Agrotechniques in Industrial Crops

Journal Homepage: https://atic.razi.ac.ir

Yield and Yield Components of Grapevines as Influenced by Mixed Nano Chelated Fertilizer, Humic Acid and Chemical Fertilizers

Isa Arji[*1], **Salameh Karimpour Kalehjoobi**[2], **Mohammad Ali Nejatian**[3], **Tarun Kumar Upadhyay**[4]

[1]*Department of Plant Production and Genetics, Faculty of Agricultural Science and Engineering, Razi University, Kermanshah, Iran*
[2]*Tak Gostar Zagros Company, Kermanshah, Iran*
[3]*Temperate Fruits Research Center, Horticultural Sciences Research Institute, Agricultural Research, Education and Extension Organization (AREEO), Karaj, Iran*
[4]*Department of Biotechnology, Parul Institute of Applied Sciences and Centre of Research for Development, Parul University, Vadodara, Gujarat, India*

ARTICLE INFO

Original paper

Article history:
Received: 10 Jul 2022
Revised: 26 Aug 2022
Accepted: 27 Sep 2022

Keywords:
Fertilization
Fruit quality
Grape
Yield
Mixed nano-chelated fertilizer

ABSTRACT

Nutrient elements are the most important factor limiting crop production in plants. In addition to reducing the yield and quality of the product, the lack of mineral elements causes nutrient deficiency in humans. Based on this, in order to study the effect of humic acid and mixed nano chelated fertilizer together with chemical fertilizers on the growth and yield of Yaqouti grape, an experiment was conducted as a randomized complete block design with 3 replications in Kandoleh area of Sahneh city of Kermanshah province in two successive years 2020 and 2021. For this purpose, ten different fertilizer treatments were considered include; mixed nano chelated fertilizer + chemical fertilizer (T1), mixed nano chelated fertilizer + humic acid with irrigation (T2), mixed nano chelated fertilizer + humic acid (T3), humic acid with irrigation + chemical fertilizer (T4), humic acid + chemical fertilizer (T5), humic acid with irrigation (T6), humic acid (T7), mixed nano chelated fertilizer (T8), chemical fertilizer (T9), control without fertilizer (T10). Fertilizer treatments have a statistically significant effect ($P \leq 0.05$) on the traits of number of berries per bunch, number of bunches per plant, bunch weight, bunch length and width, yield per plant, yield per hectare, Total Soluble Solid (TSS), Titratable Acid (TA), TSS/TA and pH of juice. Using a combination of treatments was more beneficial than single treatments. The practical result of this research is the use of treatments T1 and T3 for gardeners, respectively. Qualitative properties such as total soluble solids and TSS/TA were higher in most combined treatments, especially in the treatment of mixed nano chelated fertilizer + chemical fertilizer (T1), which was at the top.

DOI: 10.22126/ATIC.2023.8478.1076

1. Introduction

Environmental protection is one of the basic issues for human society in the 21st century (Franjic, 2018). Recently, environmental pollution has increased seriously for humans' health (Manisalidis *et al*., 2020). One of its main causes is the creation of diversity and increase in the excessive consumption of chemical fertilizers, followed by the accumulation of heavy metal elements and the pollution of environmental resources (Uddin *et al*., 2021). For this purpose, extensive efforts have been started with the aim of finding suitable solutions for improving the quality of soil, agricultural products and removing pollutants. Using organic materials of natural origin is one of these methods. (Maccarthy, 2001).

The indiscriminate use of chemical fertilizers and lack of organic matter remnants in recent years has been the reason for the dramatic decrease in the amount of organic matter in Iran's soils (Latifi and Mohammad Dost, 1998), On the other hand, excessive use of chemical fertilizers in agriculture has caused environmental problems, including physical

* Corresponding author.
E-mail address: i.arji@razi.ac.ir

destruction of the soil and imbalance of soil nutrients (Rahman and Zhang, 2018), This situation can be improved through the use of biological fertilizers (Singh *et al*., 2020). Hence, the consumption of organic fertilizers is increasing nowadays. Organic acids improve the quantity and quality of agricultural and garden crops has become widespread (Bajeli *et al*., 2016). Organic materials have significant effects in improving the biological and physicochemical properties of the soil. Also, due to the presence of hormonal compounds in organic materials, they have beneficial effects in increasing production and improving the quality of agricultural products (Samavat and Malakoti, 2005; Zaremanesh *et al*., 2020). Humic acid is one of the compounds that improve soil structure, which is obtained as an organic matter decomposition in the soil (Vikram *et al*., 2022).

