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RESEARCH ARTICLE

Vermiwash improves of vegetative growth, nutrients status, yield and quality of Red Roomy grapes

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Abstract

The Red Roomy grapevine (*Vitis vinifera* L.) is susceptible to low quality clusters and berries such as shot berries, which negatively affect its marketability. Bio-stimulants, including vermiwash, have been investigated as potential remedies for these issues. This study aimed to evaluate the effects of vermiwash on Red Roomy grapevines grown in Minia Governorate, Egypt, during the 2023 and 2024 growing seasons. Vermiwash was applied at concentrations of 5%, 7.5%, and 10%, either twice or three times during the growing period. The results demonstrated that increasing the application frequency from twice to three times and the concentration from 5% to 10% led to notable improvements in vine growth, leaf nutrient content, yield quantity, and berries quality. However, the additional benefits observed with higher concentrations and application frequencies were generally modest. Based on the findings, applying vermiwash at a concentration of 7.5% three times during the growing season is recommended as the optimal approach for enhancing the yield and quality of Red Roomy grape berries in Minia Governorate, Egypt.

***Keywords*:** Bio-Stimulants, organic fertilization, vermiwash, grapevine, shot berries

1. *Introduction*

Grapevine (*Vitis vinifera* L.) is a major fruit crop worldwide, playing a vital role in agricultural economies and the food industry. Grapevines are grown across diverse climates, including temperate, subtropical, and tropical regions, making them one of the most extensively cultivated fruit crops globally. Grapes are consumed fresh and processed into various products such as wine, raisins, juice, and seed oil, contributing significantly to their economic importance. In Egypt, grapes rank third among fruit crops, following citrus and mangoes. The cultivated area has expanded rapidly, particularly in reclaimed lands, covering approximately 190,486 feddans, with 174,715 feddans being productive and yielding an annual production of around 1,594,782 tons. Grapes are considered one of the most important export horticultural crops in Egypt. They account for 3% of horticultural crop exports and contribute 10% of their total value. Annually, Egypt exports approximately 131,000 tons of grapes, with expectations of increased export quantities in the future (M.A.L.R., 2019). Considerable efforts have been made to enhance grapevine production by addressing production challenges and optimizing horticultural practices.The Red Roomy grapevine cultivar grown in the Minia governorate especially and in Egypt generally faces challenges that negatively impact its local marketability if not solved, such as loose clusters and the presence of shot berries. In the past, traditional methods relying on hazardous chemicals were commonly used to tackle these issues. However, modern approaches now focus on environmentally friendly natural extracts that improve both yield and fruit quality. Among

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these, bio-stimulants like vermiwash have proven effective in enhancing growth, vine nutritional status, yield, and the physical and chemical characteristics of grapes across various grapevine cultivars. Vermiwash, a natural product derived from the vermiwashing of organic matter using a dense population of earthworms, has shown remarkable potential (Aghamohammadi et al., 2016; Thakur and Sood, 2019). This extract, essentially the fluid secreted by earthworms, is rich in enzymes, plant growth hormones, vitamins, and both macro- and micronutrients (Bendalam and Kaviti, 2020). Additionally, it contains beneficial compounds such as sugars, amino acids, phenols, and plant growth-promoting hormones like indole acetic acid and humic acid (Nadana et al., 2020). Vermiwash also harbors beneficial microorganisms that promote plant growth and protect against pests and diseases (Gulsar and Iyer, 2006). It is collected by passing water through layers of earthworm culture units, yielding a liquid rich in nitrogen, growth-promoting hormones, and essential enzymes (Gorakh et al., 2009). These attributes make vermiwash a highly effective nutritive and enzymatic solution for enhancing plant growth.The enzymes present in vermiwash, such as protease, amylase, urease, and phosphatase, are known to support plant growth and productivity. They stimulate crop yield and promote the activities of beneficial microbes like nitrogen-fixing bacteria (e.g., *Azotobacter*, *Agrobacterium*, and *Rhizobium*) and phosphate-solubilizing bacteria (Kaur et al., 2015). Vermiwash has been shown to improve plant growth, nutrient absorption, and overall plant health (Gudeta et al., 2021). Moreover, it has gained popularity as a foliar spray, allowing its nutrients to be efficiently absorbed by leaves, shoots, and other plant parts (Kaur et al., 2015). Studies have demonstrated that foliar application of vermiwash increases shoot and root biomass as well as total dry weight in various plants (Elumalai et al., 2013). However, there is limited research comparing vermiwash with other bio-extracts as foliar fertilizers. This study aims to investigate the effects of vermiwash as a foliar fertilizer on Red Roomy grapevines.

