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Enhancing Growth Performance, Yield and Quality of Potato Plant *via* Vermicompost and Melatonin

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THE JUSTIFICATION of this research lies in the growing demand for sustainable agricultural practices and the need to enhance crop productivity by minimizing environmental impacts. Vermicompost, rich in essential nutrients and microbial activity, offers a natural and eco-friendly approach to soil enrichment. Melatonin presents a promising avenue for enhancing crop performance, so this study investigated the effects of vermicompost and melatonin on the attributes of potato plants in Met-Fares, Bani-Ebeed district, Dakahlia governorate, Egypt. A complete randomized design in split plot system was used. Vermicompost was applied at rates of 0, 1 and 2 tons fed^{-1} served as the main factor, while melatonin was applied at the concentrations 0, 50, 75 and 100 µM, acted as the sub factor. The obtained results indicated that the values of stem length, leaf area, fresh and dry weights, leaves NPK content, tuber weight, total yield, starch content, total dissolved solids, dry matter and vitamin C exhibited a positive correlation in response to the application rates of vermicompost and melatonin concentrations. Plants performance was significantly improved in all studied traits with increasing levels of vermicompost and melatonin. Plants provided with vermicompost at 2 tons fed^{-1} and sprayed with 100 µM melatonin demonstrated the highest values for all studied traits. In addition, the findings underscore the efficacy of vermicompost and melatonin application in promoting growth, yield and quality of potato plants. Based on the observed results, the integration of vermicompost and melatonin application could be recommended in potato cultivation practices to maximize productivity and quality.

Keywords: Vermicompost, Melatonin, Potato, Sustainable agricultural.

Introduction

Potato (*Solanum tuberosum* L.) stands as a cornerstone of Egypt's agricultural landscape, wielding paramount significance as a strategic crop crucial for both nutrition value and economic vitality. With population heavily reliant on it to meet their dietary needs, potato assumes a central role in ensuring food security across the nation (Soliman et al., 2022) as it is a low-cost food for energy. Its nutritional richness, boasting a diverse array of essential nutrients such as minerals, plentiful content of starch, amino acids, and vitamins C and B, further underscores its importance in safeguarding public health

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and well-being. Moreover, beyond its domestic consumption, potato serves as a lucrative export commodity, bolstering Egypt's economic prosperity on the global stage (Ali et al., 2021 and EL-Metwally et al., 2023). In Egypt, potato cultivation area was about 0.2627 million hectares with a total production nearly 6.90 million tons in 2021 according to FAOSTAT (2023).

Despite of its vital role, potato crop in Egypt faces multifaceted challenges that necessitate concerted efforts towards enhancement and optimization. Particular attention is directed towards the utilization of vermicompost (an organic fertilizer) derived from earthworms which holds immense potential in fortifying soil fertility and supplying essential nutrients vital for improving potato growth (Singh et al., 2023). Vermicompost, often referred to as "black gold" in organic agriculture, is a nutrient-rich organic fertilizer improve soil structure by increasing its water-holding capacity, aeration, and drainage. Additionally, it is teeming with beneficial microorganisms such as bacteria, fungi, and protozoa, as these microorganisms play a vital role in nutrient cycling, organic matter decomposition, and disease suppression (Gul and Gidik, 2024 and Mohammed and Alkobaisy, 2024). In fact, because of vermicompost properties, it can be a good substitute for both chemical fertilizers and pesticides and its application may contribute to producing healthy, contaminant-free food for the growing population without negative effects on the environment. Soil application with vermicompost enhanced chlorophylls, N, P and K contents as well as total yield and quality (Abd El-Hady et al., 2021 on potato; Qasim et al., 2023 and Turan et al., 2023 on tomato and Elsaied et al., 2024 on head lettuce).

Melatonin, a naturally occurring hormone (N-acetyl-5-methoxytryptamine), an indoleamine, was first isolated in 1958 from the bovine pineal gland (Lerner et al., 1958). It's generally produced in the chloroplast and mitochondria of both leaves and roots, then transferred to the meristem, flowers and fruits (Nawaz et al., 2021). Exogenous applications of melatonin enhanced the vegetative growth, mineral content, and tubers yield and quality of potato as compared to the control treatment (Mahmoud et al., 2024). Foliar application melatonin enhanced growth, yield as well as quality of other vegetable crops (Abou El-Yazied et al., 2022 on potato; Brengi et al., 2022 on cucumber; Ibrahim et al., 2020 and Abd El-Basir, 2021 on tomato and EL-Bauome et al., 2022 on cauliflower and more recently Elsaied et al., 2024 on head lettuce under different environmental stresses.

