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Article

Nano Green Manganese and its Impact on the Growth, Yield and Fruit Properties of Flame Seedless Grapes

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Abstract: Two experiments were conducted to develop a Nano green manganese and assess its effect on grapevines. The first experiment was microbiological, where several incorporation strategies were utilized to enrich the yeast with manganese, as follows: (1) adding manganese to the liquid medium (growth phase), (2) adding after 24 h of incubation (non-growth phase). As the results, growth phase reduced the possibility of medium contamination. Manganese concentration in the yeast cells was increased as that of manganese sulphate in the medium. Manganese incorporation in yeast cells was 99.93% higher than that of the medium at 0.0195 g/l of manganese. Although the concentration of manganese in the medium raised the OD of yeast cell biomass, manganese sulphate had no passive influence on it. The second experiment was horticultural, done on Flame Seedless grapevines, since both active fresh and frozen yeast enriched with manganese resulted from the first experiment were sprayed twice a year at 10 or 20 cm^3/l comparing with manganese sulphate, and manganese chelate. The results demonstrated that yeast extracts in both forms increased the yield and improved fruit properties. The most effective treatment on vegetative growth, yield and fruit properties was the frozen yeast enriched with manganese at 20 cm^3/l.

Keywords: nano green manganese; *Saccharomyces cerevisiae*; bio fertilizer; flame seedless grape; leaf mineral content; yield; fruit properties

1. Introduction

Grapes (*Vitis vinifera*, L.) are one of the world's most popular and preferred fruit crops, since it is the world's fourth crop after citrus, apples, and bananas. Spain is the world's greatest grape producer, followed by France and Italy. In Egypt, grape is regarded as one of the most important fruit crops, coming as second after citrus. Minya governorate leads the Egypt's grape production, followed by Dakahlia and EL-Gharbia. Because of its high net return, the planted area has risen significantly over the last two decades and reached about 172.533 feddan that produced 1586342 tons [1].

Chemical fertilizers that applied in excess have an adverse effect on ground water and cause eutrophication in aquatic environments. More focus has recently been placed on less expensive, safer, and more natural additives. Due to its nontoxicity, nutritional value, and ease of application, yeast has recently gained a lot of attention in the academic community. It is a type of soluble powder or paste that is created from fresh yeast that has a high level of biological activity, or brewer's yeast.

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Additionally, yeast extract has a wealth of beneficial components, including trace elements, amino acids, nucleotides, peptides, nitrogen, and low-molecular-weight organic materials. Furthermore, it has no harmful chemicals or chemically produced hormones [2]. Both the yield and quality of needle mushrooms may be enhanced by yeast extract. Many vegetable crops showed considerable improvements in vegetative growth, yield, and quality when yeast was applied [3,7]. Vegetables also had higher elemental contents, including N, P, K, Fe, and Zn [8].

Numerous elements, such as climate, irrigation, mineral nutrition, and vineyard maintenance, affect the grape output and quality. Also, managing nutrients effectively is essential to raise the output. Micronutrients particularly play a critical role in the growth and output of vines.

Manganese is a crucial microelement for the formation of chlorophyll, it has a clear effect on the metabolism of nitrogen, and the aqueous reactions involved in photosynthesis. It is crucial for the processes of reproduction, pollination, meristematic tissue cell division, vascular tissue repair, metabolism, and transfer of carbohydrates [9].

Recently, nanotechnology has been applied to various fields, including agriculture. The term "nanomaterial" is defined as "a natural, incidental, or manufactured material containing particles, in an unbound state or as an aggregate or as an agglomerate and where, for 50% or more of the particles in the number size distribution, one or more external dimensions is in the size range 1-100 nm" in the "Recommendation on the definition of a nanomaterial" adopted by the European Commission [10], these materials' characteristics differ from those of micrometric or larger-sized materials because of their size. Also, have variations in electrical conductivity, chemical reactivity, and physical strength. Crop management may benefit greatly from the advancement of nanotechnology [11].

