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(Original Article)

Impact of Cluster Thinning and Foliar Application with Vermicompost and Humic Acid on "Ruby Seedless" Grapevines

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Abstract

Cluster and berry thinning are management techniques that adjust over-crop and provide a method for improving the quality. Furthermore, lately, a lot of attention is focused on minimizing the heavy amounts of mineral fertilizers by applying organic and bio-fertilizers such as vermicompost and humic acid. Therefore, these treatments were applied to increase the productivity and quality of Ruby Seedless table grape. To achieve this aim of this study, this study was conducted during two successive seasons of 2022 and 2023 on Ruby Seedless grape cultivar which was cultivated at the orchard of Pomology Department, Faculty of Agriculture, Assiut University. Six treatments were carried out control, humic acid at 2%/vine, humic acid to the soil at 5g/vine, vermicompost extract at 3.3ml/L, vermicompost extract at 5ml/L, cluster thinning by Removing the second cluster. Yield components, vegetative properties, berry attributes in addition to quality of grape berries were measured. The results revealed that all of the treatments were effective in improving both productivity and berry quality of the Ruby Seedless grape cultivar. In addition, spraying with vermicompost extract could be recommended as the best treatment.

Keywords: *Anthocyanins, Bio-fertilizers, Grapes, Organic fertilizers.*

Introduction

The Grape (*Vitis vinifera* L.) is regard as one of the most important fruit crops and the most popularity fruits in all over the world and Egypt. Grapes are gaining popularity thanks to their superior taste, high nutritional benefit, high antioxidant content, and higher yield (Mohamed *et al*., 2023). Grape is one of the key economic fruit crops with strong export potential under Egyptian circumstances (omar and aboryia 2020). The consumption of table grapes has been growing significantly and continuously globally. In Egypt grape occupies the third most important fruit crop after citrus and mango.

According to the Ministry of Agriculture Statistics 2022, the total area devoted to grapes attained 186404 feddans including 178485 feddans as fruitful vines producing about 1790734 tons with an average of 10.033 tons/feddan.

The Ruby Seedless cultivar has converted into one of the most important table grapes in both local and export markets. It is regarded one of Egypt's most favored seedless cultivars due to its robust growth and great fruit yield. As a result, it has high market acceptance because of its good nutritional characteristics and exportability

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(Mostafa *et al*., 2017). Ruby Seedless cultivar is a late maturing cultivar, matures through the period from mid to late August, berry oval in shape, color red to purple, seedless, and characterized by high bud fertility (harry *et al*., 1991). "Ruby Seedless" grapevine, also referred to as "King Ruby," is a hybrid of "Emperor" and "Provano 75." (Olmo *et al*., 1981).

Many factors influence grape production quality. Thinning, for example, has a more direct effect on the vine and its fruit. Fruit thinning has been used to achieve the desired loose, large berries, biggest berry weight, and earliest ripening. Thinning has a clear place in improving cluster and berry attributes. Hand thinning is vital for some grape cultivars because it increases quality and speeds up the ripening process. The amount of thinning required was determined by the cultivar, daylight, temperature, and fertilizer supply (Omar and Aborya, 2020).

Fertilization is regarded as an important method for increasing soil fertility and crop productivity (Mengel and Kirkby, 1987). However, the use of mineral fertilizers in high intensity in agricultural production increases the risk of environmental pollution and has adverse effects on human health, as well as can decrease the fruit contents of useful substances such as minerals and vitamins and increase harmful residues that remain in food. In addition to causing a decline in soil fertility, polluting the soil and water, killing microorganisms, and decreasing plant resilience to diseases. Therefore, it is important to use organic fertilizers as a possible alternative to chemical fertilizers (Pawar *et al*., 2020).

Organic fertilizers are a good source of nutrients that improve growth, yield, and fruit quality. They are also important for maintaining soil fertility, improving soil structure, aeration and encouraging the proliferation of microorganisms and increasing their activity in the soil. So, the usage of organic fertilizers is incredibly significant because of the adverse effects of mineral fertilizers and the benefits of organic fertilizers (Abo-baker., 2017).

Vermicompost, which is created by earthworms digesting a variety of organic wastes, has recently gained popularity as an environmentally benign organic fertilizer. Earthworms produce vermicompost, which is naturally rich in critical nutrients, active humic matter, phenolic compounds, and hormones (Sabir *et al.,* 2021).

Humic acid treatments are a continual therapy for agricultural systems that can be incorporated into future ecologically friendly farming operations. Biostimulants may help plants develop by increasing physiological processes and nutrient absorption. (Chen *et al*., 2004). The benefits of using humic acid, particularly in poor organic matter, alkaline soil, include enhanced nutrient uptake, tolerance to drought and temperature extremes, beneficial soil microbial activity, and soil nutrient availability. Humic materials, like auxins, can stimulate root growth (Abd El-Monem *et al*., 2008).

The aim of the present study is to investigate the effect of cluster thinning, vermicompost and humic acid on yield, vegetative growth and berry quality by using a low-cost, clean source fertilizers and thinning to improve grapes development in Ruby Seedless grape cultivar.