Considering these considerations, the overarching aim of this study is to elucidate the efficacy of vermicompost and melatonin in bolstering potato cultivation and stress tolerance in Egypt. This research endeavors to provide delineating their respective roles in augmenting soil fertility, nutrient availability, and stress tolerance, this research endeavors to provide valuable insights and practical recommendations for optimizing potato production in Egypt's agricultural landscape. Through collaborative efforts and innovative approaches, we aspire to empower Egyptian farmers with the knowledge and tools needed to sustainably enhance potato cultivation and secure the nation's food and economic future.

Materials and Methods

A field trial was conducted over two consecutive seasons (2022-2023 and 2023-2024) at a private farm situated in Met-Fares, Bani-Ebeed district, Dakahlia governorate, Egypt. The experimental design was compete randomized block design in split plot system with three replicates. The soil application of vermicompost at 0.0,1, and 2 tons fed^{-1} was randomly distributed in main plots, while foliar spray of melatonin at constructions of 0.0, 50,75, and 100µM was randomly allowed to sub plots to study their effects on growth, yield and quality attributes of potato plants.

Soil Sampling

The soil samples collected from a depth of 0-30 cm were subjected to analysis following the methodology described by Jones (2018). The characteristics of the soil are detailed in Table1.

Vermicompost

The applied vermicompost was procured from the Egyptian commercial market and incorporated into the soil before cultivation by conjunction with plowing, according to the specified treatments. Table 2 presents some properties of the applied vermicompost. Its analysis depended on the standard methods described by Tandon (2005).

Melatonin

The applied melatonin applied in the study was acquired from the Sigma Company (Sigma-Aldrich, St. Louis, MO, USA). A foliar spray solution of melatonin was prepared by dissolving it in ethanol at a concentration of 10 mM and subsequently stored at -20°C. Before application, this solution was further diluted to achieve concentrations of 50, 75, and 100 µM, following the procedure outlined by Dradrach et al. (2022).

Cultivation

The experimental unit (sub-main plot) measured 21 m^2 (5 rows x 6m long x 0.7m width) with 20 cm planting space. Tubers of the Spunta variety were obtained from the Ministry of Agricultural and Soil Reclamation (MASR). All recommended agricultural practices, except organic fertilization, were adhered to in accordance with MASR guidelines. The tubers were divided into pieces weighing approximately 40 g each. One month before planting, calcium superphosphate fertilizer (15% P_2O_5) was applied at a rate of 75 kg P_2O_5 per feddan during field preparation for all plots, alongside vermicompost treatments. Planting took place during the first week of October in both study seasons, using tuber pieces in moist soil. For nitrogen fertilization, urea fertilizer (46.5% N) was applied at a rate of 150 kg N per feddan. Traditional potassium fertilization was conducted by adding potassium sulfate fertilizer (48% K_2O) at a rate of 30.0 kg K_2O per feddan. Foliar application of melatonin was carried out three times, with a 15-day interval between each application. The application commenced 40 days after planting.

Harvesting

Tubers were harvested 98 days after planting.

Measurements

After 75 days from planting

Randomly selected samples of five plants from each Experimental unit were gathered for various measurements, encompassing stem length (cm), number of leaves plant^{-1}, leaf area (m^2 plant^{-1}), shoot fresh and dry weights (g plant^{-1}). For the analysis of the chemical composition in potato leaves during the same period, the oven-dried potato leaves underwent grinding and subsequent digestion utilizing a mixture of perchloric and sulfuric acids in a 1:1 ratio, following the methodology described by Peterburgski (1968). Total nitrogen (N), phosphorus (P), and potassium (K) (%) in potato leaves were determined using the Kjeldahl method, spectrophotometr, and a flame photometer, respectively, in accordance with the procedure described by Kalra (1997).

After 98 days from planting

Random samples of five plants from each experimental unit were selected for the determination of various yield and quality traits, including the average weight of one tuber (g), Number of tuber plant^{-1} and total tuber yield (ton fed^{-1}), starch content (%), total dissolved solids (%), dry matter (%) and vitamin C (mg 100g^{-1}). The assessment of all quality parameters followed the protocols outlined in AOAC, (2000).

