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Enhancing Head Lettuce Growth and Quality under Water Stress with Proline, Melatonin and Vermicompost Applications

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TWO FIELD experiments were done in order to reduce the effect of water stress on head lettuce, therefore this study were conducted to impact the influence of vermicompost soil addition and foliar application of proline and melatonin on growth (fresh, dry weights, leaf area, relative water content, numbers of outer leaves, in addition chlorophyll a, b, and carotene contents), yield (head height, head diameter, head weight and total yield), and quality (total dissolved solids (TDS), total carbohydrates, crude protein, total sugar, crude fiber percentages, vitamin C, vitamin E, nitrate (NO_3), nitrite (NO_2), proline, super oxidase dismutase, peroxidase and catalyse) of head lettuce (*lactuca sativa*) cv Kharga under water stress (100, 75 and 50% of full irrigation). The results showed the combined treatment of vermicompost and foliar spray with proline under 75% of full irrigation provided the highest vegetative growth, photosynthetic pigments, head yield and quality relative to other treatments including plants grown full irrigation without vermicompost and foliar spray with tap water treatments. These results suggest that yield and quality of head lettuce could be improved under abiotic stress including water scarcity through application of proline, melatonin and vermicompost, additionally these treatments could save water quantities.

Keywords: Abaiotic stres, head quality, leafy vegetable, yield.

1. Introduction

Head lettuce (*Lactuca sativa* L.) is a member of the Asteraceae family and considered one of the most important salad crops in many countries of the world. However, it is newly cultivated in Egypt mainly for export. It is a great source of antioxidants, phytochemicals that fight cancer, and vitamins A, E, and C. In addition to various minerals, it also has a little quantity of fat, dietary fiber, protein, and carbs (**Farouk et al., 2023; Abd El-Hady et al., 2024**).

Water shortage around the roots of plants causes a water stress which causes many physiological problems (**El-Ghamry et al., 2024; El-Sherpiny et al., 2024: Hafez et al., 2024**). When the amount of water absorbs by the roots decreased, the amount of nutrients also decreased which significantly affects the photosynthesis process and increase the formation of reactive oxygen species (ROS) which results in severe damage to the cell walls and their internal components. These process decreases the plant growth and normal development not occur. The effect of water deficit is more sensitive in leafy crops (**Doklega et al., 2023; EL-Bauome et al., 2022**). There many ways to face the water deficit including the use of drought-tolerant varieties and organic fertilizer such as vermicompost and applications of antioxidants e.g. melatonin and proline.

Vermicompost (the process of composting with worms to create vermicompost), an organic substance, supports plant growth and development by providing essential nutrients in accessible forms and enhancing soil's physical and biological properties. Its use reduces the incidence of plant diseases while improving soil aeration, hydraulic conductivity, and water retention. Recent research has highlighted vermicompost's significance as a key supplemental agent for fertilization and soil quality enhancement (**Abd El-Hady et al., 2021; 2023**).

Melatonin (is an endogenous micromolecular compound of indoleamine) protects the photosynthetic system by increasing the effectiveness of ROS scavengers and reducing oxidative damage brought on by dryness (**Sharma and Zheng, 2019**). It is a natural substance in both plants and animals. Melatonin is crucial for

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protecting plants from a lack of water. Through controlling stomatal motion, preserving the integrity of cell membranes, lowering cytotoxic biochemical cellular indicators like H_2O_2 and MDA, and enhancing antioxidant enzyme activities, melatonin helps sustain the water status of plants (**EL-Bauome et al., 2024**). Melatonin limits the negative effects of drought stress by regulating the creation and function of essential organic chemical substances, particularly chlorophyll, proteins and molecules connected to nitrogen (**El-Beltagi et al., 2023**). Through its affinity for hydrogen bonding, proline can promote protein stability and preserve membrane integrity (**Hossain et al., 2019; El-Shaboury et al., 2024**). It is one of the best osmoprotectants for reducing plant abiotic stress including drought, salinity and heat stress. Additionally, protect cells by increasing their capacity to absorb water and activating enzymes. It is also regarded as a powerful ROS scavenger and antioxidative defense molecule (**EL-Bauome et al., 2022; El-Beltagi et al., 2023**).

The aim of this study was to examine how organic fertilization, specifically the addition of vermicompost to soil, and foliar applications of melatonin and proline, individually and in combination, influence the growth, yield, chemical composition, quality, and storability of head lettuce plants under conditions of water stress.