The effects of nanostructured materials on plant germination and growth in recent years have been examined by many researchers. For instance, it is believed that certain plants produce more biomass and have a significantly higher germination rate because of the penetration of nanostructured materials into seeds [12]. Foliar spray of almonds with Nano-chelate super plus (zinc, iron, and manganese) improved a variety of nut characteristics, including the yield, nut length, width, and fresh and dry weight. Further, the concentration of micro elements (Zn, Fe, Cu, and Mn) in the leaves increased significantly across all treatments [13].

Many of biotic resources have been designed to leverage with them, such as algae, fungus, bacteria, and plant extracts, for the biogenesis production of metal/metal oxide nanoparticles. When compared to the methods that rely on yeast and bacteria for assistance, the use of plant extract is one of the most straightforward and straightforward eco-friendly methods for producing M/MO NPs in large quantities. Many kinds of naturally occurring bio-extracts from bacteria, yeast, and fungus have been used as effective sources for the manufacture of M/MO NPs (known as Nano green products). It has been demonstrated that the best stabilizing, capping, and reducing agent for the synthesis of regulated M/MO NPs is plant bio-extract. Techniques for biologic synthesis are highly helpful in controlling all properties, including shapes, sizes, structures, and other distinguishing qualities [14].

2. Material and Methods

2.1. First: The Microbiological Experiment

2.1.1. Microbial Sample

This study used an Egyptian *Saccharomyces cerevisiae* sample that was received from the National Research Center's Microbial Biotechnology Laboratory. As a growth medium, peptone, glucose, and yeast extract were utilized (YEPD).

2.1.2. Enrichment of Yeast with Manganese Sulphate

Several incorporation procedures were employed in this work to enrich yeast with manganese, including the following: (1) In the initial process, manganese was added to the liquid medium just after the yeast was inoculated (growth phase). (2) After a 24-hour incubation period (the non-growth phase), it was inserted for integration in the second process [15].

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After sterilizing one liter of YEPD media, 200 ml of it was split among four conical flasks and aseptically inoculated. By dissolving 500 mg of powdered manganese sulphate in 100 ml of distilled water, a manganese sulphate solution was created. Each of the four conical flasks received varying quantities of manganese sulphate solution, with concentrations of 0.0195 g/l, 0.143 g/l, 0.2 g/l, and 0.4 g/l, sequentially. The flasks were then placed in an incubator/shaker and maintained at 30°C and 120 rpm. After a 24-hour period, the dry weight, absorbance, and total manganese concentration of the yeast samples were determined.

2.1.3. Biomass Concentration Determination

Spectronic Instruments, USA created a UV Spectrophotometer that was used to measure the biomass concentration at 620 nm. 30 milliliters of a 1:1 nitric acid solution (15 milliliters of concentrated nitric acid plus 15 milliliters of Millipore water) were used to dissolve 1.0 gram of manganese metal for use in an atomic absorption spectrophotometer. The manganese metal was entirely dissolved in this solution when it was heated to 60 °C for ten minutes. The solution was cooled and filled a 1000 ml volumetric flask with Millipore water.

2.1.4. Manganese Level in Yeast Cells Determination

Using an Atomic Absorption Spectrophotometer (AAS) (Shimadzu Scientific Instrument Inc., USA), the amount of manganese in yeast cells was measured. An adapted version of Demirci and Pometto's [16] methodology was utilized to prepare samples for Atomic Absorption Spectroscopy (AAS). After centrifuging the yeast sample for 15 minutes at 10,000 rpm and 4°C. The supernatant was then removed. To remove all of the growth media that had adsorbed on the surface, the cells were washed three times with 0.9% saline water. A 300 ml Kjeldahl flask was filled with 0.1 g of dried yeast. After adding 5.0 ml of concentrated nitric acid to the dry material, it was heated to 160 °C until the violent reaction subsided. After adding 2.0 ml of concentrated sulfuric acid and continuing to boil the mixture, concentrated nitric acid was gradually added until the mixture was colorless. The heating procedure was continued until a dense sulfuric acid fume was produced. After cooling, the contents were filtered into a volumetric flask of 50 milliliters and the proper volume was adjusted by adding distilled water. Using a Flame Atomic Absorption Spectrophotometer, the sample's absorbance was determined at 213.9 nm.