The effect of biofertilizers on grape fruiting has been reported (Kannaiyan, 2002; Farg, 2006; Ahmed *et al*., 2012; Rabie and Negm, 2012; da Silva Júnior *et al*., 2018). Several studies have shown that humic acid is effective in increasing the fruit yield of different grape cultivars (Saleh *et al*., 2006; Kabeel *et al*., 2008; Ferrara and Brunetti, 2010; Abd El- Aziz, 2011; Mekawy, 2012; Vatankhah *et al*., 2016; Popscu and Popescu 2018; Ahmad *et al*., 2013) reported that biofertilizers and humic fertilizers of 5 ml per plant increased berries' weight in the Superior variety bunches. The role of biofertilizers was greater than humic acid on this trait. However, the simultaneous application of biofertilizers and humic acid increased the weight of berries in a bunch more than their single application. During the full flowering period, the application of humic acid increased the weight of the berries, titratable acid and the maturity index of Italian grapes (Ferrara and Brunetti, 2010).

Regarding the effects of chemical fertilizers on the quantitative and qualitative yield of grapes, a number of researches have been conducted, which increased the quantitative and qualitative yield of the fruit compared to the control (Yener *et al*., 2008; Bybordi and Shabanov, 2010; Mostashari, 2012; Zhu *et al*., 2022). The results of existing studies show different reactions of different types of plants to nutrients prepared in nano form. Khodabakhsh Zadeh et al. (2013) showed that the use of iron nano-fertilizers led to an increase in yield, soluble solids and sweeter grapes. The use of nano-fertilizer led to an increase in yield, fruit quality and leaf nutrients in grapes (Sabir *et al*., 2014; Mahdavi *et al*., 2022).

The preliminary results of this research, which was carried out during 2014, showed that the application of fertilizer treatments had a significant effect on the quantitative and qualitative traits of Yaqouti grapes compared to the control treatment (without fertilizer). The fruit yield varied from 7.58 tons in the control plants to 14.22 tons in the nano fertilizer + chemical fertilizer treatment. The increase in yield and yield components in treatments of nano fertilizer + chemical fertilizer and nano fertilizer + humic acid was superior to other treatments (Arji *et al*., 2020).

The purpose of this experiment was to investigate the effect of using different combinations of humic acid, chemical fertilizer and nano fertilizer on the yield and yield components of the Yaqouti grape.

2. Materials and methods

2.1. Experimental location, design and treatments

This research was carried out during two successive seasons (2020 and 2021) on Yaqouti grape vineyards in Kandoleh region, Kang, (longitude: 47º 19´ E, latitude: 34º 37´ N, altitude: 1385 m) of Kermanshah province. This experiment was implemented in the form of a randomized complete block design with 10 treatments and 3 replications. We tried to select trees of the same form in terms of size, and the number of buds on the plant was considered to be 60 buds. The number of trees in the experimental unit was 3, and a total of 90 plants were evaluated.

Fertilizer treatments include 1- Mixed nano chelated fertilizer + chemical fertilizer (T1), 2- Mixed nano chelated fertilizer + humic acid with irrigation (T2), 3- Mixed nano chelated fertilizer + humic acid soil use (T3), 4- Humic acid with irrigation + chemical fertilizer (T4), 5- Humic acid soil use + chemical fertilizer (T5), 6- Humic acid with irrigation (T6), 7- Humic acid soil use (T7), 8- Mixed nano chelated fertilizer (T8), 9- Chemical fertilizer (T9), 10 - The control (without using fertilizer) (T10).

Mixed nano chelated fertilizer for grapes contained 4% urea, 3% iron, 2% manganese and 1% boron. Mixed nano chelated fertilizer was used for grapes as a foliar spray of 3 per thousand after flowering. Chemical fertilizers were used according to the soil test and nutritional needs of grapes, including one (Kg) of urea, one (Kg) of triple superphosphate, one (Kg) of magnesium sulfate, 15 (gr) of boric acid, 50 (gr) of zinc sulfate, 150 (gr) of iron sulfate and 30 (gr) of manganese sulfate in the form of soil use in root area replacing in combination with cow manure before the start of experiment. Humic acid was applied in the form of soil use in root area replacing in the rate of 8 kg per hectare at the end of winter. Humic acid was applied at the rate of 8 (kg) per hectare in irrigation water at the stage after fruit formation.

Soil and water analysis characteristics are shown in Tables 1 and 2 respectively.

Table 1. Some physicochemical analysis of soil in the vineyard.

Soil depth (cm)	Particle-size distribution (%)					Texture	EC dS/m	pHs		OC %
		Sand	Silt	Clay	Gravell					
0-30		35.00	31.00	34.00	-	C-L	1.30	7.35		1.30
31-60		38.00	30.00	32.00	-	C-L	1.50	7.55		0.90
61-90		30.00	33.00	37.00	4.00	C-L	1.10	7.68		0.30
Soil depth (cm)	Soluble cations, (meq/l00g soil)			Soluble anions (meq/100g soil)			nutrients			
	Co_3^-	Ca+Mg	Na^+	HCO3-	Cl^-	$SO4^{-2}$	Total N%	Ava. P mg/kg	Ava. K mg/kg	TNV %
0-30	0.00	5.40	0.90	4.20	1.80	0.01	0.12	12.00	320.00	36.00
31-60	0.00	4.20	2.16	2.80	2.20	0.12	0.06	7.00	230.00	40.00
61-90	0.00	3.70	1.24	2.40	2.50	0.06	0.02	3.00	92.00	37.50

Table 2. Chemical characteristics of Water River used for the present study.