Statistical analysis

The collected data underwent were statistically analysis through Analysis of Variance (ANOVA), and the least significance differences (LSD at 0.05). This analytical approach aligned with the methodology prescribed by Gomez and Gomez (1984).

Results and Discussion

Plant performance after 75 days from planting

Tables 3 and 4 indicate the impact of vermicompost and melatonin on potato vegetative growth parameters including stem length (cm), number of leaves plant^{-1}, leaf area (m^2 plant^{-1}), shoot fresh and dry weights (g plant^{-1}) during seasons of 2022-2023 and 2023-2024. All studied parameters showed significant increment in response to the application of vermicompost, with the highest doses (2 tons fed^{-1}) compared to the control. Melatonin application also enhanced the mentioned vegetative growth parameters. Plants provided with the highest doses (100 µM/L) showed better performance followed by the rate of 75 µM, while the control plants came in the last order. The interaction between vermicompost and melatonin shows a combined effect, where the highest values are observed with the application of both vermicompost at 2 tons fed^{-1} and melatonin at 100 µM in both seasons.

Tables 5 and 6 present the effects of vermicompost and melatonin on the chemical composition of potato leaves, specifically the percentages of nitrogen, phosphorus, and potassium, for the 2022-.2023 and 2023-2024 seasons. Soil application of vermicompost caused increases in nitrogen, phosphorus and potassium contents in potato leaves and the higher doses resulted in higher nutrient levels. Exogenous application with melatonin also enhanced nutrient content compared to control treatment with higher doses increased nitrogen, phosphorus, and potassium content. The interaction between vermicompost and melatonin shows synergistic effects, so the maximum values of nitrogen, phosphorus and potassium contents in potato leaves were achieved when potato plants treated with vermicompost at a rate of 2 ton fed^{-1} and sprayed with melatonin at a rate of 100 µM. The same trend was found during both studied seasons.

The promotion of vegetative growth as well as chemical composition of potato leaves in response to vermicompost is based on its enrichment with essential nutrients (Table 2), plant growth hormones as well as beneficial microbes. Also, the application of vermicompost enhances soil health and crop productivity due to improving nutrients uptake, the presence of derivatives of vermicompost as phytohormons, humic substances and enriched microbial activities as reported by Reham et al. (2023), so it considered as an effective plant growth promoter.

The positive impact of melatonin may be due to that fact that melatonin has a similar structure to auxin specifically IAA, hence it is involved in regulating root and shoot development, so it plays the role of auxins to encourage vegetative growth of plant species (Kolář and Macháčková, 2005). Also, melatonin can regulate the biosynthesis of several plant growth regulators as auxin, abscisi c acid, gibberellins, cytokinins, ethylene, polyam ines, jasmonic acid and salicylic acid. It is an imp ortant modulator of gene expression related to pl ant growth regulators and can also mediate their activities. Several studies suggested that growth-promoting effects of melatonin on plants are comparable to other plant growth regulators (Arano and Hernández, 2018). Additionally, melatonin may regulate various physiological processes in potato plants (Elseedy et al., 2023). The previous enhanced vegetative growth performance in response to either vermicompost or melatonin (Tables 3 and 4) led to an increment in nutrients uptake, so N, P and K contents in leaves increased. The combined application of vermicompost and melatonin provides complementary benefits, leading to improved growth performance and nutrient uptake in potato plants.

Quantitative and qualitative yield (at 98 days from planting)

Tables 7, 8, 9 and 10 show the impact of applying vermicompost as soil addition, in conjunction with spraying various levels of melatonin on tuber quantitative yield, including the average weight of one tuber (g), number of tubers plant^{-1} and total tubers yield (ton fed^{-1}), as well as the qualitative aspects like starch content (%), total dissolved solids (%), dry matter (%) and vitamin C (mg 100g^{-1}) at the harvest stage during 2022-2023 and 2023-2024 seasons. The results indicated an enhancement in all studied either quantitative or qualitative in response to vermicompost levels or melatonin concentrations compared to control treatments in both seasons. Also, the combined treatment of 2 tons fed^{-1} vermicompost with 100 µM melatonin demonstrated the highest values for all studied quantitative and qualitative traits. Finally, the findings underscore the efficacy of vermicompost and melatonin application in promoting the yield and quality of potato plants.