2. Materials and Methods

Two field experiments were conducted during two seasons of 2020/2021 and 2021/2022 2022 at the experimental farm in Faculty of Agriculture, Mansoura University, Egypt. Seeds of Kharga variety were obtained from Hi-Tech Seeds Company.

Soil analyses

Prior to planting, a soil sample was gathered at random from the experimental area, between 0 and 30 cm below the surface, in order to prepare the soil and analyse its physical and chemical characteristics, as indicated in Table 1.

Table 1. Soil characteristics before planting as an average of the two studied seasons.

Soil characters		The values as average
Particle size distribution (%)	Sand	17.50
	Silt	33.00
	Clay	49.50
pH		7.97
EC, dS m^{-1}		2.60
Total $CaCO_3$, g kg^{-1}		1.75
Organic matter, g kg^{-1}		1.81
Field capacity, %		49
Saturation percentage, %		
Available nutrients (mg kg^{-1})	N	31.3
	P	8.2
	K	220

SP: Saturation percentage OM: Organic matter

The experimental design and treatments

This experiment was done in a strip-plot design with 3 replicates. Each one contained 18 treatments as follow:

The vertical-plots were allocated to three irrigation treatments as follow:

1- Full irrigation (100%) with using 1000 m^3 per feddan.

2- Water stress (75% of full irrigation) with using 750 m^3 per feddan.

3- Water stress (50% of full irrigation) with using 500 m^3 per feddan.

The above amounts of irrigation water quantities (m^3/fed.) were measured with water counter at 1.5 bar. This experiment was carried out under flood irrigation system. The irrigation requirements for this plant are 1000 m^3 fed^{-1} according to the instructions of the Egyptian Ministry of Agriculture and Soil Reclamation, **Kaniszewski *et al.* (2017)** and **El-Sherpiny *et al.* (2024).**

The horizontal plots were allocated to organic fertilization two treatments as follows:

1- Without addition of vermicompost

2- Vermicompost addition with 3 ton/fed added during soil preparation.

The sub-plots were included three foliar spraying treatments as follow:

1- Tap water

2- Melatonin was used at the rate of 100 ppm

3- Proline was used at the rate of 100 ppm.

Melatonin was obtained from Sigma-Aldrich, St. Louis, MO, USA. Proline was obtained from Elgomhoria Company. Foliar treatments were performed 5 times at 30, 40, 50, 60, and 70 days after transplanting.

Three ridges of 0.75 m in width and 5 m in length were involved in each experimental plot resulted an area of 11.25 m^2. There was a separation distance between each irrigation treatment, about 2 meters deep channels.

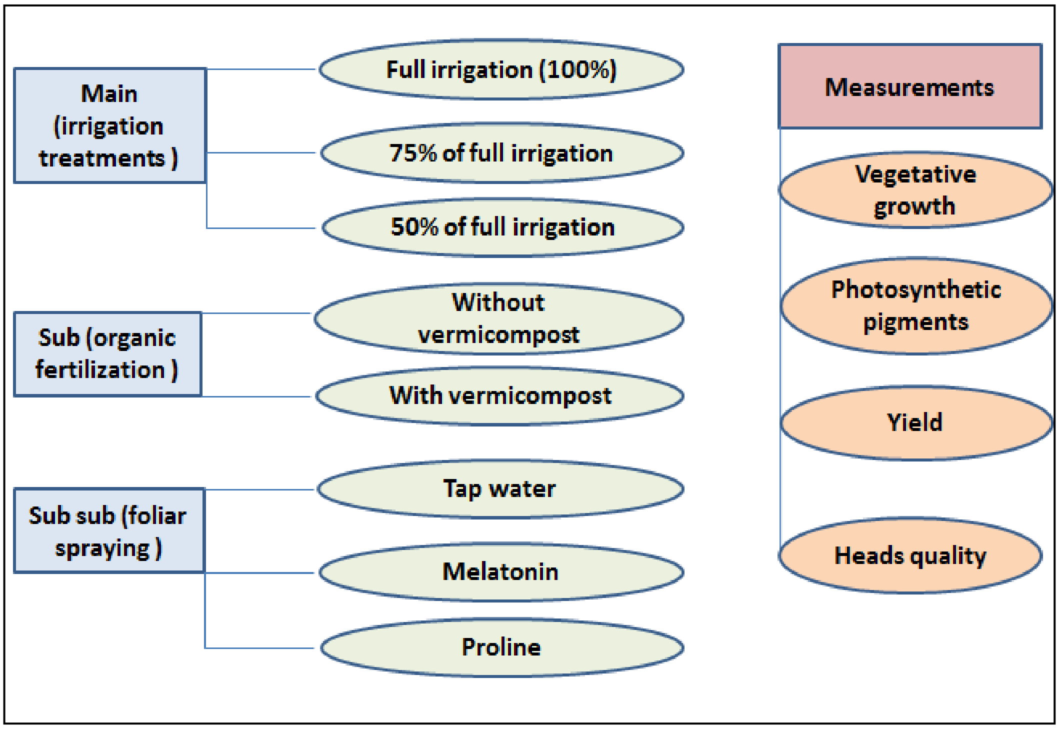

Fig. 1. Flowchart of the experiment.