2. Materials and Methods

2.1. Experimental design and plant material

The present study was carried out during the two seasons of 2023 and 2024 on forty-two head trained 15-year old Red Roomy grapevines. The uniform in vigor vines were grown in silty loam soil at 2 × 3 m apart in a private vineyard located at Matai district, Minia Governorate, Egypt. Vines were irrigated with drip irrigation system. In each season, pruning was carried out in the second week of January using the head pruning system. Each vine was pruned to retain a total of 60 buds, consisting of 12 fruiting spurs (each with four buds) and six replacements spurs (each with two buds). Analysis of the soil given in Table 1 was performed according to the procedures of Wilde et al., (1985).

2.2. Vermiwash extract

The vermiwash was prepared according to (Ismail, 2005) as follows. The vermiwash extract was obtained using a vermiwash collection device. This device comprised a 5-liter container equipped with a tap at the bottom. The container's base was layered with approximately 10 cm of gravel, followed by a 2–3 cm layer of sand. Organic waste densely populated with earthworms was added to the container, and fresh water was continuously poured in from the top. The resulting liquid, ranging in color from yellowish to black, was drained through the bottom tap and collected over a two-day extraction period.

The experiment consisted of seven treatments, varying in both the frequency and concentration of Vermiwash applications:

1. **Control:** Sprayed with water.
2. **Vermiwash 5% (twice):** Sprayed at 5% concentration at the beginning of growth and again at the berry-setting stage.
3. **Vermiwash 7.5% (twice):** Sprayed at 7.5% concentration at the beginning of growth and again at the berry-setting stage.

Table 1. Analysis of soil physical and chemical properties

Characters	Values
Sand %	8.4
Silt %	69.2
Clay %	22.4
Texture	Silty loam
pH (1:2.5 suspension)	7.78
E.C. (1:2.5 extract) (mmhos/1cm/25C$^{\circ}$)	0.72
O.M. %	1.92
$CaCO_3$ %	1.46
Total N %	0.13
Available P (Olsen method, ppm)	11
Available K (ammonium acetate, ppm)	532

Table 2. Chemical analysis of vermiwash

Properties	Unit	Vermiwash
pH		7.77
EC (dS m^{-1})	(dS m^{-1})	1.43
Organic mater	%	1.78
N	%	0.70
P	%	0.30
K	%	0.96
Ca	%	0.42
Mg	%	0.11
Fe	mg	170
Mn	mg	81
Cu	mg	70
Zn	mg	40
Total solids	mg/L	2448

4. Vermiwash 10% (twice): Sprayed at 10% concentration at the beginning of growth and again at the berry-setting stage.
5. **Vermiwash 5% (three times):** Sprayed at 5% concentration at the beginning of growth, at the berry-setting stage, and once more one month later.
6. **Vermiwash 7.5% (three times):** Sprayed at 7.5% concentration at the beginning of growth, at the berry-setting stage, and once more one month later.
7. **Vermiwash 10% (three times):** Sprayed at 10% concentration at the beginning of growth, at the berry-setting stage, and once more one month later.

Each treatment was replicated three times, with two vines per replicate. Triton B was added to all solutions at a concentration of 0.02% as a wetting agent. Spraying was performed until the runoff. All selected vines received recommended fertilization and horticultural practices, except for the foliar application of Vermiwash.

2.3. Measurements

The following parameters were measured during the two experimental seasons.