The positive response to vermicompost application may be due to, vermicompost is considered as a long-term supplier of both macro and micronutrients in available form to plants due to the microbial activity (Atiyeh et al., 2000). The presence of an increased number of mycorrhizal fungi as well as N-fixing bacteria in vermicompost promotes plant growth via different mechanisms of growth promotion. Consequently, both the increased availability of nutrients and the improved soil structure resulting from vermicompost application contributed to the observed enhancement in tuber yield and quality parameters (Singh et al., 2024). In the same manner, Vermicompost also includes different enzymes as amylase, chitinase, lipase and cellulase which are very helpful in organic matter degradation and release of the various nutrients, making them more available to plant roots (Karagöz et al., 2019). Similar results have also been reported by Musa et al. (2018) on spinach, Raksun et al. (2022) on bean and Aslam et al. (2023) on tomato that soil application with vermicompost improves growth attributes and hence, enhances overall plant productivity.

Concerning melatonin, it has a valuable role in controlling either physiological or biological processes in plants as root growth, photosynthetic activity and regulating plant hormones (Sharif et al., 2018). Also, Abou El-Yazied et al. (2022) on potato suggested that melatonin improves tubers formation and enhances tubers development. These findings are in an agreement with those mentioned by Abd El-Basir (2021) and Mumithrakamatchi et al. (2024) on tomato and Zaki and Radwan (2022) on potato. The recorded improvements in both quantitative yield and qualitative attributes of potato tubers in response to the application of vermicompost and melatonin may be attributed to the previous mentioned improved vegetative growth (Tables 4 and 5) and the enhanced leaves mineral contents (Tables 5 and 6) in both growing seasons had reflected positively on potato yield and quality.

Therefore, the combination of vermicompost and melatonin application could have facilitated better nutrient mobilization, hormone regulation and stress mitigation in potato plants, leading to enhanced growth, yield, and quality attributes. Finally, the significant improvements in potato tuber yield and quality parameters resulting from the combined application of vermicompost and melatonin can be attributed to the multifaceted benefits of vermicompost in providing nutrients and improving soil health, as well as the regulatory and protective functions of melatonin in plants. Consistent with the current study's Elsaied et al. (2024) indicated that the combination between soil application with vermicompost and foliar application with melatomun enhanced potato plants performance.

Conclusion

The findings of this study highlight the significant potential impacts of vermicompost and melatonin on enhancing growth, yield as well as quality of potato plants. Particularly noteworthy was the enhanced effect observed with the combined treatment of 2 tons per fed. of vermicompost and 100 µM melatonin, which resulted in the highest values across all studied traits. These results underscore the importance of considering integrated approaches in agricultural practices to maximize crop productivity and quality with minimizing environmental impacts. Moving forward, it can be recommended further exploration and adoption of vermicompost and melatonin application in potato cultivation and potentially in other crops as well, as part of a holistic strategy towards sustainable agriculture. By harnessing the benefits of these natural bio-stimulants, we can not only improve agricultural productivity but also contribute to environmental conservation and food security goals.

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Conflicts of interest

The authors have declared that no competing interests exist.

TABLE 1. Soil properties before cultivation in both studied seasons

Characteristics	Values	
	1st season	2nd season
Nitrogen, mg Kg^{-1}	25.5	27.3
Phosphorus, mg Kg^{-1}	7.40	9.10
Potassium, mg Kg^{-1}	205.3	222.7
Organic matter, %	1.25	1.39
EC dSm^{-1} (suspension 1: 5)	3.12	3.29
pH (suspension 1:2.5)	8.12	8.11
Clay,%	50.3	50.4
Silt,%	35.2	35.2
Sand,%	14.5	14.4
Textural class		Clay

TABLE 2. Some properties of the studied vermicompost

Property	Values
Total C, %	18.0
Total N, %	1.50
C:N ratio	12.0
EC,dSm^{-1}	6.00
pH	6.00
O.M,%	34.5
Mn, mg kg^{-1}	18.0
Zn, mg kg^{-1}	20.0
K, g kg^{-1}	5.05
P, mg kg^{-1}	0.75