Table 2. Average chemical analysis of used vermicompost during the two seasons of study.

%			C/N	%			PH	EC
OM	OC	N		P	K	SP	(1:10)	$dS\text{-}m^{-1}$
34.62	20.08	1.68	1:16	2.11	1.31	105	7.53	2.24

OM: Organic matter TC: Total carbon SP: Saturation percent

Ammonium sulphate (20.6% N) was applied at a rate of 200 kg per feddan as a nitrogen fertilizer. Potassium sulphate, with 48.0% K_2O, was applied at a rate of 75 kg per feddan as a potassium fertilizer. Calcium superphosphate, containing 15.5% P_2O_5, was applied at a rate of 200 kg per feddan as a phosphorus fertilizer.

The nitrogen and potassium fertilizers were applied in two equal doses. The first dose was administered 21 days after the transplanting date, and the second dose was applied 30 days after the first dose. Calcium super phosphate was applied during soil preparation before transplanting.

The experimental field, following the specified dimensions, was prepared for each experiment, utilizing furrow irrigation. Lettuce seedlings were promptly planted in moderately moist soil on November 4th and 8th, for the first and second seasons (2020/2021 and 2021/2022, respectively). Planting was done manually in hills spaced 30 cm apart.

Subsequent cultural practices for lettuce production adhered to the recommendations provided by the Ministry of Agriculture and Soil Reclamation, Egypt. After 90 days from transplanting, vegetative and yield data were recorded at the harvest was done in the first week of February during both studied seasons.

Table 3. Data recorded of crisp head lettuce leaves.

Parameters	Methods	References
Vegetative growth	Plant fresh and dry weights, No. of outer leaves and leaf area	Koller (1972)
Photosynthetic pigments content	Chlorophyll a, b carotene	Gavrilenko and Zigalova (2003)
Yield and its components	Head height, diameter, weight and Total yield (ton/fed)	By manual method
Heads quality	Total dissolved solids percentage (TDS)	AOAC (2019)
	Total carbohydrates percentage	Sadasivam and Manickam (1996)
	Crude protein	AOAC (2019)
	Total sugars	Sadasivam and Manickam (1996)
	Crude fiber	AOAC (2019)
	Vitamin C content	Mazumdar and Majumder (2003)
	Vitamin E content	Gimeno *et al.* (2000)
	Nitrate (NO_3) and nitrite (NO_2)	Singh (1988)
	Proline	Bates *et al*. (1973)
	Enzymatic activity	Cao *et al.* (2005), Kong *et al.* (1999)

Statistical analyses

The majority of typical analysis for irrigation trials, the strip-plot design, was used to statistically analyse all collected data in accordance with the analysis of variance (ANOVA). A combined analysis of irrigation treatment experiments was then conducted as indicated by **Gomez and Gomez (1984)** using "MSTAT-C" computer software package. Duncan's multiple range tests was used to test the differences among treatments means at 5 % level of probability as described by **Duncan (1955)**.

3. Results

3.1 Vegetative growth and pigments

Data in Tables 4 and 5 clear the effect of water stress, organic fertilization and foliar spray in vegetative growth and photosynthetic pigments, averages of vegetative growth parameters, i.e., fresh weight, dry weight, leaf area, relative water content, numbers of outer leaves, in addition pigments chlorophyll a, b, and carotene contents in the plant of head lettuce after 90 days of planting, were significantly affected by water stress, organic fertilization and foliar spray during 2020/2021 and 2021/2022 seasons.

Data in Tables 4 and 5 and Figure 2 show the water stress treatments on head lettuce. The maximum means of vegetative growth and pigments of head lettuce are recorded by irrigation head lettuce plants full irrigation (100%) compared to other treatments. Regarding the effects of organic fertilizers, data from the same tables and figure 3 show that adding vermicompost greatly increased the previously indicated metrics in both seasons when compared to untreated plants. Data in the same tables and figure 4 reveal that the parameters mentioned previously are increased significantly with proline compared to other treatments

Table 4. Fresh and dry weights/plant, leaf area, Relative water content and No. of outer leaves of head lettuce as influenced by irrigation treatments, organic fertilization and foliar application in first and second seasons.