2.2. Second: The Horticultural Experiment

Two seasons in consecutive years were used for this study on Flame Seedless grapes (*Vitis vinifera* L.). Grapevines were approximately ten years old, they were planted 1.5 by 3.5 meters apart under a flood irrigation system, trained using a bilateral horizontal cordon system, and had spur pruning (each with 2-3 eyes) at an individual grove, at Sammnod region, Gharbiya governorate, Egypt.

To ascertain the physical and chemical characteristics, soil samples were extracted from the soil at two depths: 0–30 and 30–60 cm below the soil's surface.

Results of the soil analysis (Table 1) indicate that, the texture of the soil was loamy, EC ranged from 0.4 to 0.5 ds/m, pH was 8.4, and $CaCO_3$ ranged between 1.2- 2.0%. Accordingly, the soil in this location is loamy, none saline and none calcareous.

Table 1. The experimental soil's chemical and physical characteristics.

Physical analysis								
Soil depth	Sand %	Silt %	Clay%	Texture	pH	EC ds/m	$CaCO_3$%	Organic matter%
0 – 30 cm	10.8	44	45.2	loamy	8.4	0.5	1.2	1.6
30 – 60 cm	12.8	44	43.2	loamy	8.4	0.4	2.0	1.1
Chemical analysis								

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Soil depth	N %	P%	K %	Ca%	Mg%	Fe ppm	Zn ppm	Mn ppm
0 – 30 cm	0.13	0.6	0.9	4.2	1.1	7.8	3.4	3.2
30 – 60 cm	0.10	0.6	0.6	3.4	0.9	5.5	2.4	1.8

Three replicates were implemented in a randomized complete block design (RCBD) to set up the experiment. Treatments were applied as foliar spray twice in each season, the 1st was carried out before pollination and the 2nd was done three weeks after pollination as follows:

2.2.1. Treatments

T1: Manganese Sulphate at 2.0 g/l (as control).

T2: Manganese chelate 12 % w.w (amino and organic acids) at 2.0 g/l (as farm traditional application).

T3: Active fresh yeast enriched with manganese at 10 cm^3/l.

T4: Active fresh yeast enriched with manganese at 20 cm^3/l.

T5: Frozen yeast enriched with manganese at 10 cm^3/l.

T6: Frozen yeast enriched with manganese at 20 cm^3/l.

2.2.2. Measurements

Vegetative Measurements

Using a planimeter, the average leaf area (cm^2) of each vine was determined in mid-July by measuring the fifth fully developed mature leaf from the stem tip. The diameter and average shoot length were calculated in centimeters. The number of leaves and shoots was counted.

Chemical Determinations

Leaf total chlorophyll:

By applying a Minolta chlorophyll meter (spad, 501), the total chlorophyll in leaves was measured in fresh leaf samples as spad units (spad = 100 mg chlorophyll/g fresh weight).

Leaf mineral content

In order to ascertain the mineral contents of the leaves, samples of twenty leaves, comprising the blade and petiole (the sixth leaf from the shoot tip) of each vine, were taken later in July. Following a 60–70°C oven drying period, leaves were cleaned with distilled water and allowed to reach a consistent weight. According to Jackson's approach [17], 0.2 grams of each sample's ground material was digested using a mixture of perchloric acid and sulphoric acid 1:10 (v/v) after the dried samples were ground in a stainless steel knife mill. Using the Cottenie method [18], the percentages of dry weight for nitrogen, phosphorus, and potassium were calculated. Using the atomic absorption apparatus, iron, zinc, and manganese were quantified in parts per million using the Cottenie method [18].

Yield and Fruit Quality

1. Yield/vine (kg)

Cluster numbers on each vine were totaled and weighed in order to estimate the total yield per vine (kg). The crop was picked at the ripening stage when TSS % reached 16% and color covered all bunch berries.

2. Fruit properties

2.1. Physical properties

The weight of 100 berries (g), their juice weight (g), their average cluster dimension (length and width in cm), and their average cluster weight (g) were measured.

2.2. Chemical properties

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Using a hand refractometer, the total soluble solids percentage (TSS %) in berry juice was calculated, and the total titratable acidity percentage was reported as tartaric acid /100 ml of juice [19].