CO_3^-	SAR	Na^+	Ca+Mg	Fe	$SO4^{-2}$	Cl^-	HCO_3^-	pH	TDS	EC	Water Source
meq/l	%				meq/l				mg/l	dS/m	
0	2.30	0.25	2.3	0	0.33	0.30	0.7	7.1	365	0.68	River

2.2. Following parameters were recorded

2.2.1. Fruiting characteristics

Number of bunches per vine, bunch weight (g), number of berries per bunch, bunch length (cm), yield per vine and hectare were measured.

2.2.2. Quality characteristics

Titratable Acidity (TA), pH, Total Soluble Solids (TSS) and the ratio of Total Soluble Solids to Titratable Acidity (TSS/TA) were measured.

The grape juice pH values were measured with a pH meter (Model RPB10). The grape juice TSS was measured with a refractor meter (Model WYT-4). The grape juice TA was measured by titration method. Titration was done with 10 ml of fruit juice. In the titration method, using sodium hydroxide (NaOH) 0.1 normal and with the help of phenolphthalein, one percent of the volume of consumed caustic soda was determined. Phenolphthalein turns cloudy in an acidic medium and pink in an alkaline medium. As soon as the pink color appears, adding soda stops. TA was calculated using the formula $M = 0.75 \times V$. In this formula, the amount of acid is expressed in grams per liter and the volume of soda consumed, and the constant coefficient of tartaric acid is 0.75 (Anon, 1997).

Variance analysis was done in the form of a randomized complete block design after testing the normality of the data using MSTATC statistical software and drawing graphs using Excel 97 software. The Comparison of means was done at 5% probability level by Duncan's method.

3. Results and discussion

The number of bunches per plant was statistically significant ($P \leq 0.05$) among treatments (Table 3). So that the highest number of bunches per plant, 25.42 and 27.23 bunches in 2020 and 2021 respectively, was obtained with T1 treatment. After that, the T3 treatment had the greatest effect on increasing the number of bunches in the vine compared to other treatments (Table 3). The lowest number of bunches per vine was recorded in T6, T7 and T10 (Table 3).

The bunch weight was statistically significant ($P \leq 0.05$) among treatments. The bunch weight increased in treatment groups in comparison to the control (no fertilizing) (Table 3). The highest bunch weight (318.50, 316 and 300 g in 2020 and 330.9, 319 and 318 g in 2021) obtained in the treated groups T1, T2 and T4 treatments respectively, where there was no significant difference among them. The lowest bunch weight (240-246 g in 2020 and 2021) observed in the control group (no fertilizing) (T10). The bunch weight in other fertilizer treatments was also superior to the control, confirming that the fertilizer treatments are effective on this trait in the Yaqouti grape.

Berries number per bunch was significantly affected by the fertilizer treatments with different combinations at the statistical probability (P≤0.05) (Table 3). The results obtained from this study showed that the highest number of berries in the bunch (286.4, 281, 277 and 277 in 2020 and 297, 291, 289 and 287 in 2021) recorded respectively in T1, T2, T3 and T4 treatments. In the treatments of humic acid (T7) and control (no fertilizing) (T10), the number of berries per bunch decreased, recording the lowest number of berries in the bunch.

Table 3. Mean comparison of yield and yield component of Yaghouti grape under different fertilizer treatments.

Treatments	Bunch No/Plant		Bunch Weight (g)		Berries No/Bunch	
	2020	2021	2020	2021	2020	2020
T1*	25.42^a	27.23^a	318.50^a	330.9^a	286.40^a	297.00^a
T2	22.65^ab	24.69^b	316.00^a	319.00^ab	281.00^a	291.00^a
T3	23.46^ab	26.20^ab	295.00^ab	316.00^ab	277.60^ab	289.00^a
T4	19.46^bc	23.20^bc	300.00^ab	318.40^ab	277.00^ab	287.00^a
T5	21.14^b	23.52^bc	298.00ab	304.60^b	268.00^c	281.00^b
T6	17.16^c	19.50^cd	267.00^cd	271.00^c	268.00^c	265.00^c
T7	17.20^c	19.46^cd	262.00^cd	276.60^c	258.00^d	264.00^c
T8	23.16^ab	23.50^bc	275.00^cd	273.00^c	271.00^cd	275.00^bc
T9	19.86^bc	20.80^c	285.00^c	283.00^bc	270.00^cd	280.00^b
T10	16.40^d	18.20^d	240.00^e	246.00^d	259.00^d	257.00^d

*Mixed nano chelated fertilizer + Chemical fertilizer (T1), Mixed nano chelated fertilizer + Humic acid with irrigation (T2), Mixed nano chelated fertilizer + Humic acid as soil use (T3), Humic acid with irrigation + Chemical fertilizer (T4), Humic acid as soil use + Chemical fertilizer (T5), Humic acid with irrigation (T6), Humic acid as soil use (T7), Mixed nano chelated fertilizer (T8), Chemical fertilizer (T9), Control without fertilizer (T10)

**Non-identical letters show a significant difference at a 5% probability level using Duncan's Multiple Range Test.

Table 4. Mean comparison of yield and yield component of Yaghouti grape under different fertilizer treatments.