Treatments	Fresh weight (g/plant)		Dry weight (g/plant)		Leaf area (cm^2)		Relative water content (%)		No. of outer leaves	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
A- Irrigation treatments										
100 %	1281.2 a	1278.7 a	187.1a	189.2 a	2427a	2457a	90.2a	91.26 a	9.55a	10.50 a
75 %	1059.8 b	1078.2 b	165.1b	166.9 b	2194b	2222b	86.9b	87.87 b	7.94b	8.83 b
50 %	857.3 c	935.7 c	137.9c	139.7 c	1911c	1938c	82.9c	83.98 c	6.05c	6.72 c
F. test	*	*	*	*	*	*	*	*	*	*
B- Organic fertilization										
Compost	1179.0 a	1198.3 a	177.7 a	179.7 a	2322a	2352a	88.9a	89.87 a	8.81a	9.77 a
Without	953.3 b	996.8 b	149.0 b	150.8 b	2032b	2059b	84.5b	85.5b	6.88b	7.59 b
F. test	*	*	*	*	*	*	*	*	*	*
C- Foliar application treatments										
Tap water	967.8 c	1031.8 c	153.3 c	155.2 c	2073c	2100c	85.19 c	86.22 c	7.00 c	7.77 c
Melatonin	1086.5 b	1119.5 b	165.8 b	167.7 b	2201b	2229b	87.09 b	88.07 b	8.11 b	9.05 b
Proline	1144.1 a	1141.4 a	171.1 a	172.8 a	2257a	2288a	87.86 a	88.83 a	8.44 a	9.22 a
F. test	*	*	*	*	*	*	*	*	*	*
D- Interactions (F. test)										
A × B	*	*	*	*	*	*	*	*	NS	NS
A × C	*	*	*	*	*	*	NS	NS	NS	NS
B × C	*	*	*	*	*	*	*	*	*	*
A × B × C	*	*	*	*	NS	NS	*	*	*	NS

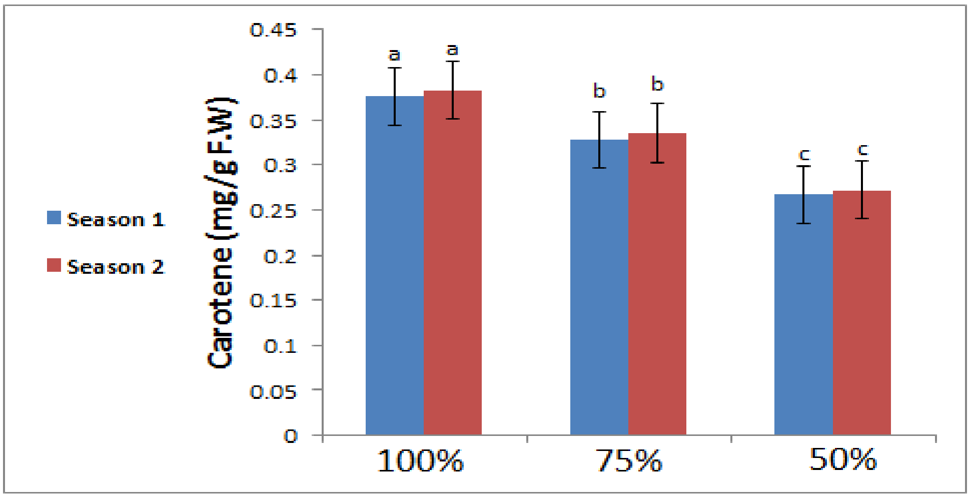

Fig. 2. Effect of water stress on carotene content of head lettuce in two seasons.