Materials and Methods

This study was carried out during two successive seasons of 2022 and 2023 on Ruby Seedless grape cultivar which was cultivated at the orchard of Pomology Department, Faculty of Agriculture, Assiut University. The experiment was conducted on Thirty years old Ruby Seedless grapevines. Vines were cultivated at 2 × 2 m apart in a clay soil. The vines were trained according to the head training system by leaving the total bud load of 60 buds/vine (16 fruiting spurs × 3 buds + 6 replacement spurs × 2 buds/vine).

Thirty uniformity vines were selected for this study and all vines received the standard agricultural practices that are used in the vineyard including soil fertilization, irrigation and pest control. The experiment consisted of six treatments arranged in randomized complete block design.

The treatment categories were as follows:

T1: Control: spraying with tap water.

T2: Spraying with Humic acid at 2%/vine.

T3: Adding Humic acid to the soil at 5g/vine.

T4: Spraying with vermicompost extract at 3.3ml/ L.

T5: Spraying with vermicompost extract at 5ml/ L.

T6: Cluster thinning by removing the second cluster.

Each treatment consisted of five replicates. Triton B at 0.1 % was added to the spraying solution in order to reduce the surface tension. The vines were sprayed using a knapsack sprayer in the early morning and the spray was done till the runoff. The whole vine was sprayed with Humic acid, Vermicompost extract while Humic acid was applied to the soil. The spraying compounds were added three times: at the beginning of growth, the second spraying was in full bloom and the third spraying was one month later. Removal the second cluster was performed before cap drop.

1. **Shoot length, leaves number and leaf area.**

After vegetative growth stops, the length of the shoot was determined, the number of leaves on the shoot and leaf area was calculated according to the following equation described by Ahmed and morsy (1999)

$$\textbf{Leaf area} = 0.44\ (W \times L) + 18.13$$

Where: W refers to Width and L refers to length.

2. **The estimated yield weight/vine and cluster weight**

At harvest, the clusters were collected to estimate the total yield weight/vine. All the clusters on each vine were counted. The invalid clusters were excluded and only the sound clusters were weighed and then the average cluster weight was calculated. The average cluster weight was multiplying in the total number of clusters/vine to estimate the total yield weight (Kg/vine). Two clusters were taken randomly from each vine and then transferred to the laboratory of fruit section to determine the following physical and chemical characteristics.

3. Berry attributes

-100 berry weight (g)

-100 berry juice weight (g)

-Berry length (L) (cm)

-Berry diameter (D) (cm)

-Berry L/D ratio

4. Cluster attributes

-Cluster rachis weight (gm)

5. Chemical properties

-Total soluble solids percentage (TSS %)

Total soluble solids percentage (TSS %) was measured by using a hand refractometer.

-Total acidity percentage (TA %)

Total acidity was determined by titrating 5 ml of diluted juice against 0.1 N NaOH solution and phenolphthalein as an indicator. TA% was calculated as grams of tartaric acid (TA) per 100 ml of berry juice and TA% was calculated according to the following equation (AOAC, 2005):

$$\textbf{Total acidity \%} = \frac{\text{MI(s)NaOH} \times \text{standard solution of NaOH(N)} \times 75}{1000 \times \text{The volume of used juice}} \times 100$$

Where: Standard solution of NaOH(N)=0.1 N, 75= the equivalent weight of tartaric acid and the volume of used juice = 5 ml.

-TSS/acid ratio was then calculated

-Total Anthocyanin (TAC)

The anthocyanin pigment was prepared through the process described by Onayemi *et al*. (2006). 20 ml of ethanol 85%+ HCL 1.5 M (by volume) solution were added to gram of berry skin samples. The samples were covered and kept in deep freeze for at least 24 hours. The extracts were completed to 50 ml of the solvent and then measured at wavelength 530 nm by spectrophotometer (Unico 1200 - USA). Results are expressed as mg anthocyanin per 100 g of fresh samples. Total anthocyanin was then calculated according to the following equation (Lees and Francis, 1971)

$$\text{Total Anthocyanin (TAC) (mg/100g fruit skin)} = (A_{535} \times V \times 100)/(98.2 \times W)$$

Where: A_{535} =absorbance of solutions was measured at a wavelength of 535 nm, V = total volume of extract in ml and W = weight of fresh sample in grams.

-Reducing sugars percentage

Reducing sugars percentage in the juice was measured according to Lane and Eynon procedure AOAC (2005).

Statistical analysis

Statistical analysis was done using a randomized complete block design (RCBD) according to (Mead *et al*., 1993) with five replications for each treatment and one vine per each. The analysis of variance (ANOVA) for each season of study, as well as the combined analysis of the two seasons of study was done by SAS software program and the treatment means were compared by using the revised L.S.D. values at 5% level of the probability (Steel and Torrie, 1980).