Treatments	Bunch Length (cm)		Yield/vine (kg)		Yield/Hectare (kg)	
	2020	2021	2020	2021	2020	2021
T1*	22.50^ab	24.10^ab	8.25^a	9.80^a	13744.80^a	16326.65^a
T2	22.40^ab	25.20^a	7.53^a	8.50^ab	12544.90^a	14161.00^ab
T3	21.80^b	24.00^ab	7.66^a	7.85^ab	12761.90^a	13078.10^ab
T4	21.60^b	23.80^ab	6.65^b	7.25^bc	11078.90^b	12078.50^bc
T5	23.60^a	25.30^a	6.98^b	7.32^bc	11628.70^b	12195.12^bc
T6	20.80^bc	22.10^bc	4.86^cd	5.50^cd	8096.70^cd	9163.00^cd
T7	21.50^b	22.50^bc	4.98^cd	5.70^cd	8296.70^cd	9496.20^cd
T8	22.90^ab	23.10^bc	6.99^b	7.35^bc	11645.30^b	12245.10^bc
T9	22.80^ab	23.50^bc	5.72^c	6.04^c	9529.50^c	10062.64^c
T10	19.80^c	20.00^c	4.65^d	5.07^d	7746.90^d	8446.62^d

*Mixed nano chelated fertilizer + Chemical fertilizer (T1), Mixed nano chelated fertilizer + Humic acid with irrigation (T2), Mixed nano chelated fertilizer + Humic acid as soil use (T3), Humic acid with irrigation + Chemical fertilizer (T4), Humic acid as soil use + Chemical fertilizer (T5), Humic acid with irrigation (T6), Humic acid as soil use (T7), Mixed nano chelated fertilizer (T8), Chemical fertilizer (T9), Control without fertilizer (T10)

**Non-identical letters show a significant difference at a 5% probability level using Duncan's Multiple Range Test.

The bunch length was significantly (P≤0.05) different among treatments (Table 4). The maximum bunch length was obtained in T5 and T2 treatments respectively during 2020 and 2021 (Table 4). The lowest bunch length was recorded in the control without fertilizer application (T10) (Table 4).

Fruit yield (kg/plant) was significantly (P≤0.05) different among treatments (Table 4). This trait is one of the important components to increase the yield of grapes per unit area. The results showed that the highest fruit yield per vine (8.25 and 9.8 kg in 2020 and 221) was obtained in T1 treatment. The lowest fruit yield per plant (4.65 and 5.07 kg in 2020 and 2021) was obtained in the control treatment without using fertilizer (T10), which is not statistically different from T6 and T7.

Fruit yield (kg/hectare) was significantly (P≤0.05) different among treatments (Table 4). The results showed that the highest fruit yield per hectare (13236 and 15318 kg in 2020 and 2021 respectively) was obtained in the T1 treatment. The lowest fruit yield per hectare (7242 and 7775 kg in 2020 and 2021 respectively) was obtained in the control treatment without using fertilizer (T10), which was not statistically significant with T6 and T7 treatments.

Fruit yield (kg/hectare) was significantly (P≤0.05) different among treatments (Table 4). The results showed that the highest fruit yield per hectare (13744 and 16326 kg in 2020 and 2021 respectively) was obtained in T1 treatment. The lowest fruit yield per hectare (7747and 8446 kg in 2020 and 2021 respectively) was obtained in the control treatment without using fertilizer (T10), which was not statistically significant with T6 and T7 treatments.

Table 5. Effect of different fertilizers treatments on quality traits of Yaghouti grape.