TABLE 3. Impact of applying vermicompost as soil addition, along with spraying various levels of melatonin on growth parameters of potato plants after75 days from cultivation during season of 2022-2023

Treatments		Stem length (cm)	No. of leaves plant^{-1}	Leaf area (m^2 plant^{-1})	Shoot fresh weight (g plant^{-1})	Shoot dry weight (g plan^{-1})
Main factor: Vermicompost treatments						
T_1:Control (Without vermicompost)		64.86	20.67	0.26	272.49	33.74
T_2:With vermicompost (1.0 tons fed^{-1})		69.44	24.00	0.34	303.76	37.41
T_3: With vermicompost (2.0 tons fed^{-1})		73.42	28.42	0.43	356.07	40.96
LSD at 5%		0.75	0.19	0.03	3.33	0.62
Sub main factor: Melatonin treatments						
F_1: (Without melatonen)		67.99	23.11	0.31	291.29	35.98
F_2: With melatonen (50 µM)		68.60	23.89	0.33	306.09	36.96
F_3: With melatonen (75 µM)		69.97	24.67	0.35	316.57	37.85
F_4: With melatonen (100 µM)		70.40	25.78	0.37	329.14	38.70
LSD at 5%		0.88	0.80	0.01	4.51	0.41
Interaction						
T_1	F_1	63.44	19.67	0.23	263.91	32.29
	F_2	63.50	20.33	0.25	266.50	33.36
	F_3	65.94	20.67	0.27	278.88	34.20
	F_4	66.55	22.00	0.28	280.68	35.13
T_2	F_1	68.43	22.33	0.30	283.85	36.01
	F_2	69.30	23.00	0.33	303.81	37.00
	F_3	70.03	24.67	0.35	308.78	37.93
	F_4	69.98	26.00	0.37	318.61	38.71
T_3	F_1	72.10	27.33	0.40	326.12	39.63
	F_2	73.00	28.33	0.41	347.97	40.54
	F_3	73.93	28.67	0.44	362.06	41.41
	F_4	74.65	29.33	0.46	388.12	42.27
LSD at 5%		1.50	1.36	0.03	7.81	0.72

TABLE 4. Impact of applying vermicompost as soil addition, along with spraying various levels of melatonin on growth parameters of potato plants after 75 days from cultivation during season of 2023-2024

Treatments		Stem length (cm)	No. of leaves plant^{-1}	Leaf area (m^2 plant^{-1})	Shoot fresh weight (g plant^{-1})	Shoot dry weight (g plan^{-1})
Main factor: Vermicompost treatments						
T_1:Control (Without vermicompost)		66.62	21.25	0.25	277.01	34.49
T_2:With vermicompost (1.0 tons fed^{-1})		71.38	24.17	0.34	309.41	38.31
T_3: With vermicompost (2.0 tons fed^{-1})		75.41	29.00	0.44	362.33	41.93
LSD at 5%		0.16	1.55	0.04	3.51	0.08
Sub main factor: Melatonin treatments						
F_1: (Without melatonen)		69.56	23.56	0.30	296.40	36.86
F_2: With melatonen (50 µM)		70.74	24.44	0.33	311.63	37.76
F_3: With melatonen (75 µM)		71.66	25.33	0.35	322.02	38.74
F_4: With melatonen (100 µM)		72.58	25.89	0.38	334.95	39.60
LSD at 5%		1.15	0.88	0.01	3.99	0.61
Interaction						
T_1	F_1	64.44	20.67	0.22	267.74	33.06
	F_2	65.54	21.00	0.23	271.68	34.07
	F_3	67.98	21.67	0.25	283.47	35.06
	F_4	68.51	21.67	0.28	285.17	35.77
T_2	F_1	70.22	23.00	0.29	289.27	36.86
	F_2	71.51	23.33	0.33	309.29	37.77
	F_3	71.79	24.67	0.36	314.89	38.90
	F_4	72.00	25.67	0.38	324.20	39.71
T_3	F_1	74.03	27.00	0.40	332.19	40.67
	F_2	75.18	29.00	0.43	353.91	41.46
	F_3	75.22	29.67	0.45	367.71	42.25
	F_4	77.23	30.33	0.48	395.48	43.33
LSD at 5%		1.98	1.52	0.02	6.92	0.08