2.2.3. Statistical Analysis

Analysis of variance was performed on all the data in accordance with Snedecor and Cochran [20]. Statistically, the least significant difference (LSD) test was used to analyze significant differences between means at $p \leq 0.05$ [21]. The Co-stat program was used to do the statistical analysis.

3. Results

3.1. The Microbiological Experiment

In this work, two distinct strategies for enriching yeast with manganese as a trace element were used. Manganese was supplied to the liquid medium immediately after the yeast was inoculated (growth phase) in the first approach, and after 24h of incubation (non-growth phase) in the second method for integration. Figure 1 illustrates manganese content in yeast cells during growth and static phases with varying manganese sulphate concentrations in the culture medium. The results indicate that when the amount of manganese sulfate in the medium grew, so did the amount of manganese in yeast cells. Manganese accumulation in yeast cells was 99.93% higher at 0.4 g/l of manganese concentration throughout the media than it was at 0.0195 g/l of manganese concentration (Figure 1).

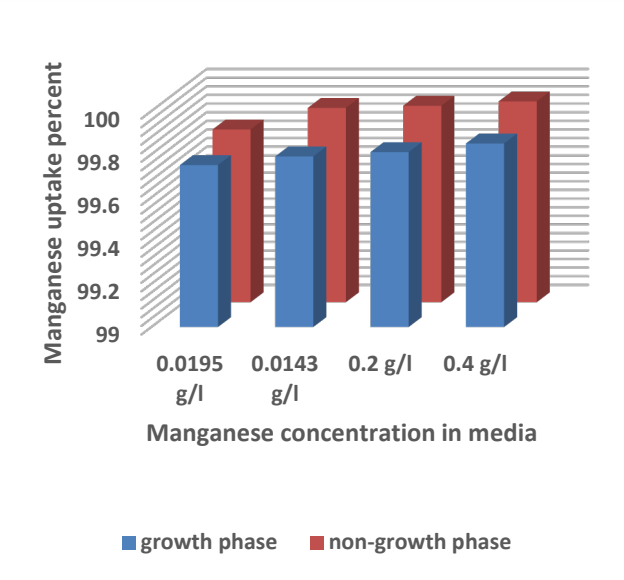

Figure 1. Effect of different methods for enrichment yeast with manganese.

Effect of manganese on the yeast cell growth biomass was calculated using a UV spectrophotometer to measure manganese absorbance. Figure 2 depicts the influence of manganese on yeast cell development. As demonstrated in the figure, the OD of manganese sulphate alone was not changed, however, the OD of yeast cell biomass was increased due to manganese concentration in the medium.

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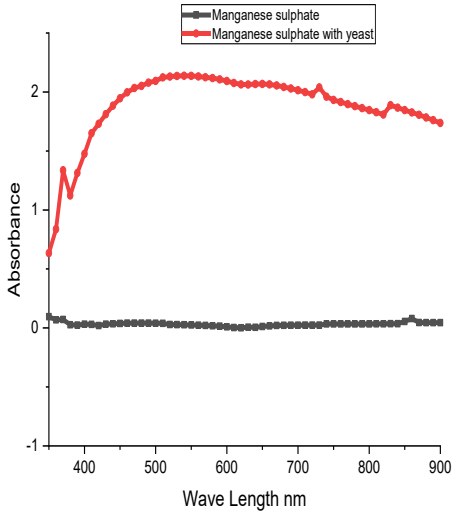

Figure 2. Effect of manganese sulphate on the yeast cell growth.

3.2. Horticultural Experiment

The results presented in Table 2 indicate that the highest significant values of nitrogen (2.20 & 2.42%) in the leaves were reflected due to the frozen yeast enriched with Mn at 20 cm^3/l as foliar spray followed by 10 cm^3/l of the same treatment in both seasons, while, the lowest values of nitrogen (1.33 & 1.55%) were recorded from manganese sulphate treatment (control) as foliar spray in the two seasons. Regarding phosphorous percentage in the leaves, there were no significant differences among the treatments in the two experimental seasons. As for potassium percentage in the leaves, it is clear that spraying active fresh yeast at 20 cm^3/l had a positive effect and recorded the highest values (2.18 & 2.40%) in the two seasons followed without significance with the frozen yeast at 20 cm^3/l. The lowest values of potassium in the leaves (1.03 & 1.25%) were observed due to spraying manganese sulphate at 2.0 g/l. This was true in the two successive seasons.