Treatments	TSS		TA	
T1*	22.60[a]	23.30[a]	0.35[e]	0.36[d]
T2	21.50[ab]	22.50[a]	0.37[e]	0.36[d]
T3	21.50[ab]	22.30[a]	0.37[de]	0.38[c]
T4	20.80[ab]	21.40[ab]	0.38[de]	0.37[cd]
T5	20.10[ab]	20.70[b]	0.39[cd]	0.38[c]
T6	19.50[bc]	19.80[b]	0.38 [c]	0.39[bc]
T7	18.40[c]	18.60[bc]	0.40 [b]	0.41[b]
T8	20.70[ab]	20.40[ab]	0.44 [a]	0.42[a]
T9	19.40[bc]	19.70[b]	0.40 [b]	0.39[bc]
T10	18.60[c]	18.10[c]	0.44 [a]	0.43[a]

*Mixed nano chelated fertilizer + Chemical fertilizer (T1), Mixed nano chelated fertilizer + Humic acid with irrigation (T2), Mixed nano chelated fertilizer + Humic acid as soil use (T3), Humic acid with irrigation + Chemical fertilizer (T4), Humic acid as soil use + Chemical fertilizer (T5), Humic acid with irrigation (T6), Humic acid as soil use (T7), Mixed nano chelated fertilizer (T8), Chemical fertilizer (T9), Control without fertilizer (T10)

**Non-identical letters show a significant difference at a 5% probability level using Duncan's Multiple Range Test.

Table 6. Effect of different fertilizers treatments on quality traits of Yaghouti grape.

Treatments	TSS/TA		pH	
T1*	63.14[a]	64.72[a]	3.81[a]	3.71[a]
T2	57.57[ab]	62.50[a]	3.72[ab]	3.67[ab]
T3	58.11[ab]	58.68[ab]	3.71[ab]	3.62[bcde]
T4	53.68[bc]	57.84[ab]	3.62[b]	3.53[fg]
T5	51.54[bc]	54.47[bc]	3.64[b]	3.63[bcd]
T6	46.32[cd]	50.77[c]	3.66[b]	3.64[bc]
T7	46.00[cd]	45.37[cd]	3.61[b]	3.60[cde]
T8	47.05[cd]	48.57[cd]	3.57[c]	3.58[def]
T9	48.50[c]	50.51[c]	3.63[b]	3.57[efg]
T10	42.27[d]	42.33[d]	3.55[c]	3.52[g]

*Mixed nano chelated fertilizer + Chemical fertilizer (T1), Mixed nano chelated fertilizer + Humic acid with irrigation (T2), Mixed nano chelated fertilizer + Humic acid as soil use (T3), Humic acid with irrigation + Chemical fertilizer (T4), Humic acid as soil use + Chemical fertilizer (T5), Humic acid with irrigation (T6), Humic acid as soil use (T7), Mixed nano chelated fertilizer (T8), Chemical fertilizer (T9), Control without fertilizer (T10)

**Non-identical letters show a significant difference at a 5% probability level using Duncan's Multiple Range Test.

Total soluble solid (TSS) was significantly (P≤0.05) different among treatments (Table 5). In T1 treatment, the highest TSS (22.6 and 23.3 % in 2020 and 2021 respectively) recorded. After that, T2, T3 and T4 ranked next. In the control treatment without using fertilizer (T10), the lowest percentage of TSS (18.6 and 18.1 % in 2020 and 2021 respectively) observed.

Titratable acidity (TA) was significantly (P≤0.05) different among treatments (Table 5), so that T10 (control treatment) and T8 had the highest amount of TA. The lowest level of acidity was in T1 and T2 treatments (Table 5).

TSS/TA ratio was significantly (P≤0.05) different among treatments (Table 6). The highest TSS/TA ratio (63.14 and 64.72 in 2020 and 2021) was in T1 and T2 (57.57 and 62.5 in 2020 and 2021 respectively) treatments. The lowest TSS/TA was obtained in the control treatment without using fertilizer (Table 6).

The pH trait of the fruit juice was significantly affected by different treatments (Table 6). The highest pH of the juice was in T1 treatment. The lowest juice pH occurred in control (T10) and T4 treatments.

Bunches per vine, bunch weight, berries No/bunch, and bunch length were statistically significant ($P \leq 0.05$) among treatments (Tables 3 and 4). The number of bunches per vine varied between 16-27 according to the treatments. So that the highest number of bunches per vine 27.23 and 26.20 (bunches/vine) was obtained with the treatment T1 and T3, in 2021 respectively.

The bunch weight varied between 240 – 330g according to the treatments. The bunch weight higher than 300g was recorded in T1, T2, T3, T4 and T5 treatments during 2021. The bunch weight in other fertilizer treatments was also superior to the control, and it is confirmed that the fertilizer treatments are effective on this trait in the Yaqouti grape.

The berries No/bunch varied between 259-297 according to treatments. The berries No/bunch higher than 280 recorded in combining treatments (T1 T2, T3, T4 and T5 in 2021). Fruit yield per vine was near to twice in some combination treatment in compare to control treatment. In some combinations of treatments, the vine fruit yield was almost double compared to the control treatment.

