantly according to Duncan's multiple range test at a significance level of ≤ 0.05.

Table 8. Effect of Foliar Spray with Organic Nutrient Optimus Plus, Boron, Cultivars, and Their Interaction on the Percentage of Starch in Tubers after Harvest

Cultivars	Organic Nutrient concentrations ml L^{-1}			Mean effect of Cultivars
	0	2	4	
Lady Roseeta	12.8152 c	13.8931 b	13.8931 b	14.22371 a
Hermes	9.5835 e	10.6555 d	14.0661 b	11.43504 b
Mean effect of Organic Nutrient	11.19936 c	12.27428 b	12.27428 b	

Means sharing the same letter within each factor and interaction do not differ significantly according to Duncan's multiple range test at a significance level of ≤ 0.05.

Table 9. Effect of Foliar Spray with Organic Nutrient Optimus Plus, Boron, Cultivars, and Their Interaction on the Specific Gravity of Tubers at the First Site.

Cultivars	Organic Nutrient concentrations ml L^{-1}			Mean effect of Cultivars
	0	2	4	
Lady Roseeta	1.0735820 c	1.0793208 b	1.0903403 a	1.0810810 a
Hermes	1.0563762 e	1.0620834 d	1.0802422 b	1.0662339 b
Mean effect of Organic Nutrient	1.0649791 c	1.0707021 b	1.0852912 a	

Means sharing the same letter within each factor and interaction do not differ significantly according to Duncan's multiple range test at a significance level of ≤ 0.05.

The results of Table (10) indicate that the percentage of protein in tubers did not differ significantly among treatments with organic nutrient spray

Regarding the interaction effect between organic nutrient spray and cultivars on the percentage of protein in tubers, no significant differences were observed for this trait.

Table 10. Effect of Foliar Spray with Organic Nutrient Optimus Plus, Boron, Cultivars, and Their Interaction on the Percentage of Protein in Tubers.

Cultivars	Organic Nutrient concentrations ml L^{-1}			Mean effect of Cultivars
	0	2	4	
Lady Roseeta	11.0911 a	10.6822 ab	9.8644 ab	10.5459 a

Hermes	9.3867 ab	11.0578 a	10.7511 ab	10.3985 a
Mean effect of Organic Nutrient	10.2389 a	10.8700 a	10.3078 a	

Means sharing the same letter within each factor and interaction do not differ significantly according to Duncan's multiple range test at a significance level of ≤ 0.05.

The results of the tables discussed in relation to quantitative and qualitative yield traits indicated that both concentrations of the organic nutrient under study showed significant superiority over the untreated control in some quantitative yield traits, specifically average tuber weight and average marketable tuber weight only, as well as in all studied qualitative yield traits.

This may be attributed, as noted by (Ibrahim,2012), to the role of organic fertilization in increasing plant moisture content, which enhances the efficiency of photosynthesis and stimulates physiological activity. These improvements positively affect both the quantity and quality of yield. Similarly, (Jamal,1998) indicated that organic nutrients contain glycosidic compounds that help plant cells retain water, in addition to their role in activating the antioxidant enzyme system, which contributes to improved plant growth and productivity.

The observed differences in significant superiority among the foliar spray concentrations of the organic nutrient for quantitative and qualitative yield traits may be attributed to the genetic differences between the two cultivars. This is because quantitative and qualitative yield traits are controlled by the cultivars' genetic makeup and the influence of environmental conditions surrounding the plants, which affect gene expression related to enzyme activity specific to each cultivar. Consequently, significant differences between cultivars in quantitative and qualitative yield traits were observed, as indicated by the results of the tables. The significant variation observed between the two cultivars in terms of yield quantity and quality may be attributed to genetic differences, as these traits are largely governed by the plant's genetic makeup and its interaction with environmental factors. Such interactions can activate specific enzymes related to yield performance (Taha,2007). Moreover, the combined effect of genetic and environmental factors plays a critical role in determining both the quantity and quality of yield (Kumar etal,2000 , Ibraheem and Alsultan,2025 , Taha etal,2025 , Abbas and Ibraheem,2025 , Ibraheem etal.2025 , Ibraheem and Mahmoud,2024 , Ibraheem and Mahmoud,2024 , Hussein and Ibraheem, 2023 , Ibraheem,2023)

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