Table 2. Effect of active fresh and frozen yeast enriched with manganese on N, P and K percentage in the leaves of Flame Seedless grapes.

Treatment	N%		P%		K%	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
T1	1.33f	1.55f	0.40a	0.62a	1.03d	1.25d
T2	1.47e	1.69e	0.48a	0.70a	1.13c	1.33c
T3	1.73d	1.95d	0.30a	0.52a	1.94b	2.16b
T4	1.87c	2.09c	0.32a	0.54a	2.18a	2.40a
T5	1.98b	2.20b	0.38a	0.60a	1.98b	2.20b
T6	2.20a	2.42a	0.40a	0.62a	2.13a	2.35a

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The results tabulated in Table 3 indicate that the frozen yeast extract enriched with manganese at the rate of 20 cm^3/l gave the highest values of Fe, Zn and Mn, since this treatment recorded the highest significant values of Fe (107.0 & 109.3 ppm), Zn (55.80 & 56.92 ppm) and Mn (49.53 & 50.65 ppm) in both seasons. Meanwhile, the lowest values of Fe (99.7& 101.0 ppm), Zn (29.50 & 30.62 ppm) and Mn (19.73 & 20.85 ppm) were obtained when the grapevines sprayed with manganese sulphate treatment in the two seasons.

Table 3. Effect of active fresh and frozen yeast enriched with manganese on Fe, Zn and Mn ppm in the leaves of Flame Seedless grapes.

Treatment	Fe ppm		Zn ppm		Mn ppm	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
T1	99.7d	101.0d	29.50f	30.62f	19.73f	20.85f
T2	105.0b	106.3b	32.73e	33.85e	22.10e	23.22e
T3	98.8d	99.9d	49.50c	50.62c	41.90d	43.02d
T4	102.0c	103.3c	47.36d	48.48d	44.83c	45.95c
T5	104.0b	105.3b	52.40b	53.52b	47.80b	48.92b
T6	107.0a	109.3a	55.80a	56.92a	49.53a	50.65a

The results presented in Table 4 and Figures 3 and 4 show that spraying grapevines with the frozen yeast enriched with Mn at 20 cm^3/l was significantly responsible for motivating the growth parameters such as shoot length, number of leaves per shoot and leaf area compared with the other treatments. Increasing concentration of frozen yeast enriched with Mn in this study was associated with the promotion. The maximum values of shoot length, number of leaves per shoot, leaf area and chlorophyll content were observed on the vines received the frozen yeast enriched with manganese at 20 cm^3/l followed by 10 cm^3/l of the same form in both experimental seasons, while the vines treated with manganese sulphate and manganese chelate as foliar application recorded lower values in both seasons. Regarding shoot diameter, no significant difference was detected among the treatments.

Table 4. Effect of active fresh and frozen yeast enriched with manganese on shoot length, shoot diameter and No. of leaves/shoot of Flame Seedless grapes.

Treatment	Shoot length (cm)		Shoot diameter (mm)		No. of leaves/shoot	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
T1	87.00e	89.03e	0.46a	0.48a	14.66bc	16.01bc
T2	89.00de	91.10de	0.46a	0.47a	14.00c	16.03c
T3	91.00cd	93.23cd	0.43a	0.46a	15.00bc	17.18bc
T4	94.33c	96.35c	0.46a	0.46a	18.00a	20.14a
T5	100.33b	102.43b	0.43a	0.46a	16.00b	18.22b
T6	107.00a	109.01a	0.50a	0.51a	19.33a	21.40a

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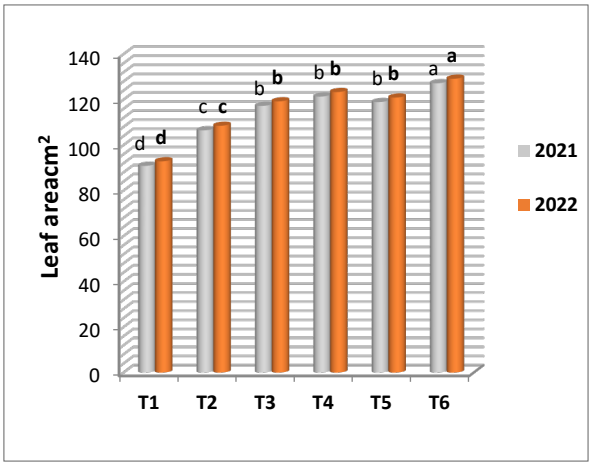

Figure 3. Effect of different treatments on leaf area and chlorophyll content in the two seasons.