Humic acid is very effective on increasing soil fertility and absorption of elements (Noroozisharaf and Kaviani, 2018; Abourayya *et al*., 2020). The effect of humic acid on grape fruiting has been reported (Farg, 2006; Rabie and Negm, 2012; Ahmed *et al*., 2013; Popescu and Popescu, 2018). Ahmed et al. (2013) reported that bio and humic acid fertilizers of 5 ml per plant increase the leaf area, bunch weight and fruit yield in Superior grape variety. The simultaneous application of biofertilizers and humic acid increases the leaf surface, bunch weight and fruit yield in grapes more than their individual application. Akin (2011) reported that the application of humic acid greatly increased the yield, cluster weight, and berry weight in Horoz Karasi variety, but it had no significant effect on Göküzum variety. Bunch weight increased in grape cultivars with humic acid as foliar application (Popescu and Popescu, 2018). Reports have been published on the positive effect of nano nutrients on yield and yield components of grapes (Kok and Bal, 2016; Popescu and Popescu, 2018). Our results were consistent with the results of many researchers on bunch and berry characteristics of Yaqouti grape under humic, nano and chemical fertilizers. The results of this experiment showed that the combination of humic acid, nano fertilizer and chemical fertilizers increased the number, weight and length of the bunches and fruit yield, which was in line with the results of some mentioned researches.

Boron element has a major effect on the longitudinal growth of the cell, which leads to the growth of different plant organs (El-Aal *et al*., 2010). Zinc and boron cause a significant increase in the length and weight of the bunch in grape cultivars (Mostafa *et al*., 2006). In this study, the lowest bunch length was assigned to the control treatment, so no fertilizer was used in this treatment, it can be expected that this reduction in bunch length may be due to the lack of micronutrients.

By chelating essential elements, humic acid increases the absorption of elements and soil fertility. Humic acid also reduces the need for other fertilizers and improves soil air exchange and increases the conditions for the development of soil microorganisms (Zanin *et al*., 2019). Humic acid is used as fertilizer in certain plants, which increases the yield of trees (Fagbenro and Agboola, 1993). Several reports have shown that humic acid is effective in increasing the fruit yield of different grape cultivars (Saleh *et al*., 2006; Abada,. 2009; Abd El- Aziz, 2011; Popescu and Popescu, 2018). Many Research has been reported on the effect of nano-fertilizers on the yield of grapes (Sabir *et al*., 2014; Al-masri *et al*., 2018; Sefan and El-Boray, 2019). The results of this research showed that the use of humic acid plus chemical fertilizers or the use of nano fertilizers with chemical fertilizers led to an increase in yield in Yaqouti grape cultivar (Saleh *et al*., 2006; Kabeel *et al*., 2008; Asgharzade and Babaeian, 2012; Sabir *et al*., 2014; Al-masri *et al*., 2018; Popescu and Popescu, 2018; Sefan and El-Boray, 2019). Our results confirmed previous results with such treatments during 2013 (Arji *et al*., 2018). In this regard, the use of humic acid and mixed nano chelated fertilizers increased absorption and ultimately increased yield. Therefore, the use of chemical fertilizers alone can be more effective in increasing yield compared to the combined use of several types of fertilizers.

Humic acid has a positive effect on various aspects of photosynthesis by improving the production of sugar, protein and vitamins in the plant and plays a role in increasing the yield and quality of the product (Mayhew, 2004). Popescu and Popescu (2018) reported that humic acid as foliar application improved berry quality of grapevine. Nano fertilizer had a beneficial effect on fruit quantity traits in grape especially when applied twice (El-Masri *et al.*, 2021). Biofertilizer and humic acid improve cluster and berry characteristics of grape (Kok and Bal, 2016).

Akin (2011) reported that the application of humic acid increased brix and maturity index in Göküzum grapes, but in Horoz Karasi cultivar, brix and maturity index decreased compared to the control. The use of chemical fertilizer with humic acid increased the total soluble solids and TSS/TA and reduced the TA of grape (Popescu and Popescu, 2018). Sefan and El-Boray (2019) investigated the effect of Nano fertilizer in grape. Their results showed that total soluble solid and TSS/TA were increased with the use of nano fertilizer. During the full flowering period, the application of humic acid increased the titratable acidity and the maturity index of Italian grapes (Ferrara and Brunetti, 2010). Abd El-Razek et al. (2011) evaluate different level of nitrogen and potassium effect on "Crimson Seedless" grapes. Their results showed that with the increase in potassium supply, the soluble solids increased, but the acid concentration decreased. Potassium plays an important role in the balance of other elements and sugar transport in grapes. More supply of potassium increases the content of total dissolved solids and reduces the total acidity of the berries (Martín *et al.*, 2004; Zlámalová *et al.*, 2015). Conradie and Saayman (1989) conducted long-term research on the effect of NPK mineral fertilization on the quality of grapes. Their results showed that specific relationships of antagonism were among nutrient ions, so that potassium ions played an important role in reducing nitrogen and acidity of grapes. In Round seedless grapes, 1% KNO3 foliar spraying gave the highest grape yield, while the highest quality traits like TSS and TA were obtained with 2% KNO3 foliar spraying (Aydın *et al.*, 2005).

