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Potato Production by Using Different Magnesium and Vermiwash Spray Applications

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A FIELD experiment was conducted to study the effects of different concentrations of vermiwash (1, 3 and 6 L fed^{-1}) complemented by foliar application of magnesium (1000, 2000 and 4000 ppm) on growth, yield, nutritional status of potato plant (*Solanum tuberosum*, L. cv Kara) at the Agricultural Production and Research Station, National Research Centre (NRC), Nubaria Province, Egypt during two successive winter seasons 2023 and 2024.

The obtained results revealed that the combination between using vermiwash and Mg foliar application resulted in improved growth and yield parameters of potato plants. As for crop quality, including the protein and starch content of tubers and the total chlorophyll content of leaves, it was noted that spraying magnesium and vermiwash was important in improving these qualities in potato plants during the two successive growing seasons, especially with spraying high concentrations of magnesium and vermiwash. Spraying magnesium increased the tubers' nitrogen and magnesium content, while there was no significant effect on both phosphorus and potassium. Spraying vermi-wash on plants had little effect on the nitrogen and phosphorus content of tubers, while it did not significantly affect the potassium and magnesium content of tubers.

In order to get a high crop with high quality requirements, it is vital to consider spraying plants with magnesium, one of the primary nutrients important for plant life. Vermiwash is another organic material that soil worms can make and that can be utilized to produce a high yield.

Keywords: Magnesium, Vermiwash, Potato, Growth, Yield, Nutrients content.

Introduction

Pioneering work in plant nutrition has been underway since the late 19th and early 20th centuries, wherein the biological roles of the majority of nutrients and complicated nutritional diseases have been thoroughly examined. While other crucial nutrients, like magnesium, were long neglected in terms of soil and plant tests and fertilization programs, research efforts continued to concentrate on crop productivity and quality as well as the major nutrients that determine productivity, such as nitrogen, phosphorus, and potassium. Magnesium was dubbed "The forgotten element in crop productivity" since its lack was not thought to be a significant worry for crop yield **(**Tian *et al*., 2021). Magnesium is a crucial nutrient for crop development and productivity because it regulates protein synthesis, enzyme function, and the distribution of carbohydrates (He *et al*., 2020). Magnesium directly contributes to the photosynthesis process of the shoot and the synthesis of photosynthesis metabolites since it is the primary component of chlorophyll in the light-capturing complex of chloroplasts (Li *et al*., 2024).

After water has passed through a worm action column, a liquid known as vermiwash is recovered. It is a combination of earthworm mucus secretion and excretory products. It comprises growth-promoting hormones, primary enzymes, and nitrogen as a nitrogenous excretory product (Kaur *et al*., 2015). Vermiwash is used in agriculture as a solids substitute and supplement to deliver nutrients efficiently and rapidly to increase crop yield and plant growth by foliar spraying. Vermiwash is inexpensive, easily accessible, and safe for the environment (Fathima and Sekar, 2014). According to Sobha *et al.*, (2003), using vermiwash topically has

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improved plant physiology, which in turn has led to increased agricultural output and quality. One of the important crops in Egypt for both local consumption and export is the potato (*Solanum tuberosum*, L.) (Hussein and Sabbour, 2024). Due to its high starch content and plenty of vitamins B and C, potatoes are a significant source of affordable energy (El-Damarawy *et al*., 2025)

This experiment sought to ascertain how vermiwash and magnesium affected the growth, yield characteristics, and nutrient content of potato (*Solanum tuberosum*, L. cv. Kara) plants cultivated in sandy soil.

Materials and Methods:

This study was carried out at the experimental station of the National Research Centre in Nubaria region, Egypt, during the two winter seasons of 2023 and 2024 to investigate the response of potato (*Solanum tuberosum*, L. cv Kara) to foliar application of magnesium and vermiwash on growth, quantity and quality yield and nutritional status of potato plants. The tubers were planted on the 4th week of January during the two seasons on one side of ridge at distance of 25 cm between plants and 75 cm within rows. Some chemical properties of soil were determined (Table 1) using the standard procedures outlined by Cottenie (1980).