TABLE 5. Impact of applying vermicompost as soil addition, along with spraying various levels of melatonin on chemical constituents in leaves of potato plants after 75 days from cultivation during season of 2022-2023

Treatments		Nitrogen (%)	Phosphorus (%)	Potassium (%)
Main factor: Vermicompost treatments				
T_1:Control (Without vermicompost)		2.74	0.303	2.93
T_2:With vermicompost (1.0 tons fed^{-1})		3.17	0.336	3.41
T_3: With vermicompost (2.0 tons fed^{-1})		3.56	0.379	3.84
LSD at 5%		0.01	0.008	0.06
Sub main factor: Melatonin treatments				
F_1: (Without melatonen)		3.00	0.325	3.24
F_2: With melatonen (50 µM)		3.12	0.336	3.36
F_3: With melatonen (75 µM)		3.18	0.342	3.42
F_4: With melatonen (100 µM)		3.31	0.355	3.55
LSD at 5%		0.05	0.003	0.04
Interaction				
T_1	F_1	2.53	0.288	2.78
	F_2	2.66	0.300	2.89
	F_3	2.78	0.307	2.95
	F_4	2.98	0.319	3.09
T_2	F_1	3.05	0.320	3.20
	F_2	3.15	0.332	3.39
	F_3	3.18	0.339	3.44
	F_4	3.31	0.354	3.62
T_3	F_1	3.43	0.367	3.75
	F_2	3.55	0.377	3.81
	F_3	3.59	0.380	3.87
	F_4	3.65	0.392	3.95
LSD at 5%		0.09	0.006	0.07

TABLE 6. Impact of applying vermicompost as soil addition, along with spraying various levels of melatonin on chemical constituents in leaves of potato plants after 75 days from cultivation during season of 2023-2024

Treatments		**Nitrogen (%)**	**Phosphorus (%)**	**Potassium (%)**
Main factor: Vermicompost treatments				
T_1:Control (Without vermicompost)		2.82	0.316	2.99
T_2:With vermicompost (1.0 tons fed^{-1})		3.28	0.350	3.50
T_3: With vermicompost (2.0 tons fed^{-1})		3.68	0.394	3.93
LSD at 5%		0.06	0.009	0.01
Sub main factor: Melatonin treatments				
F_1: Control (Without melatonen)		3.10	0.338	3.32
F_2: With melatonen (50 µM)		3.21	0.350	3.43
F_3: With melatonen (75 µM)		3.29	0.356	3.50
F_4: With melatonen (100 µM)		3.42	0.369	3.63
LSD at 5%		0.04	0.004	0.11
Interaction				
T_1	F_1	2.60	0.300	2.84
	F_2	2.73	0.313	2.95
	F_3	2.86	0.320	3.02
	F_4	3.08	0.332	3.15
T_2	F_1	3.15	0.333	3.28
	F_2	3.24	0.347	3.45
	F_3	3.30	0.353	3.54
	F_4	3.42	0.368	3.71
T_3	F_1	3.55	0.381	3.85
	F_2	3.66	0.391	3.90
	F_3	3.72	0.395	3.94
	F_4	3.78	0.408	4.04
LSD at 5%		0.08	0.006	0.19

TABLE 7. Impact of applying vermicompost as soil addition, along with spraying various levels of melatonin on tubers yield of potato plants after harvest (98 days from cultivation) during season of 2022-2023

Treatments		Average tuber weight (g)	No. of tuber plant^{-1}	Yield (Ton fed^{-1})
Main factor: Vermicompost treatments				
T_1:Control (Without vermicompost)		211.75	2.63	11.77
T_2:With vermicompost (1.0 tons fed^{-1})		286.25	2.24	13.60
T_3: With vermicompost (2.0 tons fed^{-1})		349.92	2.07	15.38
LSD at 5%		1.89	0.04	0.20
Sub main factor: Melatonin treatments				
F_1: Control (Without melatonen)		255.78	2.43	12.83
F_2: With melatonen (50 µM)		274.56	2.36	13.44
F_3: With melatonen (75 µM)		291.22	2.27	13.81
F_4: With melatonen (100 µM)		309.00	2.19	14.25
LSD at 5%		4.51	0.10	0.44
Interaction				
T_1	F_1	179.67	2.85	10.88
	F_2	203.00	2.74	11.82
	F_3	220.67	2.55	11.95
	F_4	243.67	2.40	12.43
T_2	T1	260.33	2.34	12.94
	F_2	281.00	2.23	13.35
	F_3	293.00	2.22	13.86
	F_4	310.67	2.15	14.24
T_3	F_1	327.33	2.10	14.66
	F_2	339.67	2.10	15.15
	F_3	360.00	2.04	15.63
	F_4	372.67	2.03	16.07
LSD at 5%		7.82	0.17	0.76