2.3.1. Vegetative growth

Vegetative growth traits such as main shoot length (cm) and total leaf area (m^2) per vine were measured according to Ahmed and Morsy, (1999).

2.3.2. Nutrients analysis

Elements of N, P, K and Mg in leaves were determined according to (Chapman and Pratt, 1965 and Balo et al., 1988).

2.3.3 Berries set %

The berries set percentage was estimated by caging three flower clusters on previous labelled shoots per vine in perforated white paper bags before blooming, thereafter, berry set was calculated as follows:

$$Berries\ set\ \% = \frac{Number\ of\ berries\ per\ cluster}{Total\ number\ of\ flowers\ per\ cluster} x100$$

2.3.4. Harvesting

Harvesting was recorded when the TSS/ acid reached 25/ 1 for the control treatment.

2.3.5. Yield and quality of berries

The following traits were recoded to express yield and quality of berries: (1) Yield expressed in weight (kg) and number of clusters/vines, (2) Weight (g), length and width of cluster (cm), (3)Percentages of shot berries, (4) Physical and chemical characteristics of the berries namely berry weight (g), berry length (cm), berry width (cm), TSS %, total acidity % (as g tartaric acid/100 ml juice), total sugar (A O A C, 2000).

2.4. Statistical analysis

The experimental design for this trial was a randomized completely blocks design (RCBD) with four replications. Data was analyzed with the analysis of variance (ANOVA) procedure of the XLSTAT program version 2020.5: XLSTAT 2020.5.1. Treatments were compared by Duncan's multiple range tests at 5% level of probability in the average of two seasons of study (mean with a different letter(s) are significantly different) (Steel and Torrie, 1980).

3. Results and Discussion

3.1. Effect of vermiwash on the main shoot length, leaf area and percentages of N, P and K in the leaves in Red Roomy grapevine

The data presented in Table 3 clearly show that spraying vermiwash at 5–10% concentration, either twice or three times, significantly enhanced the main shoot length, leaf area, and the percentages of N, P, and K in leaves compared to the untreated control. The stimulating effect increased with higher

frequencies and concentrations. However, no significant differences were observed between the two higher concentrations (7.5% and 10%). The highest values were obtained from vines sprayed three times with vermiwash at 7.5%, while the lowest values were recorded for untreated vines. These trends were consistent across both seasons. The observed effects of Vermiwash on cell division and the biosynthesis of organic compounds likely contributed to improved growth parameters. Additionally, its nutrient content positively impacted root development, enhancing nutrient uptake. Previous studies by Hatti et al. (2010) and Elumalai et al. (2013) also reported similar results, noting that foliar applications of vermiwash improved vegetative growth due to its richness in macro- and micronutrients (Palanichamy et al., 2011; Sundaravadivelan et al., 2011; Quaik et al., 2012; Manyuchi et al., 2013). The positive impacts of vermiwash can be attributed to its high content of sugars, amino acids, phenols, and plant growth-promoting hormones, such as humic acid and indole acetic acid, which stimulate seedling growth and may also act as bio-pesticides.

3.2. Effect of vermiwash on berry set percentage and yield and yield components in Red Roomy grapevine

Data presented in Tables 3 and 4 demonstrate that the percentage of berry setting, number of clusters per vine, yield, cluster weight, cluster length, and cluster width were significantly enhanced by applying Vermiwash two or three times at concentrations of 5–10%, compared to the untreated control. Treating vines three times with vermiwash at 7.5% provided the most economical yield. Under this optimal treatment, the yield in the two seasons reached 8.86 and 10.21 kg per vine, compared to 6.03 and 5.43 kg from untreated vines. However, the treatments did not affect the number of clusters per vine during either season. These findings were consistent across both seasons.The observed improvements in yield and cluster characteristics align with the findings of Palagani and Singh (2017) and Venkataramana et al. (2009), who reported that foliar applications of vermiwash increased yields, potentially due to enhanced chlorophyll and nitrogen content in leaves. vermiwash is rich in vitamins, plant growth-promoting hormones such as auxins and gibberellins, enzymes, symbiotic microbes, macronutrients, micronutrients, and other bioactive substances that collectively contribute to improved plant yield (Karuna et al., 1999; Awadhpersad et al., 2021).