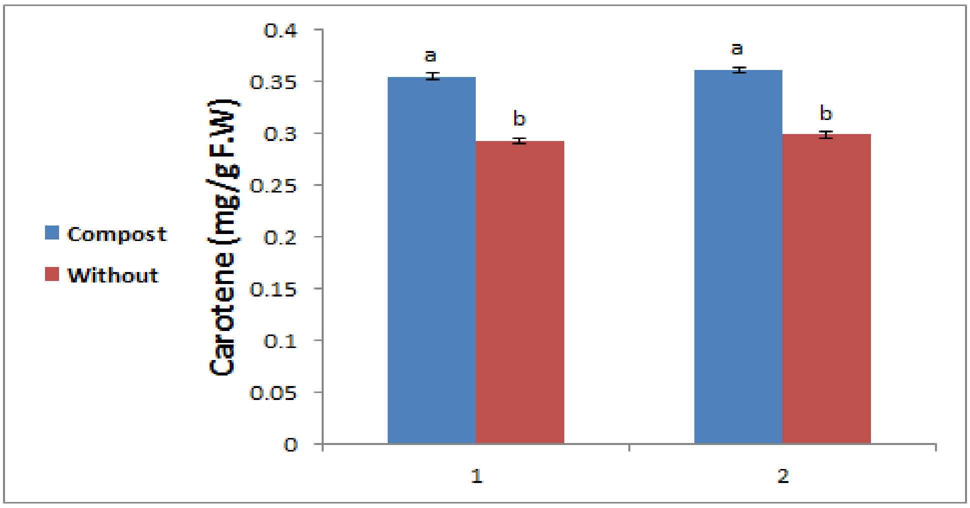

Fig. 3. Effect of vermicompost on carotene content of head lettuce in two seasons.

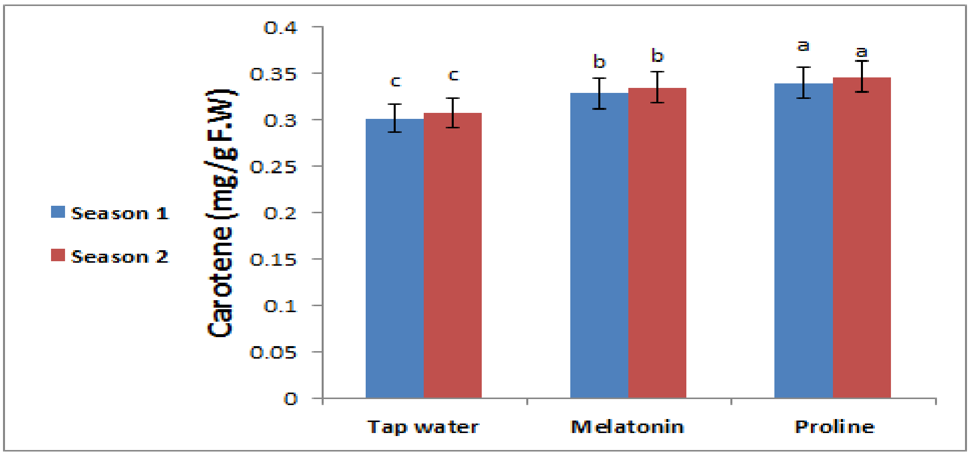

Fig. 4. Effect of proline and melatonin on carotene content of head lettuce in two seasons.

Table 5. Chlorophyll a, chlorophyll b contents in head lettuce leaves as influenced by irrigation treatments, organic fertilization and foliar application at first and second seasons.

Treatments	Chlorophyll a (mg/g F.W)		Chlorophyll b (mg/g F.W)	
	1st	2nd	1st	2nd
A- Irrigation treatments				
100 %	0.934 a	0.948 a	0.454 a	0.463 a
75 %	0.873 b	0.893 b	0.431 b	0.440 b
50 %	0.803 c	0.821 c	0.399 c	0.407 c
F. test	*	*	*	*
B- Organic fertilization				
Compost	0.908 a	0.925 a	0.443 a	0.452 a
Without	0.832 b	0.849 b	0.413 b	0.421 b
F. test	*	*	*	*
C- Foliar application treatments				
Tap water	0.844 c	0.861 c	0.416 c	0.423 c
Melatonin	0.877 b	0.895 b	0.431 b	0.441 b
Proline	0.889 a	0.906 a	0.437 a	0.446 a
F. test	*	*	*	*
D- Interactions (F. test)				
A × B	*	*	*	*
A × C	NS	NS	NS	NS
B × C	*	*	*	*
A × B × C	*	NS	*	*

3.2 Yield and its components

Averages of yield parameters in the plant at harvest, *i.e.*, head height, head diameter, head weight and total yield of head lettuce were significantly affected by organic fertilization and foliar spray under water stress during 2020/2021 and 2021/2022 seasons (Table 6). Data shows that the maximum means of previous measurements of head lettuce are recorded by irrigation head lettuce plants full irrigation (100%) compared to other treatments.

Table 6. Head height and head diameter of head lettuce as affected by the interaction among irrigation treatments, organic fertilization and foliar application treatments during first and second seasons.