TABLE 8. Impact of applying vermicompost as soil addition, along with spraying various levels of melatonin on tubers yield of potato plants after harvest (98 days from cultivation) during season of 2023-2024

Treatments		Average tuber weight (g)	No. of tuber plant^{-1}	Yield (ton fed^{-1})
Main factor: Vermicompost treatments				
T_1:Control (Without vermicompost)		196.25	2.81	11.68
T_2:With vermicompost (1.0 tons fed^{-1})		284.92	2.27	13.70
T_3: With vermicompost (2.0 tons fed^{-1})		355.92	2.05	15.53
LSD at 5%		2.88	0.01	0.13
Sub main factor: Melatonin treatments				
F_1: Control (Without melatonen)		253.00	2.51	12.97
F_2: With melatonen (50 µM)		271.67	2.39	13.40
F_3: With melatonen (75 µM)		287.44	2.33	13.86
F_4: With melatonen (100 µM)		304.00	2.27	14.31
LSD at 5%		4.33	0.01	0.21
Interaction				
T_1	F_1	170.67	3.01	10.94
	F_2	191.67	2.80	11.42
	F_3	204.00	2.75	11.94
	F_4	218.67	2.67	12.42
T_2	T1	254.67	2.41	13.08
	F_2	276.67	2.30	13.52
	F_3	295.67	2.21	13.90
	F_4	312.67	2.15	14.30
T_3	F_1	333.67	2.10	14.91
	F_2	346.67	2.07	15.27
	F_3	362.67	2.04	15.74
	F_4	380.67	2.00	16.20
LSD at 5%		7.50	0.01	0.36

TABLE 9. Impact of applying vermicompost as soil addition, along with spraying various levels of melatonin on tubers quality of potato plants after harvest (98 days from cultivation) during season of 2022/2023

Treatments		Strach (%)	TDS (%)	Dry matter (%)	Vitamin C (mg.100g)
Main factor: Vermicompost treatments					
T_1:Control (Without vermicompost)		12.28	5.12	19.63	18.66
T_2:With vermicompost (1.0 tons fed^{-1})		13.58	5.87	21.08	20.87
T_3: With vermicompost (2.0 tons fed^{-1})		14.82	6.56	22.66	22.95
LSD at 5%		0.35	0.11	0.05	0.34
Sub main factor: Melatonin treatments					
F_1: (Without melatonen)		13.06	5.60	20.53	20.10
F_2: With melatonen (50 µM)		13.43	5.77	20.95	20.57
F_3: With melatonen (75 µM)		13.73	5.94	21.33	21.05
F_4: With melatonen (100 µM)		14.02	6.10	21.69	21.59
LSD at 5%		0.16	0.08	0.34	0.25
Interaction					
T_1	F_1	11.75	4.85	19.03	18.18
	F_2	12.19	5.05	19.50	18.32
	F_3	12.47	5.21	19.87	18.81
	F_4	12.72	5.38	20.13	19.35
T_2	T1	13.12	5.61	20.44	20.02
	F_2	13.48	5.80	20.88	20.67
	F_3	13.71	5.96	21.31	21.11
	F_4	14.02	6.13	21.68	21.67
T_3	F_1	14.31	6.33	22.11	22.11
	F_2	14.63	6.46	22.48	22.72
	F_3	15.02	6.65	22.80	23.22
	F_4	15.31	6.80	23.25	23.75
LSD at 5%		0.28	0.14	0.59	0.42

TABLE 10. Impact of applying vermicompost as soil addition, along with spraying various levels of melatonin on tubers quality of potato after harvest (98 days from cultivation) during season of 2022-2023