Results

1. Vegetative properties

Leaf area (cm^2)

Data presented Table 1 shows the influence of Humic acid, Vermicompost and Cluster thinning on leaf area of Ruby Seedless grape cultivar. During the 1st season the majority of tested treatments had a significant effect on leaf area with an exclusion of T2 and T3. The most successful treatment in this respect was T4. Such treatment (T4) increases leaf area by 20.75 % over the control. The data presented emphasized that most of the treatments had significant effect on leaf area in the 2nd season with the exception of T6. The most effective treatments in this respect were T3 followed by T4 and T5. The increment percentage of T3, T4 and T5 was 11.51, 9.37 and 8.23 % over the control, respectively. The two seasons' average data showed that all the treatments excelled control with the exception of T2. T4 surpassed all treatments and recorded the highest value of leaf area (72.29). Such treatment T4 increased leaf area by 15.50 % over the control.

leaves number

The obtained results Table 1 showed that there was no significant variation between the treatments and the control on leaves number in 1st season. During the 2nd season the same trend of the 1st season was observed. Mean of two season study showed that. There were no significant differences between most of the treatments.

Shoot length (cm)

Table 1 showing the effect of Humic acid, Vermicompost and Cluster thinning on shoot length of Ruby Seedless grape cultivar. There were significant differences between treatments and the control on shoot length in 1st and 2nd seasons. During the 1st season, T4 had the longest shoot followed by T5 and T3 (74.1, 73 and 70.6 cm respectively). The increment percentage of T4, T5 and T3 was 18.75, 16.99 and 13.14 % over the control, respectively. During the 2nd season the treatments T3, T4 and T2 had the highest values (61.5, 57.9 and 56.3 respectively). The increment percentage of such treatments was 19.88, 12.87 and 9.75 % over the control, respectively. The combined analysis over the two years of study demonstrated that T3 surpassed all the treatments with significant difference between most of the treatments followed by T4 and T5. The increment percentage of T3, T4 and T5 was 16.18, 16.09 and 13.19 % over the control, respectively.

Table 1. Effect of Humic acid, Vermicompost and Cluster thinning on Leaf area, Leaves number and Shoot length of Ruby Seedless grape cultivar during 2022 and 2023 seasons

Treatment	Leaf area (cm^2)			Leaves number			Shoot length (cm)		
	2022	2023	Mean	2022	2023	Mean	2022	2023	Mean
T1	67.46 CB	57.71 C	62.59 CD	12.5 A	8.8 A	10.65 AB	62.4 D	51.3 C	56.85 D
T2	64.072 D	59.624 BC	61.85 D	12.7 A	9.1 A	10.90 AB	69.5 C	56.3 B	62.90 BC
T3	66.892 CD	64.352 A	65.62 BC	12.8 A	9.4 A	11.10 A	70.6 BC	61.5 A	66.05 A
T4	81.456 A	63.12 AB	72.29 A	12.1 A	9.6 A	10.85 AB	74.1 A	57.9 AB	66.00 A
T5	74.554 B	62.46 AB	68.51 B	12 A	8.7 A	10.35 B	73 AB	55.7 BC	64.35 AB
T6	72.12 BC	55.112 C	63.62 CD	12.7 A	8.8 A	10.75 AB	67.4 C	54.3 BC	60.85 C

T1= Control, T2= Humic acid (2%/vine), T3= Humic acid (5g/vine), T4= Vermicompost extract (3.3ml/L), T5= Vermicompost extract (5ml/L), T6= Cluster thinning. Similar characters in the same column indicate that there were no significant differences between the treatments and the control.

2. Yield components

Yield (Kg/ vine)

Table 2 showing the effect of Humic acid, Vermicompost and Cluster thinning on yield of Ruby Seedless grape cultivar. The presented data suggested that the treatments significantly increased the yield in the 1st and 2nd seasons of study. During the 1st season of study. T5 overtop all treatments and recorded the greatest value of yield (16.48 Kg/vine) followed by T2 and T4 with no significant differences between the 3 treatments. The increment percentage of T5, T2 and T4 was 44.06, 37.76 and 32.17 % over the control, respectively. The 2nd season results took the same trend as the 1st one. The most effective treatments were T5, T2 and T4. The increment percentage of T5, T2 and T4 was 54.71, 54.31 and 18.24 % over the control, respectively. The combined analysis over the two years of study indicated that all the treatments excelled control respecting the yield (Kg/vine). The highest values in this respect were T5 followed by T2 and then T4. The increment percentage of T5, T2 and T4 was 48.98, 45.56 and 25.60 % over the control, respectively.

Clusters number

Data presented in Table 2 illustrates the effect of Humic acid, Vermicompost and Cluster thinning on clusters number of Ruby Seedless grape cultivar. During the 1st season of study. T2 surpassed all treatments and recorded the highest value of clusters number (46) followed by T5. The increment percentage of T2 and T5 was 17.35 and 8.16 % over the control, respectively. During the 2nd season of study. T2 significantly exceeded the control and showed the greatest value (51.2) followed by T4. The increment percentage of T2 and T4 was 19.63 and 5.14 % over the control, respectively. Two seasons' average data showed that all the treatments exceeded the control respecting the clusters number with an exclusion of T3 and T6. The best treatment in this respect were T2 (48.60) followed by T5 whereas there was non-significant variation between majority of the treatments. Such treatment T2 increases clusters number by 18.54 % over the control.