3.3. Effect of vermiwash on the quality of berries in Red Roomy grapevine

Data in Table 5 show that foliar application of vermiwash, applied two or three times at concentrations of 5–10%, significantly improved berry quality. This was evident from increased berry weight, length, and width, as well as higher total soluble solids (TSS) and total sugars. Additionally, there was a reduction in shot berries (%) and total acidity compared to the untreated control. The improvements in berry quality were positively correlated with increased application frequency (from twice to three times) and concentration (from 5% to 10%). However, negligible differences were observed in quality parameters when vermiwash was applied three times or at concentrations of 7.5% and 10%. As a result, the recommended application protocol for vermiwash is three sprays at a concentration of 7.5%. This treatment produced the best results for berry quality. In contrast, untreated vines exhibited inferior quality across all parameters. These results were consistent over two seasons. The positive effects of vermiwash on quality parameters can be attributed to its role in enhancing the biosynthesis and translocation of organic compounds, particularly carbohydrates, which advance fruit maturity and improve berry

Table (3): Effect of concentrations and frequencies of Vermiwash on main shoot length, leaf area (cm^2), percentages of N, P and K and berry setting of Red Roomy grapevines during 2023 and 2024 seasons.

Treatment	Main shoot length (cm)		Leaf area (cm^2)		Leaf N %		Leaf P %		Leaf K %		Berry setting %	
	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024
Control	67.67 D	72.10 C	65.37 D	68.93 E	1.65 D	1.78 D	0.19 E	0.18 D	1.67 F	1.69 D	6.46 D	6.67 D
Vermiwash at 5 % twice	71.13 CD	74.80BC	73.10 CD	77.07 D	1.81 C	1.99 CD	0.21 DE	0.22 CD	1.77 E	1.81 C	7.33CD	7.96 CD
Vermiwash at 7.5 % twice	73.90 BCD	75.50 BC	79.83 BC	82.90 CD	2.03 B	2.15 BD	0.24 CD	0.26 BC	1.9 D	1.93 BC	8.01 BC	8.17 BC
Vermiwash at 10 % twice	78.63 AB	80.37AB	85.83 B	90.60 B	2.17 B	2..25 AB	0.27 BC	0.29 B	2.01 BC	2.03 B	8.44 B	8.76 B
Vermiwash at 5 % three times	76.73 BC	75.87 BC	84.00 B	88.20 BC	2.12 B	2.29B	0.26 C	0.28 BC	1.97 CD	1.99 BC	8.50 B	8.500 B
Vermiwash at 7.5 % three times	84.53 A	86.93A	99.80 A	101.03 A	2.41 A	2.39 A	0.32 A	0.32 A	2.13 A	2.11 A	9.98 A	9.33 A
Vermiwash at 10 % three times	80.40 AB	86.63A	98.13 A	100.133 A	2.33 A	2.33 A	0.30 AB	0.31 A	2.08AB	2.10 A	9.33 A	9.300 A

Table 4. Effect of concentrations and frequencies of Vermiwash on No. of clusters/ vine, the yield, cluster weight, the cluster length (cm.) and Cluster width (cm.) of Red Roomy grapes during 2023 and 2024 seasons