Field experiment was arranged as factorial experiment (two ways) based on randomized complete block design with four repetitions. First factor was levels of foliar application of vermiwash (1, 3 and 6 L fed^{-1}). The second factor was levels of foliar application of magnesium (1000, 2000 and 4000 ppm). All vermiwash and magensium were sprayed 20, 40, and 60 days after seedling.

Table 1. Some physical and chemical properties at different depth of the soil used.

Soil properties		Values	
		First season	Second season
Particle size distribution (%)	Sand	92.32	93.0
	Silt	5.68	4.56
	Clay	2.00	2.44
	Texture	Sandy soil	Sandy soil
$CaCO_3$ (%)		2.11	2.14
$pH_{(1:2.5\ soil\ suspension)}$		7.80	7.70
EC (dS m^{-1})		1.60	1.72
Soluble caions (mmol L^{-1})	Ca^{++}	6.02	6.96
	Mg^{++}	3.97	3.16
	Na^{+}	3.64	5.20
	K^{+}	2.37	1.88
Soluble anions (mmol L^{-1})	CO_3^{--}	-	-
	HCO_3^{-}	0.64	0.64
	Cl^{-}	4.10	7.82
	SO_4^{--}	6.02	8.74
Available nutrients (mg kg^{-1})	N	32.2	28.5
	P	4.05	4.00
	K	88.6	58.5

Vermiwash extract preparation:

Vermiwash was extracted from vermicompost through vermiwash collecting device. This device consists of 5 L container with a tap at the bottom, with the bottom of container filled with gravel (about 10 cm thickness), and followed by sand layer (2 to 3 cm thickness). Organic waste with heavy population of earth worms was filled into the container and fresh water was continually added from top. The watery yellowish to black was extracted vermiwash drainage out from bottom tap and collected up to 2 days of extraction (Ismail, 2005). Table (2) shows the chemical analysis of vermiwash.

Table 2. Some chemical analysis of vermiwash.

	EC dSm^{-1}	pH	N	P	K	Fe	Mn	Zn	Cu
Vermiwash	(1:10)		%			ppm			
	3.60	7.35	0.90	0.68	0.25	0.80	0.16	0.001	0.04

Mineral fertilizers N, P, and K were added in the recommended amounts by the Egyptian Ministry of Agriculture (432 kg N/hectare, 84.0 kg P_2O_5/hectare and 204.0 kg K_2O/hectare in the forms

of ammonium sulfate, single super phosphate and potassium sulfate, respectively). A random sample of four plants was taken from each experimental unit to determine the growth parameters, i.e. (plant height "cm" and tuber diameter "cm"). At harvest (115 days from planting), a representative sample of 10 healthy tubers from each experiment plot was selected from the larger sizes to obtain the quality of tuber as follows:

1. Tuber yield.
2. Total Starch content.
3. Crude protein percentage "multiplying total nitrogen percentage by 6.25 to give the crude protein content"
4. N, P and K content.

Biochemical determination:

Total chlorophyll was determined in representative fresh leaves samples according to Moran (1982). Soluble starch content in potato tubers was determined following Malik and Srivastava (1979).

Nutritional status:

Total nitrogen content was estimated by modified Kjeldahl's methods (Motsara and Roy, 2008). The percentages of phosphorus and potassium in the acid digested samples of potato tuber were determined. Phosphorus was determined calorimetrically by NH_4-Metavanidate method (Kalra, 1998). Potassium was flame photometrically estimated (Dewis and Freitas, 1970). Magnesium was determined using the Atomic absorption spectrophotometer (Perkin Elemer 1100 B).

Statistical Analysis:

All data were subjected to statistical analysis using Mstatc software. The comparison among means of the different treatments was determined, as illustrated by Snedecor and Cochran (1982). Means of the treatments were compared by the Least Significant Differences Test at (0.05) level of significance.