Cluster weight (g)

The results obtained (Table 2) revealed that most of the treatments significantly exceeded control during the 1st season of study. During the 1st season the best treatment in this respect were T4 followed by T5 and T3. The increment percentages of T4, T5 and T3 were 40.65, 32.28 and 26.17 % over the control, respectively. Data indicated that most of the treatments significantly surpassed the control during the 2nd season of study. The treatments of T5, T6 and T2 had the highest results (380.94, 344.12 and 310.96 gm, respectively). The increment percentage of T5, T6 and T2 was 58.67, 43.34 and 29.52 % over the control, respectively. Mean of two season study illustrated that T5 recorded the greatest value of cluster weight (383.27 gm) surpassed all treatments with significant difference between most of the treatments. Such treatment T5 increased cluster weight by 44.20 % over the control.

Table 2. Effect of Humic acid, Vermicompost and Cluster thinning on Yield, Clusters number and Cluster weight of Ruby Seedless grape cultivar during 2022 and 2023 seasons.

Treatment	Yield (Kg/vine)			Clusters number			Cluster weight (gm)		
	2022	2023	Mean	2022	2023	Mean	2022	2023	Mean
T1	11.44 B	10.2 B	10.82 D	39.2 B	42.8 B	41.00 B	291.5 C	240.08 D	265.79 C
T2	15.76 A	15.74 A	15.75 A	46 A	51.2 A	48.60 A	344.4 BC	310.96 BC	327.68 B
T3	14.26 AB	11.775 B	13.02 BC	38.8 B	41.75 B	40.28 B	367.8 AB	283.65 C	325.73 B
T4	15.12 A	12.06 B	13.59 B	37.6 B	45 AB	41.30 B	410 A	272.18 CD	341.09 B
T5	16.48 A	15.78 A	16.12 A	42.4 AB	41.2 BC	41.80 B	385.6 AB	380.94 A	383.27 A
T6	11.54 B	11.52 B	11.53 CD	31 C	33 C	32.00 C	357.4 AB	344.12 AB	350.76 AB

T1= Control, T2= Humic acid (2%/vine), T3= Humic acid (5g/vine), T4= Vermicompost extract (3.3ml/L), T5= Vermicompost extract (5ml/L), T6= Cluster thinning. Similar characters in the same column indicate that there were no significant differences between the treatments and the control.

3. Berry measurements

Berry length (cm)

Table 3 showing the effect of Humic acid, Vermicompost and Cluster thinning on berry length of Ruby Seedless grape cultivar. Although the treatments surpassed the control respecting the berry length in the 1st and 2nd seasons, their increases were not significant. During the 1st season the most successful treatment in this respect were T4 followed by T6 and T5. In the 2nd season the best treatment in this respect was T5. The combined analysis over the two years of study demonstrated that the majority of treatments did not have a significant effect. T4 surpassed all treatments and showed the highest value of berry length (1.58 cm).

Berry diameter (cm)

Data presented in Table 3 show the influence of Humic acid, Vermicompost and Cluster thinning on berry diameter of Ruby Seedless grape cultivar. There were no significant differences between majority of the treatments in the 1st and 2nd seasons. In the 1st season the highest values were obtained from the vines treated with T4 followed by T6 and T2. During the 2nd season the most effective treatment in this respect was T4. Two season's average data showed that T4 surpassed all the treatments and recorded the highest value of berry diameter (1.44 cm).

Berry L/D ratio

Table 3 showing the effect of Humic acid, Vermicompost and Cluster thinning on berry L/D ratio of Ruby Seedless grape cultivar. During the 1st season all the treatments excelled control respecting the berry L/D ratio. The best treatment in this respect was T4. In the 2nd season all the treatments exceeded control respecting the berry L/D ratio with an exclusion of T4. T5 had significant differences compared with the control while the rest of the treatments were not significant. The meaning of two studied seasons revealed that. T5 outperformed all the treatments and recorded the highest value of berry L/D ratio (1.11). There was not-significant variation between the treatments.

Table 3. Effect of Humic acid, Vermicompost and Cluster thinning on Berry length, Berry diameter and Berry L/D ratio of Ruby Seedless grape cultivar during 2022 and 2023 seasons.

Treatment	Berry length (cm)			Berry diameter (cm)			Berry L/D ratio		
	2022	2023	Mean	2022	2023	Mean	2022	2023	Mean
T1	1.402 B	1.632 B	1.52 B	1.3 A	1.502 A	1.40 A	1.078 A	1.088 AB	1.08 A
T2	1.444 AB	1.638 B	1.54 AB	1.334 A	1.502 A	1.42 A	1.086 A	1.094 AB	1.09 A
T3	1.408 B	1.6425 AB	1.53 B	1.302 A	1.5 A	1.40 A	1.084 A	1.095 AB	1.09 A
T4	1.522 A	1.638 B	1.58 A	1.358 A	1.516 A	1.44 A	1.12 A	1.082 B	1.10 A
T5	1.438 AB	1.692 A	1.57 AB	1.316 A	1.512 A	1.41 A	1.096 A	1.12 A	1.11 A
T6	1.47 AB	1.646 AB	1.56 AB	1.344 A	1.506 A	1.43 A	1.094 A	1.094 AB	1.09 A

T1= Control, T2= Humic acid (2%/vine), T3= Humic acid (5g/vine), T4= Vermicompost extract (3.3ml/L), T5= Vermicompost extract (5ml/L), T6= Cluster thinning. Similar characters in the same column indicate that there were no significant differences between the treatments and the control.