Treatments	Total yield (ton/fed)		Head height (cm)		Head diameter (cm)		Head weight (g)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
A- Irrigation treatments								
100 %	19.27 a	19.22 a	22.58 a	23.37 a	22.60 a	23.39 a	1083.1 a	1081.5 a
75 %	15.31 b	15.97 b	21.08 b	21.79 b	21.01 b	21.76 b	860.3 b	898.7 b
50 %	11.56 c	13.17 c	19.19 c	19.85 c	19.06 c	19.71 c	649.6 c	740.8 c
F. test	*	*	*	*	*	*	*	*
B- Organic fertilization								
Vermicompost	17.44 a	17.99 a	21.94 a	22.68 a	21.93 a	22.71 a	980.1 a	1012.3 a
Without	13.32 b	14.25 b	19.96 b	20.66 b	19.85 b	20.53 b	748.6 b	801.7 b
F. test	*	*	*	*	*	*	*	*
C- Foliar application treatments								
Tap water	13.62 c	14.83 c	20.18 c	20.89 c	20.18 c	20.93 c	765.4 c	834.3 c
Melatonin	15.75 b	16.54 b	21.16 b	21.85 b	21.06 b	21.82 b	885.1 b	930.3 b
Proline	16.77 a	17.00 a	21.51 a	22.26 a	21.42 a	22.11 a	942.6 a	956.3 a
F. test	*	*	*	*	*	*	*	*
D- Interactions (F. test)								
A ×B	*	*	*	*	*	NS	*	*
A ×C	*	*	*	*	*	NS	*	*
B ×C	*	*	*	*	*	*	*	*
A ×B ×C	*	*	*	*	*	NS	*	*

However, the obtained results present in Table 5 indicate that the parameters mentioned previously are increased significantly with vermicompost addition compared to untreated head lettuce plants**.** Data in the same table reveal that the parameters mentioned previously are improved significantly with proline compared to other treatments, followed by melatonin.

3.3 Heads quality

Means of heads quality parameters *i.e.*, total dissolved solids (TDS), total carbohydrates, crude protein, total sugar, crude fibers percentages, vitamin C, vitamin E, nitrate (NO_3), nitrite (NO_2), proline, super oxidase dismutase, peroxidase and catalyse contents in head lettuce at harvest were significantly affected by water stress, organic fertilization as vermicompost addition and foliar spray with tap water, melatonin, and proline as well as their interactions during 2020/2021 and 2021/2022 seasons (Tables 7, 8,9 and 10).

The maximum means of these characters are recorded by irrigation head lettuce plants full irrigation (100%) in both seasons, except, proline, super oxidase dismutase, peroxidase and catalyse contents in head lettuce, which resulted under the influence of water stress (50% of full irrigation) in both seasons. It can be seen that the highest values of quality in head lettuce are formed with vermicompost addition compared to untreated head lettuce plants (without vermicompost) in both seasons, except, nitrate (NO_3), nitrite (NO_2), proline, super oxidase dismutase, peroxidase and catalyse contents in head lettuce, which produced from untreated head lettuce plants (without vermicompost) in the two seasons. The statistical analysis of the collected data on the subject of quality parameters in head lettuce plants Tables (7-10) reveal that the parameters mentioned previously are increased significantly with proline compared to other treatments, except, super oxidase dismutase, peroxidase and catalyse contents in both seasons.

Table 7. Crude protein, total sugars, crude fiber, total soluble solids (TSS) and total carbohydrates percentages of head lettuce as influenced by irrigation treatments, organic fertilization and foliar application at first and second seasons.

Treatments	Crude protein (%)		Total sugars (%)		Crude fibres (%)		TSS (%)		Total carbohydrates (%)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
A- Irrigation treatments										
100 %	2.14 a	2.19 a	0.91 a	1.01 a	1.63 a	1.69 a	6.20 a	6.30 a	3.04 a	3.09 a
75 %	1.88 b	1.91 b	0.69b	0.77 b	1.33 b	1.37 b	5.48 b	5.57 b	2.73 b	2.77 b
50 %	1.59 c	1.62 c	0.44 c	0.49 c	0.95 c	0.99 c	4.46 c	4.52 c	2.36 c	2.39 c
F. test	*	*	*	*	*	*	*	*	*	*
B- Organic fertilization										
Compost	2.03 a	2.07 a	0.82 a	0.91 a	1.49 a	1.54 a	5.89 a	5.98 a	2.91 a	2.96 a
Without	1.71 b	1.74 b	0.54b	0.60 b	1.11 b	1.15 b	4.87 b	4.94 b	2.51 b	2.54 b
F. test	*	*	*	*	*	*	*	*	*	*
C- Foliar application treatments										
Tap water	1.76 c	1.79 c	0.58 c	0.65 c	1.17 c	1.22 c	5.04 c	5.11 c	2.56 c	2.61 c
Melatonin	1.90 b	1.94 b	0.71 b	0.78 b	1.34 b	1.38 b	5.45 b	5.54 b	2.75 b	2.78 b
Proline	1.96 a	1.99 a	0.75 a	0.84 a	1.40 a	1.45 a	5.65 a	5.75 a	2.82 a	2.86 a
F. test	*	*	*	*	*	*	*	*	*	*
D- Interactions (F. test)										
A × B	*	*	*	*	*	*	*	*	*	*
A × C	NS	NS	NS	*	*	*	*	*	*	NS
B × C	*	*	*	*	*	*	*	*	*	*
A × B × C	*	*	*	NS	*	*	*	*	*	*