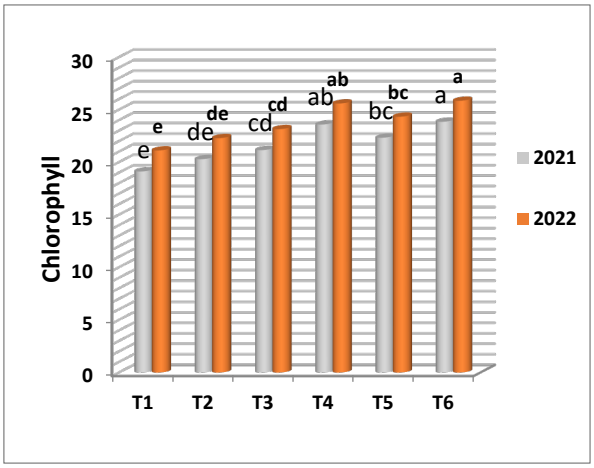

Figure 4. Effect of different treatments on leaf area and chlorophyll content in the two seasons.

The results presented in Table 5 and Figures 5 and 6 illustrate that the highest significant values of cluster number per vine, cluster weight, weight of 100 berries and yield (kg) in the two seasons were obtained from the frozen yeast enriched with manganese at 20 cm^3/l as spraying application. Meanwhile, manganese sulphate (control) recorded the lowest number of clusters per vine, cluster weight, weight of 100 berries and yield per vine in the first and the second seasons.

Table 5. Effect of active fresh and frozen yeast enriched with manganese on number of clusters/vine and cluster weight of Flame Seedless grapes.

Treatment	No. clusters/vine		Cluster weight (g)	
	1st season	2nd season	1st season	2nd season
T1	11.00e	13.05e	343.0c	349.3c
T2	14.00d	16.13d	453.3b	468.3b
T3	14.66cd	16.70cd	473.6b	478.6b
T4	16.33b	18.42b	490.0b	485.0b
T5	15.66bc	17.43bc	476.0b	477.0b
T6	**18.33a**	**21.00a**	**553.0a**	**560.0a**

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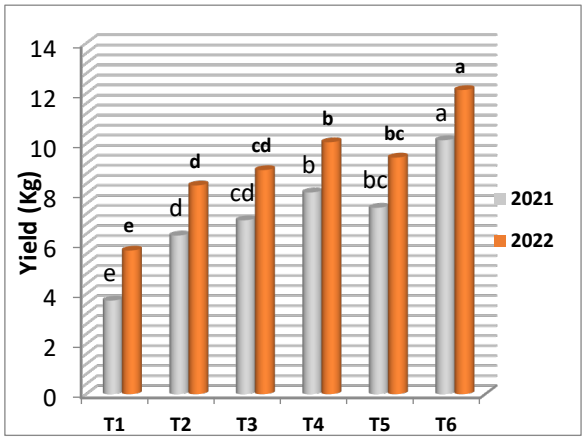

Figure 5. Effect of different treatments on the yield per vine and weight of 100 berries in the two seasons.

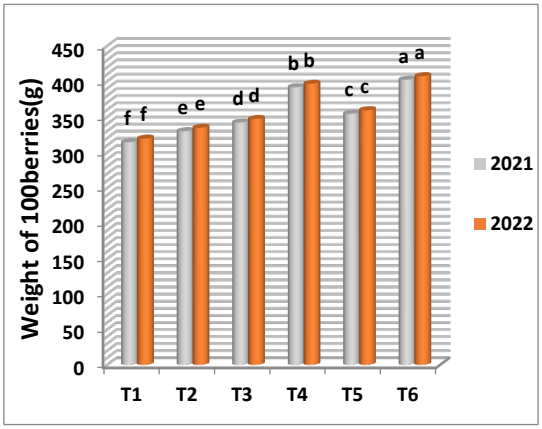

Figure 6. Effect of different treatments on the yield per vine and weight of 100 berries in the two seasons.