100 berries weigh (gm)

Data from Table 4 showed that the majority of tested treatments significantly increased the 100 berries weight. During the 1st season the best treatment in this respect was T4 followed by T6 and T5 (224.8, 220.8 and 214.4 g, respectively). The increment percentage of T4, T6 and T5 was 24.89, 22.67 and 19.11 % over the control, respectively. T5 and T2 had significant differences compared with the control and recorded the best value compared with the rest of the treatments in the 2nd season. The increment percentage of T5 and T2 was 41.35 and 40 % over the control, respectively. The combined analysis over the two years of study indicated that most of tested treatments significantly increased 100 berries weight. The most successful treatments in this respect were T6 followed by T5. The increment percentage of them was 29.80 and 29.68 % over the control, respectively.

100 berries juice weight (gm)

The presented data found in Table 4 show the influence of Humic acid, Vermicompost and Cluster thinning on 100 berries juice weight of Ruby Seedless grape cultivar. The presented data demonstrated that all the treatments had significant effect on juice weight in the 1st and 2nd seasons. In the 1st season the highest juice weight were taken from T4, T6 and T5 (180.2, 174.8 and 166.4, respectively). The increment percentage of T4, T6 and T5 was 39.91, 35.71 and 29.19 % over the control, respectively. During the 2nd season the greatest values were obtained from the vines treated with T5 followed by T2 and T6. The increment percentage of T5, T2 and T6 was 45.25, 43.39 and 37.63 % over the control, respectively. Two seasons' average data showed that all the treatments excelled the control respecting the juice weight. The most effective treatment in this respect were T5 followed by T6 and T2. The increment percentage of T5, T6 and T2 was 36.87, 36.63 and 30.31 % over the control, respectively.

Table 4. Effect of Humic acid, Vermicompost and Cluster thinning on 100 Berries weight and 100 Berries juice weight of Ruby Seedless grape cultivar during 2022 and 2023 seasons.

Treatment	100 berries weight (gm)			100 berries juice weight (gm)		
	2022	2023	Mean	2022	2023	Mean
T1	180 B	163 B	171.50 C	128.8 C	118 C	123.40 C
T2	200 AB	228.2 A	214.10 AB	152.4 BC	169.2 A	160.80 AB
T3	186.8 B	220.75 A	203.78 AB	142.2 C	156.75 AB	149.48 B
T4	224.8 A	176.8 B	200.80 B	180.2 A	133.4 BC	156.80 AB
T5	214.4 A	230.4 A	222.40 A	166.4 AB	171.4 A	168.90 A
T6	220.8 A	224.4 A	222.60 A	174.8 AB	162.4 A	168.60 A

T1= Control, T2= Humic acid (2%/vine), T3= Humic acid (5g/vine), T4= Vermicompost extract (3.3ml/L), T5= Vermicompost extract (5ml/L), T6= Cluster thinning. Similar characters in the same column indicate that there were no significant differences between the treatments and the control.

4. Chemical constituents

Total soluble solids percentage (TSS %)

Data presented in Table 5 show the influence of Humic acid, Vermicompost and Cluster thinning on Total soluble solids (TSS %) of Ruby Seedless grape cultivar. In the 1st season all the treatments exceeded control respecting the TSS% with an exclusion of T4 and T3. The most successful treatment in this respect was T6. Such treatment (T6) increased TSS% by 6.76 % over the control. The data presented emphasized that all the treatments had significantly increased TSS% in the 2nd season. The best value in the 2nd season was T3 with significant differences. The increment percentage of T3 was 14.75 % over the control. The combined analysis over the two years of study indicated that the best treatments were T5 and T6 which recorded 19.02 and 18.74, respectively. The increment percentage of T5 and T6 was 9.56 and 7.95 % over the control, respectively.

Total acidity percentage (TA %)

Data from Table 5 showed the influence of Humic acid, Vermicompost and Cluster thinning on Total acidity (TA %) of Ruby Seedless grape cultivar. The most of tested treatments had significant effect on total acidity % in the two seasons. In the 1st season the best treatment in this respect was T5. Such treatment significantly decreased total acidity percentage. During the 2nd season the best treatment in this respect was T2. The two season average data showed that the lowest values were obtained from the vines treated with T2.

Table 5. Effect of Humic acid, Vermicompost and Cluster thinning on Total soluble solids (TSS %), Total acidity (TA %) and Total soluble solids/Acid ratio of Ruby Seedless grape cultivar during 2022 and 2023 seasons

Treatment	Total soluble solids%			Total acidity%			TSS/TA ratio		
	2022	2023	Mean	2022	2023	Mean	2022	2023	Mean
T1	17.16 AB	17.56 C	17.36 B	0.441 A	0.38 A	0.41 A	38.984 B	47.078 A	43.03 B
T2	17.76 AB	18.48 BC	18.12 AB	0.33 B	0.31 B	0.32 B	53.966 A	60.394 A	57.18 A
T3	16.96 B	20.15 A	18.56 A	0.334 B	0.34 AB	0.34 B	51.944 A	59.343 A	55.64 A
T4	17.56 B	18.44 BC	18.00 AB	0.333 B	0.33 AB	0.33 B	53.244 A	58.39 A	55.82 A
T5	18.08 AB	19.96 AB	19.02 A	0.325 B	0.356 AB	0.34 B	56.604 A	56.972 A	56.79 A
T6	18.32 A	19.16 ABC	18.74 A	0.341 B	0.346 AB	0.34 B	54.058 A	55.814 A	54.94 A

T1= Control, T2= Humic acid (2%/vine), T3= Humic acid (5g/vine), T4= Vermicompost extract (3.3ml/L), T5= Vermicompost extract (5ml/L), T6= Cluster thinning. Similar characters in the same column indicate that there were no significant differences between the treatments and the control.