Ahmed et al. (2013) reported that bio- and humic fertilizers of 5 ml per plant increase the percentage of total soluble solids and decrease acidity in grapes of the Superior variety. However, the simultaneous application of biofertilizers and humic acid was more effective in increasing the percentage of total soluble solids and reducing acidity in the fruit than using them alone. These results were in line with our results on quality traits of Yaqouti grape cultivar, where higher TSS and TSS/TA recorded in combination treatment of humic acid and chemical fertilizer and nano fertilizer + chemical fertilizers.

Bybordi and Shabanov (2010) foliar spraying with MgSO4xH2O, ZnSO4.7H2O (1%) on Sahebi, Soltani and Ghezel grape cultivars, increased total soluble solids. The highest pH value was recorded from foliar spraying with 0.80% magnesium sulfate and 0.40% zinc sulfate. Nikkhah et al. (2013) reported that the application of zinc and boron is highly effective on the amount of total soluble solids in grapefruit, but it did not affect pH and titratable acid. In this experiment, pH decreased in the vine under individual treatment and control conditions. This result was consistent with Bybordi and Shabanoy (2010) result.

4. Conclusion

In conclusion, the highest number of berries per bunch, number of bunches per vine, bunch weight, bunch length, yield per vine, and yield per hectare were recorded in Yaqouti grapes in the treatment of mixed chelated nano fertilizer + chemical fertilizer (T1). The results showed that the weight of the bunch with more than 300 g, the highest number of berries per bunch and the higher yield per plant were obtained by nano fertilizer + chemical fertilizer (T1), nano fertilizer + humic acid with irrigation (T2), nano fertilizer + humic acid as soil use (T3) and humic acid with irrigation + chemical fertilizer (T4). Using a combination of treatments was more beneficial than single treatments. In this research, the treatments of nano fertilizer + chemical fertilizer (T1) and nano fertilizer + humic acid as soil use (T3) are recommended for gardeners, respectively.

Qualitative properties such as total soluble solids and TSS/TA were higher in most combined treatments, especially in the treatment of nano fertilizer + chemical fertilizer (T1), which was at the top. In general, treatments of nano fertilizer + chemical fertilizer (T1), nano fertilizer + humic acid with irrigation (T2) are primarily recommended for the Yaqouti grape variety production. Treatments of nano fertilizer + humic acid with soil use (T3) and humic acid with irrigation + chemical fertilizer (T4) were recommended.

Conflict of interests

All authors declare no conflict of interest.

Ethics approval and consent to participate

No human or animals were used in the present research.

Consent for publications

All authors read and approved the final manuscript for publication.

Availability of data and material

All the data are embedded in the manuscript.

Authors' contributions

All authors had an equal role in study design, work, statistical analysis and manuscript writing.

Informed consent

The authors declare not to use any patients in this research.

Funding/Support

This study was supported by Razi University, Kermanshah, Iran.

Acknowledgement

This article was achieved based on the material and equipment of Razi University, that the authors thanks it.

References

Abada M.A.M. 2009. Reducing the amount of inorganic N fertilizers in Superior grape vineyard by using organic and biofertilizers and humic acid. Egyptian Journal of Agricultural Research 87(1):17-344.

Abd El-Aziz Y.Z. 2011. Response of Thompson seedless grapevines to application of organic fertilizer humic acid and some biofertilizers. Ph. D. Thesis. Faculty of Agriculture Minia University, Egypt.

Abd El-Razek E., Treutter D., Saleh M.M.S., El-Shammaa M., Amera A.F., Abdel-Hamid N. 2011. Effect of nitrogen and potassium fertilization on productivity and fruit quality of 'crimson seedless' grape. Agriculture and Biology Journal of North America. 2(2): 332-342. https://doi.org/10.5251/abjna.2011.2.2.330.340

Abourayya MS., Kaseem N.E., Mahmoud T.S.M., Rakha A.M., Eisa R.A., Amin O.A. 2020. Impact of soil application with humic acid and foliar spray of Milagro bio-stimulant on vegetative growth and mineral nutrient uptake of Nonpareil almond young trees under Nubaria conditions. Bulletin of the National Research Centre. 44, 38. https://doi.org/10.1186/s42269-020-00296-x

Ahmed F.F., Ragab M.A., Merwad E.A.M., Mekawy A.Y. 2012. Improving productivity of Thompson seedless grapevine by application of some vitamins, humic acid and farmyard manure extract. Minia Journal of Agricultural Research and Development. 32(3):131 - 145.

Ahmed H.M.A., Faissal, F.A., Moawad F.E., Abdelaal M.A. 2013.The beneficial effects of some humic acid, Em1 and weed control treatments on fruiting of superior grapevines. Stem Cell. 4(3): 25-38.

Akin A. 2011. Effects of cluster reduction, herbagreen and humic acid applications on grape yield and quality of HorozKarasi and Göküzüm grape cultivars. African Journal of Biotechnology. 10(29): 5593-5600.