The results in Table 6 show that treating Flame Seedless grapevines with that yeast extract enriched with Mn significantly improved cluster length, cluster width and juice weight of 100 berries compared with the other treatments. Spraying frozen yeast extract enriched with manganese at 20 cm^3/l gave the highest values of cluster length, cluster width and juice weight of 100 berries in both experimental seasons. While spraying vines with manganese sulphate recorded the lowest values of cluster length, cluster width and juice weight of 100 berries.

Table 6. Effect of active fresh and frozen yeast enriched with manganese on cluster length, cluster width and juice weight of 100 berries of Flame Seedless grapes.

Treatment	Cluster length (cm)		Cluster width (cm)		Juice wt./100 berries (g)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
T1	17.33c	19.19c	14.61c	16.50c	208.14d	213.17d
T2	21.33b	23.42b	16.18bc	18.16bc	217.55d	225.16d
T3	22.00b	24.17b	16.31abc	18.26abc	235.37c	245.11c
T4	23.00ab	25.01ab	16.74ab	18.83ab	263.53b	271.82b
T5	22.66b	24.84b	16.41ab	18.35ab	244.28c	249.11c
T6	25.00a	27.93a	18.12a	20.10a	278.64a	280.36a

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As shown in Table 7, spraying frozen yeast extract enriched with Mn at 20 cm^3/l scored the highest values of TSS. Regarding acidity, manganese sulphate treatment gave the highest values, while frozen yeast extract enriched with Mn at 20 cm^3/l scored the lowest values in the both seasons with significant difference among the treatments.

Table 7. Effect of active fresh and frozen yeast enriched with manganese on TSS and acidity in the juice of Flame Seedless grapes.

Treatment	TSS %		Acidity %	
	1st season	2nd season	1st season	2nd season
T1	16.80d	17.32d	0.67a	0.70a
T2	17.26cd	18.76cd	0.64a	0.67a
T3	17.73cd	18.59cd	0.58b	0.60b
T4	19.26ab	20.29ab	0.56bc	0.59bc
T5	18.13bc	19.24bc	0.53c	0.54c
T6	20.33a	21.29a	0.53c	0.52c

4. Discussion

Manganese (Mn) is essential for oxidation and reduction activities in the plant like electron transport during photosynthesis. In addition, manganese has a function in the synthesis of chlorophyll and is necessary for photosystem. Manganese is an activating element that activates more than 35 different enzymes [9]. Using fertilizers containing manganese improves the rate at which carbohydrates like starch are synthesized and photosynthesized. A manganese shortage lowers the efficiency of photosynthesis, which lowers agricultural output and quality. This is due to the metabolic function of manganese in the activation of enzymes involved in the metabolism of carbohydrates and nitrate-reducing enzyme activity. Regarding the microbiological experiment, yeasts have been employed as a mean of delivering mineral supplements because of their high protein content and capacity to assimilate metals into their cells. It is well known that yeasts can gather metal ions from aqueous solutions through a variety of physicochemical processes. The concentration of manganese in yeast cells increased as the concentration of manganese sulphate in the medium increased because manganese incorporation in yeast cells was 99.93% higher at 0.4 g/l of manganese concentration in the medium than at 0.0195 g/l of manganese concentration in the medium. Prior research shown that 75 mg l^{-1} $MnSO_4$ was incorporated in yeast cells [22]. The two techniques for manganese enrichment of yeast did not differ significantly from one to another. Therefore, in order to reduce the possibility of medium contamination, the first approach (growth phase) was used. Consequently, the first strategy (growth phase) was selected in order to reduce the possibility of medium contamination. Our findings indicate that while manganese sulfate had no passive influence on yeast cell biomass, the quantity of manganese in the medium enhanced the OD of yeast cell biomass. Regarding this matter, reports have indicated that the ash of yeasts cultivated in diverse substrates often contains a wide range of substances. These findings showed that Cu^{2+} and Mn^{2+} ions induce cell death starting from several millimolar levels [23].