TSS/TA ratio

The obtained results found in Table 5 revealed that all the treatments excelled control respecting the TSS/TA ratio in the 1st and 2nd seasons. The best treatment was T5 followed by T6 and T2 which showed the greatest values in the 1st season 56.604, 54.058 and 53.966, respectively. The increment percentage of T5, T6 and T2 was 45.20, 38.69 and 38.46 % over the control, respectively. During the 2nd season T2 and T3 outperformed all treatments and recorded the highest values of TSS/TA ratio (60.394 and 59.343, respectively). The increment percentage of T2 and T3 was 28.27 and 26.04 % over the control, respectively. Mean of two season study showed that the majority of tested treatments significantly increased TSS/TA ratio. The highest value was obtained from T2, which recorded 57.18. Such treatment T2 increased TSS/TA by 32.88 % over the control.

Reducing sugar%

The presented data found in Table 6 show the influence of Humic acid, Vermicompost and Cluster thinning on reducing sugar of Ruby Seedless grape cultivar. During the 1st season all the treatments surpassed the control respecting the reducing sugar. The best values were obtained from the vines treated with T4. The increment percentage of T4 was 25.93 % over the control. T5 outperformed all treatments and showed the highest value of reducing sugar (16.229) in the 2nd season without significant differences. Such treatment (T5) increased by reducing sugar by 9.15 % over control. The combined analysis over the two years of study indicated that the most effective treatment in this respect was T5. The increment percentage of T5 was 13.86 % over the control.

Anthocyanin (mg/ 100g)

Table 6 shows the effect of Humic acid, Vermicompost and Cluster thinning on anthocyanin of Ruby Seedless grape cultivar. All the treatments exceeded the control respecting the anthocyanin in the 1st and 2nd seasons. During the 1st season the most effective treatment in this respect was T6. Such treatment (T6) increased anthocyanin by 35.75 % over the control. In the 2nd season the results took the same trend as the 1st one, the increment percentage of T6 was 19.53 % over the control. The two seasons' average data showed that most of the tested treatments had significant effects on anthocyanin. The greatest values were obtained from the vines treated with T6. Such treatment (T6) increased anthocyanin by 28.29 % over the control.

Table 6. Effect of Humic acid, Vermicompost and Cluster thinning on Reducing sugar and Anthocyanin of Ruby Seedless grape cultivar during 2022 and 2023 seasons.

Treatment	Reducing sugar%			Anthocyanin (mg/ 100g)		
	2022	2023	Mean	2022	2023	Mean
T1	12.96 C	14.874 A	13.92 B	27.34 C	23.41 C	25.24 C
T2	14.164 BC	15.572 A	14.87 AB	32.38 B	23.66 C	28.02 B
T3	14.86 AB	16.108 A	15.48 A	29.98 BC	24.88 BC	27.43 B
T4	16.316 A	14.882 A	15.60 A	30.54 BC	27.06 A	28.80 B
T5	15.47 AB	16.229 A	15.85 A	36.46 A	26.08 AB	31.27 A
T6	14.66 B	16.004 A	15.33 A	37.1 A	27.66 A	32.38 A

T1= Control, T2= Humic acid (2%/vine), T3= Humic acid (5g/vine), T4= Vermicompost extract (3.3ml/L), T5= Vermicompost extract (5ml/L), T6= Cluster thinning. Similar characters in the same column indicate that there were no significant differences between the treatments and the control.

Discussion

Grapes are regarded one of the most promising crops in Egypt. The expansion and enhancement of the Egyptian grape industry necessitates solving all production problems.

Using biofertilizers like humic acid (HA), which is one of the primary components of humic materials, has been shown to have various indirect and direct effects on plant development in recent years. The indirect effects are mostly exerted through qualities such as enrichment of soil nutrients, increase of microbial population, increasing cation exchange capacity (CEC), and improving soil structure; whereas direct effects are various biochemical actions exerted at the cell wall, membrane, or cytoplasm that are primarily hormonal in nature (Chen *et al.*, 2004; Varanini and Pinton, 2000).

Our results clearly shown that HA spraying boosted the yield of Ruby Seedless table grapes in 2022 and 2023. The increase in total yield was most likely due to the effect of HA fertilization, which stimulated plant growth and, as a result, yield by acting on mechanisms involved in cell respiration, photosynthesis, protein synthesis, water and nutrient uptake, microbial population growth, and enzyme activities (Chen *et al*., 2004).