Table 8. Vitamin C and vitamin E contents of head lettuce as influenced by irrigation treatments, organic fertilization and foliar application at first and second seasons.

Treatments	Vitamin C (mg/100 g)		Vitamin E (mg/100 g)	
	1st	2nd	1st	2nd
A- Irrigation treatments				
100 %	3.72 a	3.79 a	4.24 a	4.30 a
75 %	3.20 b	3.26 b	3.52 b	3.56 b
50 %	2.59 c	2.63 c	2.69 c	2.72 c
F. test	*	*	*	*
B- Organic fertilization				
Vermicompost	3.50 a	3.58 a	3.93 a	3.99 a
Without	2.84 b	2.88 b	3.03 b	3.07 b
F. test	*	*	*	*
C- Foliar application treatments				
Tap water	2.93 c	2.98 c	3.16 c	3.21 c
Melatonin	3.23 b	3.28 b	3.55 b	3.60 b
Proline	3.35 a	3.41 a	3.73 a	3.78 a
F. test	*	*	*	*
D- Interactions (F. test)				
A × B	*	*	*	*
A × C	*	*	*	*
B × C	*	*	*	*
A × B × C	*	*	*	*

Table 9. Nitrate (NO_3-N), nitrite (NO_2-N) and proline contents of head lettuce as influenced by irrigation treatments, organic fertilization and foliar application at first and second seasons.

Treatments	NO_3-N (ppm)		NO_2-N (ppm)		Proline (µg/g FW)	
	1st	2nd	1st	2nd	1st	2nd
A- Irrigation treatments						
100 %	774.1 a	783.6 a	2.90 a	2.94 a	10.80 c	11.05 c
75 %	661.9 b	671.2 b	2.27 b	2.31 b	14.81 b	15.04 b
50 %	549.3 c	555.5 c	1.53 c	1.55 c	17.62 a	18.03 a
F. test	*	*	*	*	*	*
B- Organic fertilization						
Vermicompost	631.8 b	640.4 b	2.09 b	2.12 b	14.12 b	14.42 b
Without	691.7 a	699.7 a	2.38 a	2.42 a	14.71 a	14.99 a
F. test	*	*	*	*	*	*
C- Foliar application treatments						
Tap water	641.9 c	650.1 c	2.13 c	2.16 c	14.40 a	14.70 a
Melatonin	662.7 b	670.6 b	2.23 b	2.26 b	12.77 b	13.04 b
Proline	680.7 a	689.6 a	2.34 a	2.38 a	16.06 c	16.38 c
F. test	*	*	*	*	*	*
D- Interactions (F. test)						
A × B	NS	NS	NS	*	*	NS
A × C	NS	NS	NS	*	NS	*
B × C	*	*	*	NS	*	NS
A × B × C	*	*	*	*	*	*

Table 10. Super oxidase dismutase, peroxidase and catalyse contents of head lettuce as influenced by irrigation treatments, organic fertilization and foliar application at first and second seasons.