Various amounts of copper, zinc, and manganese sulfate salts were applied to *Saccharomyces cerevsiae* colonies because the cells' vitality decreased and they became inactive from a biological perspective at greater concentrations of microelements [22]. The concentrations of the trace minerals and the method of addition had an impact on the biomass increase. The best outcome of the studies reported in this study was 14 g/l of yeast biomass with an enriched content of accumulated microelements, which included 33.9 mg of manganese, 1143.4 mg of zinc, and 1145.8 mg of copper.

Previous investigations using yeast revealed that certain metals, like copper, caused yeast cells to expand quickly over the course of 13–20 hours, during which time oxygen demand outpaced

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oxygen supply [24]. Therefore, it is possible to draw the conclusion that the medium's composition, which aids in the yeast cells' constant oxygen supply and promotes the growth of the yeast as well as its capacity to incorporate the trace elements from the medium in high concentrations, is primarily responsible for the growth of the yeast in the presence of trace elements.

Concerns over the horticultural experiment's relationship between food safety and human health are growing. In this text, natural sources (compost, seaweed extracts, yeast, etc.) are crucial [25,28]. Farmers are growing more interested in employing natural sources as bio-control agents in agriculture to ensure food safety [29,30]. Comparatively speaking to the other treatments, the effects of spraying frozen yeast enhanced with manganese at a rate of 20 cm^3/l on shoot length and diameter, number of leaves / shoot, leaf area, chlorophyll content, cluster weight, yield, weight of 100 berries, TSS, and leaf mineral content are favorable. Many earlier research papers showed similar conclusions [31,35]. Applying 'Keitte' mango trees with 0.2 percent of yeast spray once had fully blossomed proved to be highly effective in boosting output and its constituents, as well as enhancing fruit quality [31]. By applying algae extracts to sour orange trees twice at 1, 2 and 3% after fruit-set, fruit quality was improved. This was attributed to improvements in fruit length, width, fresh weight, and size as well as in fruit moisture, fruit juice, fruit peel moisture, total soluble solids, ascorbic acid content in juice, and peel thickness [32]. Spraying grapevines with GA3 plus 0.4% active dry yeast obtain heavy and less compact cluster and hasten the ripening with fairly good Flame Seedless berries quality [33]. The application of8% yeast and yeast enriched with zinc on grapes had improved fruit chemical characteristics i.e. soluble solid content and some physical characteristics (cluster width and weight of 100 berries) [34,35].

Crop development is positively impacted by yeast [36,37]. Yeast is a naturally occurring (harmless and nonpolluting) component that contains many of minerals, particularly N, P, and K, also proteins, vitamin B, and natural hormones like cytokinin and IAA. These factors may be connected to the effects of yeast extract. It has been discovered that axeins, hormones, vitamins, chelating agents, and yeast-produced enzymes stimulate cell growth and division, nutrition absorption, protein synthesis, and enhance net photosynthesis [38,39].

5. Conclusions

In the microbiological experiment, the first approach (growth phase) was chosen to lower the possibility of medium contamination, according to the results of several incorporation strategies employed to enrich yeast with manganese. As the quantity of manganese sulfate in the media increased, so did the concentration of manganese in yeast cells. Manganese incorporation in yeast cells was 99.93% higher at 0.4 g/l of manganese concentration in the media than it was at 0.0195 g/l of manganese concentration in the medium. Zinc content in the medium caused an increase in the optical density (OD) of yeast cell biomass, but manganese sulphate had no passive influence on it.

In relation to the horticultural experiment, it can be inferred that spraying frozen yeast enriched with manganese at 20 cm^3/l is the most effective treatment followed by the same form at 10 cm^3/l for improving shoot length, shoot diameter, number of leaves / shoot, leaf area, leaf chlorophyll content, cluster weight, yield per vine, weight of 100 berries, juice weight of 100 berries, TSS%, and leaf mineral content in the two studying seasons. In particular, when applied frozen yeast as foliar spray, it lowers the rate at which manganese fertilizer is utilized to achieve optimal production, hence mitigating the pollution that arises from the use of chemical fertilizers.

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