Treatments		Starch (%)	TDS (%)	Dry matter (%)	Vitamin C (mg.100g)
Main factor: Vermicompost treatments					
T_1:Control (Without vermicompost)		12.48	5.29	19.94	19.08
T_2:With vermicompost (1.0 tons fed^{-1})		13.81	6.07	21.45	21.40
T_3: With vermicompost (2.0 tons fed^{-1})		15.04	6.79	23.00	23.50
LSD at 5%		0.25	0.02	0.24	0.22
Sub main factor: Melatonin treatments					
F_1: (Without melatonen)		13.27	5.79	20.89	20.62
F_2: With melatonen (50 µM)		13.66	5.96	21.29	21.00
F_3: With melatonen (75 µM)		13.93	6.12	21.64	21.56
F_4: With melatonen (100 µM)		14.25	6.32	22.03	22.12
LSD at 5%		0.20	0.19	0.27	0.31
Interaction					
T_1	F_1	11.95	5.01	19.34	18.64
	F_2	12.39	5.21	19.79	18.68
	F_3	12.64	5.35	20.15	19.23
	F_4	12.94	5.57	20.48	19.77
T_2	T1	13.36	5.81	20.87	20.51
	F_2	13.74	5.98	21.30	21.08
	F_3	13.90	6.15	21.63	21.72
	F_4	14.23	6.35	21.99	22.27
T_3	F_1	14.50	6.56	22.47	22.71
	F_2	14.84	6.69	22.78	23.24
	F_3	15.25	6.85	23.14	23.72
	F_4	15.57	7.05	23.62	24.34
LSD at 5%		0.34	0.33	0.47	0.54

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تعزيز أداء النمو والمحصول والجودة لنبات البطاطس عن طريق السماد الدودي والميلاتونين

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تهدف الزراعة المستدامة الى تطبيق نظم صديقة للبيئة للحفاظ على مكونات النظام البيئي وتقليل التلوث الناتج عن المواد الكيماوية وتحسين انتاجية الحاصلات البستانية. يعد التسميد العضوي بسماد الفيرمكمبوست (السماد الدودي) من ركائز التسميد العضوي المستدام حيث يعزز محتوى التربة من العناصر الغذائية والكائنات الحية الدقيقة التي تنعكس على خصوبة التربة وبالتالي زيادة الانتاجية. كما أن الرش الورقي بالميلاتونين ينشط معظم العمليات الحيوية داخل النبات والتي تزيد من كمية وجودة المحصول. أجريت التجربة بقرية ميت فارس – محافظة الدقهلية – مصر حيث تم استخدام تصميم القطاعات العشوائية الكاملة بنظام القطع المنشقة حيث تناولت هذه الدراسة تأثير السماد الدودي الذي تم اضافته بمعدلات ٠.و١ و٢ طن للفدان بمثابة العامل الرئيسي، في حين كان الميلاتونين (رش ورقى) بتركيزات ٠,٠ و٥٠ و٧٥ و١٠٠ ميكرومتر بمثابة العامل المنشق. تم الرش بالميلاتونين ثلاث مرات خلال مراحل نمو النبات حيث كانت أول معاملة لرش النباتات بعد ٤٠ يوما من الزراعة. تم تقييم المدلولات المختلفة التي تعبر عن النمو والمحصول والجودة. أوضحت النتائج المتحصل عليها زيادة في قيم طول الساق، والمساحة الورقية، والوزن الطازج والجاف، ومحتوي الأوراق من النيتروجين والفسفور والبوتاسيوم، ووزن الدرنات، والمحصول الكلي، والمادة الجافة ومحتوى النشا وفيتامين C، والمواد الصلبة الكلية الذائبة نتيجة لاضافة كلا من الفيرمكمبوست والميلاتونين. وأدى زيادة معدلات كل منهما الى تسجيل أعلى القيم لجميع الصفات محل الدراسة. أدى اضافة السماد الدودي بمعدل ٢ طن فدان-١ مع الرش الورقي بالميلاتونين بمعدل ١٠٠ ميكرومتر الى تسجيل أعلى القيم لجميع الصفات المدروسة. كما تؤكد النتائج فعالية استخدام السماد الدودي والميلاتونين في تعزيز نمو وإنتاجية وجودة درنات البطاطس. بناءً على النتائج، يمكن التوصية بدمج استخدام السماد الدودي والميلاتونين في ممارسات زراعة البطاطس لزيادة الإنتاجية والجودة.

الكلمات الدالة: السماد الدودي – الميلاتونين – البطاطس – الزراعة المستدامة.