Treatments	Super oxidase dismutase (Activity Unit $min^{-1}g^{-1}$)		Peroxidase (Activity Unit $min^{-1}g^{-1}$)		Catalyse (Activity Unit $min^{-1}g^{-1}$)	
	1st	2nd	1st	2nd	1st	2nd
A- Irrigation treatments						
100 %	202.0 c	209.4 c	0.442 c	0.450 c	35.16 c	35.55 c
75 %	239.2 b	247.6 b	0.614 b	0.629 b	42.81 b	43.27 b
50 %	284.6 a	294.6 a	0.824 a	0.841 a	52.10 a	52.79 a
F. test	*	*	*	*	*	*
B- Organic fertilization						
Vermicompost	217.6 b	225.2 b	0.514 b	0.524 b	38.44 b	38.87 b
Without	266.3 a	275.8 a	0.739 a	0.756 a	48.27 a	48.87 a
F. test	*	*	*	*	*	*
C- Foliar application treatments						
Tap water	259.3 a	268.7 a	0.706 a	0.721 a	46.78 a	47.40 a
Melatonin	237.5 b	245.3 b	0.607 b	0.619 b	42.50 b	42.98 b
Proline	229.0 c	237.6 c	0.568 c	0.580 c	40.78 c	41.23 c
F. test	*	*	*	*	*	*
D- Interactions (F. test)						
A × B	*	*	*	*	*	*
A × C	*	*	*	*	*	*
B × C	*	*	*	*	*	*
A × B × C	*	*	*	*	*	*

4. Discussion

Leafy vegetables including lettuce are highly affected by water stress. Here, vermicompost as soil addition as well as foliar application of melatonine and proline were applied to improve the growth, yield and quality of head lettuce grown under water stress. The increases in vegetative growth traits of head lettuce due to full irrigation (100%) may be attributed to the fact that conserve more water around roots, which created favorable conditions for plant roots to absorb the necessary amount of water and the accessible mineral components. The osmotic process transports water from the soil to the roots by dissolving it when the roots osmotic absorption force is greater than that of the soil's solution. The amount of water in the soil and the amount absorbed by the roots are directly related to one another. Lack of water around the roots of the plant reduced the amount of dissolved nutrients, which in turn reduced the amount of nutrients absorbed. It also slowed down the rate at which the solution moved through the plant tissue, which reduced enzematic activities and the ability of the plant to produce dry matter and chlorophyll a, b, and chlorophylls (a+b), which was reflected in the low size of plant growth indicated by the aforementioned measurements. These results are in agreement with the direction of previous studies by **Metwaly and El-Shatoury (2017a)** on cabbage **Metwaly and El-Shatoury (2017b)** on potato, **El-Sayed *et al.* (2019)** on sweet pepper and **Zaki and Radwan (2022)** on potato.

Vermicompost improves soil aeration, biodiversity, drainage, and water retention in addition to boosting soil aeration. Additionally, Vermicompost is added to soil to improve its ability to retain water and to make certain micronutrients more readily available to plant roots. These micronutrients are critical for the synthesis of amino acids and growth regulators, nucleic acid, cell wall, enzymes, and other compounds, as well as it facilitates sugar mobilization in plants, that enhance chlorophyll a, b, and chlorophylls (a+b). It had a beneficial influence on the efficiency of the photosynthetic process and thus boosted the generation of dry matter. It also affected cell development and elongation that finally affected in plants. These results similar to those mentioned by **Pathma and Sakthivel (2012)** on vermicompost, **Frasetya *et al.* (2019)** on lettuce and **Doklega and Imryed (2020)** on head lettuce.

Proline improved plant growth through its affinity for hydrogen bonding, proline can promote protein stability and preserve membrane integrity, and it is also possible that it scavenged the reactive (ROS) which destroy cells under conditions of water sress. It is one of the best osmoprotectants for reducing plant stress. Additionally, protect cells by increasing their capacity to absorb water and activating enzymes. It is also regarded as a powerful ROS scavenger and antioxidative defence molecule. While, melatonin protects the photosynthetic system by increasing the effectiveness of ROS scavengers and reducing oxidative damage brought on by dryness. It is a natural substance that both plants and animals contain. Melatonin is crucial for protecting plants from a lack of water. Through controlling stomatal motion, preserving the integrity of cell membranes, lowering cytotoxic biochemical cellular indicators like H_2O_2 and MDA, and enhancing antioxidant enzyme activities, melatonin helps sustain the water status of plants during droughts. Melatonin limits the negative effects of drought stress by regulating the creation and function of essential organic chemical substances, particularly chlorophyll, proteins, and molecules connected to nitrogen. These results are in an agreement with those mentioned by **Kahlaoui *et al.* (2013), Sharma and Zheng (2019)** and **Hossain *et al.* (2019).**

5. Conclusion

Current results show that water stress (75% of full irrigation) plus vermicompost and foliar spray with proline gave superiority in vegetative growth, photosynthetic pigments, head yield and quality compared with plants had full irrigation without vermicompost and foliar spray with tap water treatments. These results suggest that possible improvements in leaf yield and quality of head lettuce under water stress through application of proline, melatonin and vermicompost.

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