In addition, HA resulted in increases in all productivity indices, including cluster weight, berry size, and berry weight. This is because, as previously mentioned that HA can aid in soil nutrient enrichment, microbial population expansion, better cation exchange capacity (CEC), and soil structure improvement; however, the probable hormones in the HA should also be considered. As a result, we discovered that HA increased productivity and productivity indicators, which led to an increase in exportable yield. The results presented above were consistent with those obtained by (Popescu and Popescu., 2018; Sabir *et al*., 2021; Arji *et al*., 2022; Ahmed., 2023; Rasouli., 2024).

The beneficial effects of humic acid, which activate the availability, uptake, and translocation of most nutrients, may be responsible for the increase in vegetative parameters. This effect speeds up the synthesis of proteins and carbohydrates, promotes cell division, and aids in the development of meristematic tissues. Furthermore, it controls the tree's vegetative growth and makes plants resistant to root infections (Kannaiyan, 2002). These results are consistent with information from earlier research (Abdelaal *et al*., 2013; Birjely and Al-Atrushy., 2017; Atawia *et al*., 2021; Ahmed., 2023).

Also, the increases indicated in chemical properties of berries, whether increase TSS, reducing sugars and anthocyanin or reduce total acidity, leads to enhanced quality attributes and hasten ripening. Humic acid reduces acidity in the juice of the berries through increasing its content of sugars and carbohydrates, which leads to a decrease in the total acidity of the juice (Philip and Kuykendall., 1973). and the increase in total sugars, that is probably related to the important role of humic acid in raising the nutrients of the vine and the development of roots produces an increase in the activity of hormone-like substances (Lateef *et al*., 2021), and the transfer of these substances to the kernels thus iincreasingthe total sugars. This results agreement with (Abdelaal *et al*., 2013; Mohamadineia *et al*., 2015; Ibrahim and Ali., 2016; Birjely and Al-Atrushy., 2017; Ahmed., 2023; Rasouli., 2024).

They determined that humic, organic, and bio fertilization could be applied to increase the growth characteristics, production, and fruit quality of different grape cultivars; but there are some researchers whose results varied from ours (Birjely and Al-Atrushy., 2017; Popescu and Popescu., 2018; Arji *et al*., 2022).

Particularly in organic agriculture systems, which offer numerous benefits for the environment and human health, sustainable agricultural methods may be helpful in preserving soil quality and boosting crop output (Scotti *et al*., 2015). Vermicompost (VC) is one of the sustainable tools that has drawn the most attention lately. It is a natural product made from the interaction of earthworms and plant wastes (Blouin *et al*., 2019), and it is rich in macro and micronutrients, plant growth regulators, beneficial microorganisms like bacteria, fungi, actinomycetes, antibiotics, phytohormones, and bacteria that fix nitrogen and potassium (Yatoo *et al*., 2020).

Our results demonstrated that applying vermicompost to Ruby Seedless table grapes improved their quality and productivity; the rise in productivity and all productivity metrics was most likely caused by The best methods for increasing grapevine yield were organic fertilizers' positive impacts on root development, nutrient solubility, soil workability, and the extraction of soil hormones and cytokinin production (El-Mahdy *et al*., 2017). Applying vermicompost is regarded as one of the best ways to restore reduced soil fertility, preserving soil quality and nutrient availability, which may be linked to increased fruit output and weight. Additionally, organic fertilizers improve the uptake and translocation of most nutrients, which is reflected in increased protein and carbohydrate synthesis, promote cell division and tissue development, and increase the production of natural hormones like IAA, GA3, and cytokinins. These factors boost root development and vegetative growth of the plant, which in turn improve fruit quality and productivity (Kannaiyan, 2002). This results agreement with (Trentin *et al*., 2019; Sabir *et al*., 2021; Rosado *et al*., 2022; Elsayed and El-Shewaikh., 2023).

Additionally, the rise in chemical properties, whether they are an increase in TSS, anthocyanin, or a decrease in total acidity, is what causes the improvement in berry quality. The strong correlation between fertilization and increasing soil nutrients, which has been favorably connected to providing energy for soil microbial activity and altering microbial communities, is likely the cause of this improvement (Zhu *et al*., 2022). Furthermore, vermicomposts (bio-humus) have been shown to include a variety of phytohormones (Scaglia *et al*., 2016), and these phytohormones can significantly improve fruit quality. This results in according to the previous studies indicated by (Sabir *et al*., 2021; Yeole., 2021; Abdel-Salam *et al*., 2022; Elsayed and El-Shewaikh., 2023).

Thinning is regarded as a method for enhancing grapevine quality and controlling production that doesn't require any particular expertise. Additional benefits may result from controlling yield, including enhanced plant health, a reduction in disease, increased shoot growth, and an improvement in the ratio of the vines' vegetative to generative activity. The largest berries, the heaviest berry weight, and the quickest ripening have all been achieved through berry thinning. Since fewer clusters of grapes on a vine result in better photosynthetic assimilation and higher grape quality, cluster thinning directly affects the balance between nutrient supply and vine requirements (Reynolds *et al*., 1994).