Results and Discussion:

Table (3) was indicated to the main effects of Mg and vermiwash on potato growth and yield parameters. Both Mg and vermiwash significantly influenced all measured parameters. Increasing Mg concentrations and vermiwash rates generally resulted in taller plants, more leaves, and higher tuber yields. The synergistic effect of Mg and vermiwash was pronounced in the two consecutive seasons. The highest total yield was achieved when added the highest Mg concentration (4000 ppm) and vermiwash rate (6 fed¹).

In order to determine the best and most cost-effective dosage of magnesium for potatoes, Talukder *et al*., (2009) investigated the effects of five different amounts of magnesium 0, 5, 10, 15, and 20 kg ha^{-1}on potato development and yield. They found that magnesium significantly impacted potato tuber yield, with 10 kg Mg ha^{-1} producing a greater tuber yield. Orlovius and McHoul (2015**)** reported that using mg fertilization at 25 kg per feddan led to increase potato growth and yield, and using magnesium fertilizers that are more soluble helps reduce the chance of magnesium insufficiency and the resulting yield and financial losses. Hassan *et al.* (2023) found that magnesium fertilization significantly improved the growth and yield of potato plants grown in sandy soil.

Vermiwash is recognized to have a significant impact on plant growth and development, promoting growth rate, improving crop output, and producing high crop yields (Sundararasu and Jeyasankar, 2014). When compared to the control treatments, two applications of vermi-wash spray improved the nutritional contents, yield parameters, and vegetative development traits of potato plants (Abdrabbo *et al*., 2019). Vermiwash is used as a bio-fertilizer in sustainable agriculture, where it was found to significantly improve the growth characteristics of tomato plants (Awadhpersad *et al*., 2021).

The results in Table (4) were shown the di interaction between spraying different concentrations of vermiwash with magnesium on the growth and yield parameters of potato during the two growing seasons. In two consecutive growing seasons, raising the concentration of vermiwash from 1 to 6 L fed^{-1} and increasing the concentration of magnesium spray from 1000 to 4000 ppm greatly improved the growth and yield metrics of potato plants. In two consecutive growing seasons, the treatment with the highest concentration of vermiwash and magnesium has produced the highest values for potato growth and yield parameters.

When sprayed to brinjal plants, Sudararasu and Jeyasankar (2014) found that vermiwash spray improved growth (plant height and number of leaves) and yield (number of flowers and fruits per plant) metrics. According to Fathima and Sekar (2014), a modest concentration of vermiwash effectively promotes seed germination and the growth of seedlings. Vermiwash's potential for seed germination and seedling vigor may be explained by the nutrients and growth-promoting compounds it contains (Chattopadhyay, 2015). Since vermiwash is an organic liquid fertilizer made with earthworms and contains nutrients and growth-promoting hormones, foliar application is recommended for obtaining sustainable crops (Tharmaseelan *et al*., 2024).

Additionally, magnesium is involved in the phloem's transportation of metabolic materials, or photoassimilates (Torabian *et al*., 2021). Additionally, it has been demonstrated that magnesium influences plant diseases (Huber *et al*., 2013). Consequently, plant development and yield

are correlated with magnesium (Cakmak, 2013). According to Altarugio *et al.*, (2017), magnesium foliar spraying improved maize and soybean yield performance.

Table 3. Main effect of Mg and vermiwash concentrations on potato growth and yield.