Treatment	No. of clusters/ vine		Yield/ vine (kg)		Cluster weight (g.)		Cluster length (cm.)		Cluster width (cm.)		Shot berries %	
	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024
Control	22 A	22 A	6.03 C	5.43 E	305.33 C	315.00 C	17.16 D	18.66 D	6.66 C	7.33 D	7.36 A	7.6 A
Vermiwash at 5 % twice	21 A	19 A	7.36 BC	5.86 DE	313.00 C	323.00 C	19.10 CD	20.56 CD	7.13 C	8.33 CD	6.2 B	6.7 B
Vermiwash at 7.5 % twice	21 A	20 A	6.62 BC	7.68 CD	362.33 B	382.33 B	20.36 BC	22.43 BC	8.40 B	9.36 BC	5.46 B	6.4 B
Vermiwash at 10 % twice	21 A	21 A	7.897 B	8.50 BC	385.3 B	397.67 B	21.76 B	23.46 B	9.16 B	10.16 B	5.2 B	6.4 B
Vermiwash at 5 % three times	20 A	19 A	7.32 BC	8.36 BC	374.67 B	387.33 B	21.10 BC	22.73 B	8.86 B	9.90 B	4.00 C	4.9 C
Vermiwash at 7.5 % three times	22 A	22 A	8.75 A	11.21 A	441.00 A	441.67 A	25.80 A	27.30 A	11.63 A	12.23 A	4.33 C	5.0 C
Vermiwash at 10 % three times	22 A	20 A	8.863 A	9.69 AB	431.33 A	439.67 A	25.13 A	26.86 A	11.03 A	11.66 A	4.76 BC	5.6 C

Table 5. Effect of concentrations and frequencies of Vermiwash on Berry weight (g.), Berry length (cm.), Berry width (cm.), T.S.S %, Total sugars % and Total acidity % of Red Roomy grapes during 2023 and 2024 seasons

Treatment	Berry weight, g		Berry length, cm		Berry width, cm		T.S.S, %		Total sugars, %		Total acidity, %	
	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024
Control	4.67 D	4.99 D	1.99 F	2.20 C	1.79 E	1.92 C	18.90 D	19.53 E	15.93 D	16.60 E	0,720 A	0.736 A
Vermiwash at 5 % twice	5.05 C	5.42 C	2.15 E	2.36 BC	1.90 DE	2.07 BC	19.90 C	20.46 D	16.90 C	17.46 D	0.660 B	0.673 B
Vermiwash at 7.5 % twice	5.4567 B	5.73 BC	2.30 D	2.52 AB	2.00 CD	2.25 AB	21.03 B	21.10CD	18.00 B	18.00 CD	0.608 C	0.612 C
Vermiwash at 10 % twice	5.80 A	6.0533 B	2.44 BC	2.67 A	2.09 BC	2.43 A	22.03 A	21.70 ABC	18.93 A	18.60ABC	0.586 CD	0.573 C
Vermiwash at 5 % three times	5.71 AB	6.01 AB	2.39 CD	2.62 A	2.07 BC	2.37 AB	21.80AB	21.50CD	18.70 AB	18.40 BC	0.595 CD	0.584 C
Vermiwash at 7.5 % three times	5.89 A	6.16 A	2.67 A	2.59 A	2.43 A	2.09 BC	22.23 A	22.23 A	19,00 A	19.10 A	0.560 D	0.577 C
Vermiwash at 10 % three times	5.86 A	6.21 A	2.56 AB	2.69 A	2.19 B	2.36 AB	21.96 A	21.96AB	18.76AB	18.86 AB	0.576 CD	0.559 C

quality. Khan et al. (2014) reported that foliar application of vermiwash positively influences plant interactions with beneficial microorganisms, such as arbuscular mycorrhizal fungi, which may further enhance plant health and productivity. Furthermore, changes in soil microbial activity in response to foliar application of Vermiwash could have contributed to the observed quality improvements. Vermiwash is rich in vitamins, plant growth-promoting hormones (e.g., auxins and gibberellins), enzymes, symbiotic microbes, macronutrients, and micronutrients, as well as other bioactive substances that collectively support improved plant quality (Karuna et al., 1999; Awadhpersad et al., 2021).

4. Conclusion

Applying Vermiwash to Red Roomy grapevines three times at a concentration of 7.5% is highly effective in enhancing berry quality and resolving issues such as cluster looseness and shot berries. This treatment significantly improves both the yield quantity and quality, making it a practical and economical solution for improving grape production in Minia Governorate, Egypt .

Authors' Contributions
All authors are contributed in this research confirmed and approved
Data Availability Statement
Data presented in this study are available on fair request from the respective author
Conflicts of Interest
The authors disclosed no conflict of interest

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