Our results showed that cluster-thinned vines had a higher cluster mass than un-thinned vines, which might be attributable to The positive impact of thinning on yield and cluster weight is frequently related to This method will help change the crop by reducing the number of berries that absorb nutrients and photosynthesis from the vines (Mohamed *et al.*, 2023), resulting in a natural compensatory increase in the rest of the clusters when the entire cluster is reduced (GIL-Muñoz *et al.*, 2009), which leads to an increase in the quality of the remaining clusters. Many workers verified our results. (Fazekas *et al*., 2012; Özer *et al*., 2012; Xi *et al*., 2020; Ivaniševic *et al*., 2020; Mohamed *et al*., 2023).

The increase in leaf area, number of leaves and shoot length reached by thinning was previously achieved by Abd El-Wahab. (2006); Xi *et al*. (2018); Fawzi *et al*. (2019).

On the other side, other researchers discovered that cluster thinning decreased the yield weight and cluster weight (Ferree *et al*., 2003; Fazekas *et al*., 2012).

The increase in physical qualities could be linked to a change in the leaf/fruit ratio, which promotes fruit growth while reducing competition among remaining fruits for photo assimilates (Palmer *et al.*, 1997). Also, Agusti *et al*. (2000) shown that thinning treatments enhance both fruit weight and size. In this regard, berry size compensation is only relevant while the berries are in phase I of development, which occurs within the first 3-4 weeks after the initial set. During this stage, cell division occurs in the berry, and the removal of competing clusters may alter carbon partitioning, allowing for a larger berry diameter (Skinkis, 2019). In general, cluster thinning had a tendency to increase the mass of berries; comparable results were found by various writers (Ferree *et al*., 2003; Abd El-Wahab, 2006; Fazekas *et al*., 2012; Özer *et al*., 2012; Fawzi *et al*., 2019; Omar and Aboryia., 2020; Mohamed *et al*., 2023).

On the other side, Ferree *et al*. (2003), Fawzi *et al*. (2019) and Mohamed *et al*. (2023) found that cluster thinning decreased berry weight, berry length and L/D ratio.

Our results suggested that thinning treatment improved grape quality. This could be attributed to cluster thinning accumulating carbohydrates content, which activates the process of growth and development, increasing berry weight and hastening ripening. This is reflected on extending fruit ripening and improving its quality by boosting sugars and soluble solids levels and decreasing total acidity.

In terms of anthocyanin content, the results reveal that cluster thinning produced berries with higher anthocyanin content in their skins than those that were not thinned Dokoozlian and Hirschfeldt. (1995) discovered that soluble solids levels of Flame Seedless berry juice at harvest were higher for cluster thinned vines than for un-thinned vines, and that there was a link between this parameter and berry color; consequently, thinned vines accumulated color faster than un-thinned vines. Also, Guidoni *et al*. (2002) proposed that sugar content could regulate flavonoid accumulation in grape berries and discovered that cluster thinning significantly increased the soluble solid content and total sugars of the berry mesocarp, leading to the hypothesis that berry sugar concentration may influence berry anthocyanin composition. This approach also enhances ethylene production in some fruits, indicating advanced maturity (Lopez *et al*., 2011). These findings are consistent with those reported by several researchers, such as Ferree *et al*., 2003; Özer *et al*., 2012; Fawzi *et al*., 2019; Omar and Aboryia., 2020; Xi *et al*., 2020; Mohamed *et al*., 2023.

On the other side, Abd El-Wahab (2006); Ivaniševic *et al*. (2020) and Mohamed *et al*. (2023) found that cluster thinning increased total acidity and decreased anthocyanin and TSS.

Conclusion

It's recommended to spray Vermicompost extract at 5ml/L at the beginning of growth, full bloom and a month after full bloom to improve most vegetative, physical and chemical properties of Ruby Seedless grape cultivar.

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تأثير خف العناقيد والرش الورقي بكمبوست الديدان وحمض الهيوميك على كرمات العنب الروبي عديم البذور

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الملخص

يعتبر خف العناقيد من الطرق الفعالة التي تعمل علي تحسين جودة الحبات. بالإضافة الي ذلك، في الآونة الاخيرة، اتجه الاهتمام نحو خفض الكميات الهائلة المستخدمة من الاسمدة المعدنية من خلال تطبيق الاسمدة العضوية والحيوية مثل مستخلص كمبوست الديدان وحمض الهيوميك، لذلك تم تطبيق هذه المعاملات لزيادة انتاجية وجودة عنب الروبي عديم البذور. ولتحقيق هذا الهدف اجريت هذه الدراسة خلال موسمين متتاليين 2022، 2023 على صنف العنب الروبي عديم البذور في مزرعة الفاكهة بكلية الزراعة جامعة اسيوط. وكانت المعاملات كالتالي الكنترول، حمض الهيوميك 2% كرمة، حمض الهيوميك 5 جرام/ كرمة، مستخلص كمبوست الديدان 3.3 مل / لتر، مستخلص كمبوست الديدان 5 مل / لتر، خف العناقيد بإزالة العنقود الثاني. اظهرت النتائج التي تم الحصول عليها ان جميع المعاملات كانت فعالة في تحسين كلا من الانتاجية وجودة الحبات بالإضافة الى انه يمكن التوصية بالرش بمستخلص كمبوست الديدان بتركيز 5 مل / لتر كأفضل معاملة.

الكلمات المفتاحية: العنب، الأسمدة الحيوية، الأسمدة العضوية، الأنثوسيانين.