Treatments	Plant length cm	No. leaves	No. of tubers /plant	Yield per plant Kg	Total yield ton fed^{-1}
First season					
Vemiwash rates (L fed^{-1})					
1	40.7	55.2	10.7	2.30	19.3
3	40.9	59.1	11.9	2.38	19.4
6	41.2	65.3	14.2	2.72	22.8
LSD $_{0.05}$	0.25	3.55	2.44	0.50	1.51
Mg concentrations (ppm)					
1000	40.6	56.1	10.8	2.21	19.5
2000	40.8	60.1	11.9	2.31	20.0
4000	41.1	67.2	14.7	2.44	23.2
LSD $_{0.05}$	0.24	3.60	1.12	0. 10	1.49
Second season					
Vemiwash rates (l fed^{-1})					
1	40.6	55.1	10.6	2.32	19.2
3	40.9	59.1	11.8	2.39	19.4
6	41.1	64.5	14.0	2.73	22.6
LSD $_{0.05}$	0.23	3.53	2.43	0.50	1.50
Mg concentrations (ppm)					
1000	40.5	56.0	10.8	2.22	19.4
2000	40.7	60.2	12.0	2.31	20.3
4000	41.0	67.1	14.8	2.41	23.5
LSD $_{0.05}$	0.22	3.56	0.52	0.09	1.52

Table 4. Di-interaction between Mg and vermiwash concentrations on potato growth and yield.

Vermiwash rates L fed^{-1}	Mg conc. ppm	Plant length cm	No. leaves	No. of tubers /plant	Yield per plant kg	Total yield ton fed^{-1}
			First season			
1	1000	40.8	59.3	11.1	2.12	17.1
	2000	48.7	62.4	11.4	2.28	19.1
	4000	51.5	63.5	14.0	2.67	22.4
3	1000	44.6	65.3	10.5	2.00	17.8
	2000	50.1	69.5	12.6	2.42	20.3
	4000	53.2	70.4	14.4	1.76	23.1
6	1000	46.0	67.1	9.95	1.83	18.3
	2000	52.3	70.2	12.7	2.48	20.9
	4000	56.1	71.7	14.5	2.95	23.3
LSD $_{0.05}$		3.62	4.02	1.40	0.32	2.66
			Second season			
1	1000	40.6	59.2	11.0	2.13	17.2
	2000	48.7	62.3	11.3	2.27	19.0
	4000	51.3	63.5	13.9	2.66	22.4
3	1000	44.5	65.3	10.4	2.01	17.7
	2000	50.0	69.4	12.5	2.40	20.4
	4000	53.1	70.2	14.3	1.77	23.1
6	1000	46.1	67.1	9.91	1.82	18.3
	2000	52.2	70.1	12.6	2.47	20.8
	4000	55.9	71.5	14.4	2.93	23.1
LSD $_{0.05}$		3.60	4.00	1.39	0.31	2.64

Vermiwash and magnesium had the greatest effects on the quality of potato yield and total chlorophyll in leaves, according to the results in Table (5). Over the course of the two growing seasons, it was discovered that the starch and protein content of potato tubers as well as the overall chlorophyll content of the leaves grew dramatically with increasing concentrations of vermiwash and magnesium. The third concentration of vermiwash (6 L fed^{-1}) and magnesium (4000 ppm) gave the highest values of crop quality coordinates during the two successive growing seasons.

The beneficial impact of magnesium foliar spraying on tuber quality may be explained by the mineral's function in phosphorylation and protein synthesis (Mengel and Kirkby, 2001). According to Khalid *et al*., (2009), the accumulation of total chlorophyll in thyme leaves increased significantly when magnesium was applied. Applying magnesium greatly enhanced photosynthetic pigments (Wafaa H. Abd El-Aleem *et al*., 2016). Soybean protein increased dramatically after 200 ppm vermiwash foliar spray was applied (Lende *et al*., 2007). Palve *et al*., (2024) showed that spraying vermiwash at a rate of 30% led to an increase in total chlorophyll in the leaves.

It is clear from the Figure (1) the di-interaction between spraying different concentrations of vermiwash and several concentrations of magnesium on the quality of potato yield, represented by the content of potato tubers of protein and carbohydrates, as well as the content of total chlorophyll in the leaves. The results revealed that both Mg and vermiwash significantly influenced potato yield quality. Increasing Mg concentrations and vermiwash rates generally led to higher starch content, protein content, and total chlorophyll. The interaction between Mg and vermiwash was also observed, with the most favorable effects on yield quality and total chlorophyll in leaves occurring at higher Mg concentrations and vermiwash rates. The combination of 4000 ppm Mg and 6 fed^{-1} vermiwash consistently resulted in the highest starch, protein, and total chlorophyll values in both seasons.

Table 5. Main effect of Mg and vermiwash on potato yield quality and total chlorophyll in leaves.

Treatments	Starch	Protein	Total Chlorophyll
	%		100 mg g^{-1}
First season			
Vemiwash rates (l fed^{-1})			
1	60.1	6.94	48.6
3	61.2	7.38	50.1
6	61.3	7.68	51.3
$LSD_{0.05}$	0.33	0.71	4.22
Mg concentrations (ppm)			
1000	61.4	7.13	55.4
2000	62.5	7.44	58.2
4000	63.7	8.13	62.1
$LSD_{0.05}$	1.11	0.82	2.11
Second season			
Vemiwash rates (l fed^{-1})			
1	60.1	6.95	48.5
3	61.1	7.37	50.1
6	61.2	7.69	51.2
$LSD_{0.05}$	0.33	0.70	4.23
1000	61.4	7.14	55.6
2000	62.4	7.46	58.5
4000	63.6	8.11	62.0
$LSD_{0.05}$	1.10	0.81	2.10

The positive effects of Mg and vermiwash on potato yield and quality can be attributed to several factors. Mg is essential for chlorophyll synthesis, which is directly related to photosynthesis and plant growth. Furthermore, magnesium is an activator of numerous enzyme systems involved in protein synthesis, nucleic acid synthesis, and glucose metabolism **(**Fiorentini *et al*., 2021). Magnesium's function as the primary atom of the chlorophyll molecule, which transforms light energy into chemical energy and is necessary for photosynthesis, may explain why foliar spray contains it (El-Metwally *et al*., 2011). According to Khalid *et al*., (2009), applying magnesium resulted in a notable rise in the concentration of photosynthetic pigments. Magnesium is a crucial component of chlorophyll and one of the elements required for plant growth and development (Rajonandraina *et al*., 2023). The soybean leaf treatment with 200 ppm vermiwash had the highest

levels of total chlorophyll and nitrogen. (Lende *et al*., 2007). Foliar spray of vermiwash increase increased leaf area and total Chlorophyll (Siamak *et al*., 2017). According to Awadhpersad *et al*., (2021), spraying vermiwash in salty circumstances boosted tomato leaf area and total chlorophyll.

Table (6) was shown the main effect of vermiwash and magnesium on the content of nutrients (nitrogen, phosphorus, potassium, magnesium) in potato tubers during the two successive growing seasons. Both Mg and vermiwash significantly influenced the concentrations of N, P, K, and Mg in the tubers. Increased Mg concentrations generally led to higher N levels in potato tubers. This is likely due to Mg's role in protein synthesis and amino acid uptake. Mg supplementation did not significantly affect P content in potato tubers. There was no significant of Mg on K content. As expected, increasing Mg concentrations significantly increased Mg levels in potato tubers. Vermiwash application had a less pronounced effect on N content compared to Mg. However, there was a slight increase in N content with higher vermiwash rates. Vermiwash was slightly increased P content and had a negligible effect on K and Mg content in potato tubers.

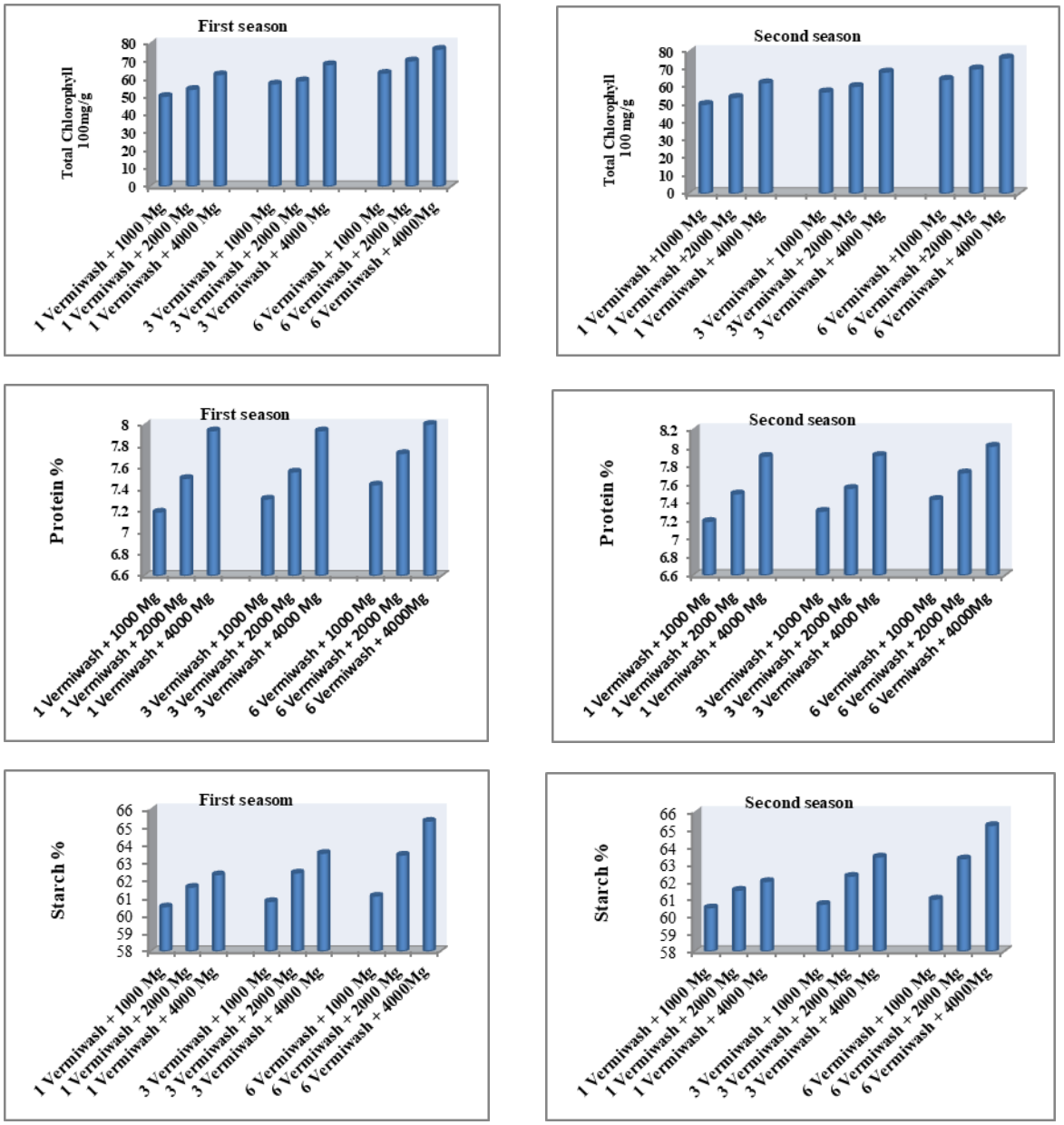

Fig. 1. Di-interaction between Mg and vermiwash concentrations on potato yield quality and total chlorophyll in leaves.

Table 6. Main effect of Mg and vermiwash on nutrients content of potato tubers.

Treatments	N	P	K	Mg
		%		
		First season		
Vemiwash rates (l fed^{-1})				
1	1.11	0.20	2.45	0.030
3	1.18	0.21	2.51	0.032
6	1.26	0.21	2.56	0.038
LSD $_{0.05}$	0.10	0.02	0.07	0.07
Mg concentrations (ppm)				
1000	1.14	0.21	2.50	0.040
2000	1.19	0.22	2.53	0.045
4000	1.30	0.23	2.57	0.052
LSD $_{0.05}$	0.11	0.02	0.05	0.008
		Second season		
Vemiwash rates (l fed^{-1})				
1	1.12	0.21	2.44	0.031
3	1.17	0.22	2.52	0.033
6	1.25	0.22	2.55	0.038
LSD $_{0.05}$	0.09	0.01	0.02	0.006
Mg concentrations (ppm)				
1000	1.13	0.21	2.49	0.041
2000	1.20	0.22	2.51	0.046
4000	1.28	0.23	2.55	0.051
LSD $_{0.05}$	0.10	0.01	0.04	0.007

According to El-Fouly *et al.*, (2012), Magnesium foliar fertilization considerably enhanced the concentrations and uptake of nearly all assessed macro and micronutrients in the organs of wheat and faba bean plants. Plants having higher nutritional levels (N, P, K, and Mg) responded better to magnesium treatment, per Khalid *et al.*, (2009). Although magnesium is very important, it should be viewed as a nutrient that helps plants absorb nitrogen and convert it into plant biomass (Torabian *et al*., 2021). Sheren A. Abd El–Hamied, (2018) reported that the amount of N, P, and K in the leaves increased when vermiwash was sprayed at a 15% rate. Higher agricultural yields result from vermiwash's increased nutrient content, which makes nutrients like N, P, K, and Mg more readily available to plants (Aboelsoud and Ahmed, 2020).

The di-interaction between Mg and vermiwash on the nutrient contents of potato tubers was presented in Table (7). With an increase in the concentration of vermiwash spray, most of the tubers' content of nutrients increased significantly with an increase in the rates of magnesium spraying. At high concentrations of both magnesium and vermiwash, it gave the highest values for the element content of potato tubers.

Vermiwash has different levels of N, P, K, and Mg, thus when it was sprayed on plants, the nutrients in the leaves increased (Deepthi *et al*., 2021). The vermiwash liquid is high in nutrients and plant-beneficial components, according to Zarei *et al*., (2018). By increasing the concentrations of nitrogen, potassium, and magnesium in leaves and reversing the reduction of root vitality brought on by acid stress, magnesium promoted balanced nutrient absorption (Lv *et al*., 2024).

Conclusion:

Magnesium should be taken into consideration as one of the major nutrients, and attention should be paid to fertilizing plants with it, as many farmers neglect it, as this nutrient plays an important role in the life of plants that cannot be ignored. These findings suggest that the combined application of Mg and vermiwash can be a promising strategy to enhance potato production and nutritional value. The highest total yield of potato was achieved when added the highest Mg concentration (4000 ppm) and vermiwash rate (6 L fed^{-1}).

Table 7. Di-interaction between Mg and vermiwash on nutrients content of potato tubers.

Vermiwash rates l fed^{-1}	Mg conc. ppm	N	P	K	Mg
		First season	%		
	1000	1.15	0.20	2.46	0.032
1	2000	1.20	0.22	2.52	0.036
	4000	1.27	0.23	2.55	0.042
	1000	1.17	0.21	2.47	0.038
3	2000	1.21	0.23	2.53	0.042
	4000	1.27	0.23	2.57	0.048
	1000	1.19	0.22	2.49	0.043
6	2000	1.22	0.24	2.55	0.049
	4000	1.28	0.25	2.58	0.055
LSD $_{0.05}$		0.07	0.02	0.05	0.007
		Second season			
	1000	1.15	0.21	2.45	0.033
1	2000	1.21	0.22	2.51	0.036
	4000	1.26	0.23	2.56	0.042
	1000	1.18	0.21	2.47	0.039
3	2000	1.21	0.23	2.52	0.043
	4000	1.27	0.23	2.56	0.049
	1000	1.19	0.22	2.48	0.046
6	2000	1.23	0.24	2.56	0.050
	4000	1.29	0.26	2.57	0.056
LSD $_{0.05}$		0.06	0.02	0.07	0.006

Consent for publication:
All authors declare their consent for publication.

Author contribution:
The manuscript was edited and revised by all authors.

Conflicts of Interest:

The author declares no conflict of interest.

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