Anon, 1997. Official Methods of Analysis of the Association of Official analytical Chemists, AOAC, Gaithersburg, MD, 16theds.

Arji I., Karimpour Kolejooei S., Nejatian M.A. 2020. Investigating the effect of humic acid, nano fertilizer and chemical fertilizer treatments on the quantitative and qualitative characteristics of Yaqouti grapes in Kermanshah province. Extension Grape Journal. 1(1):1-8.

Asgharzade A., Babaeian M. 2012. Investigating the effects of humic acid and acetic acid foliar application on yield and leaves nutrient content of grape (*Vitis vinifera* L.). African Journal of Microbiology Research 6(31): 6049-6054.https://doi.org/10.5897/AJMR12.425

Aydın S., Akgül A., Çoban H. 2005. The effects of foliar application of potassium (K) on yield and quality of vineyards in Alaehir district. C.B.Ü. Applied Natural Science Institıte Publication. 1: 23-27.

Bajeli J., Tripathi S., Kumar A., Tripathi A., Upadhyay R.K. 2016.Organic manures a convincing source for quality production of Japanese mint (*Mentha arvensis* L.). Industrial Crops and Products. 83: 603-606. https://doi.org/10.1016/j.indcrop.2015.12.064

Bybordi A., Shabanov A. 2010. Effects of the foliar application of magnesium and zinc on the yield and quality of three grape cultivars grown in the calcareous soils of Iran. Notulae Scientia Biologicae. 2(1):81-86. https://doi.org/10.15835/nsb223575

Conradie W.J., Saayman D. 1989. Effect of long-term nitrogen, phosphorus and potassium fertilization on Chenin Blanc vines II. Leaf analyses and grape composition. American Journal of Enology and Viticulture. 40:91-98.

da Silva Júnior S., Stamford N.P., Oliveira W.S., Silva E.V.N., Santos C.E.R.S., de Freitas A.D.S., da Silva V.S.G. 2018. Microbial biofertilizer increases nutrient uptake on grape (*Vitis labrusca* L) grown in an alkaline soil reclaimed by sulfur and Acidithiobacillus. Australian Journal of Crop Science.12(10):1695-1701. https://doi.org/10.21475/ajcs.18.12.10.p1454

El-Aal F.S.A., Shaheen A.M., Ahmed A.A., Mahmoud A.R. 2010. Effect of foliar application of urea and amino acids mixtures as antioxidants on growth and characteristics of Squash. Research journal of agriculture and biological sciences. 6:583-588.

El Masri I. Y., Al Akiki M., Jamal Eldin N., Ghantous G., El Sebaaly Z., Hammoud M., Sassine Y.N. 2021. Conventional vs. nano-Ca fertilizers effects on traditional table grape Tfiefihi. Journal of Plant Nutrition. 44(20): 3020-3033. https://doi.org/10.1080/01904167.2021.1936032

El-Masri I.Y., Samaha C., Sassine Y. N., Assadi F. 2018. Effects of nano-fertilizers and greenhouse cultivation on phenological development-stages and yield of seedless table grapes varieties. In IX International Scientific Agriculture Symposium" AGROSYM 2018", Jahorina, Bosnia and Herzegovina, 4-7 October 2018. Book of Proceedings (pp. 192-196). University of East Sarajevo, Faculty of Agriculture.

Fagbenro J.A., Agboola A.A. 1993. Effect of different levels of humic acid on the growth and nutrient uptake of teak seedlings. Journal of Plant Nutrition. 16:1465-1483. https://doi.org/10.1080/01904169309364627

Farg S.G. 2006. Minimizing mineral fertilizers in grapevine farm to reduce the chemical residuals in grapes. M.Sc. Thesis, Institute of Environmental studies and Research. Ain Shams University, Egypt. 67 p.

Ferrara G., Brunetti G. 2010. Effects of the times of application of a soil humic acid on berry quality of table grape (*Vitis vinifera* L.) cv Italia. Spanish Journal of Agricultural Research. 8:817-822. https://doi.org/10.5424/1283

Franjic S. 2018. Importance of environmental protection on the global level. Scientific Journal of Research and Reviews. 1(2): SJRR.MS.ID.000506. https://doi.org/10.33552/SJRR.2018.01.000506

Kabeel H., Abd El- Atif. F.M., Baza M.S.M. 2008. Growth, fruiting and nutritional status of "Le-Conte" pear trees in response to mineral and humate fertilizers. Annals of Agricultural Science. 46(2):139-156.

Kannaiyan S. 2002. Biotechnology of Biofertilizers. Alpha Science International Ltd Pangabourne England. Springer Dordrecht. 376P.

Khodabakhsh Zadeh S., Rasoli M., Maleki M. 2013. Effect of iron nano fertilizer on some growth factors and antioxidant enzymes of grape. First National Conference on Nanotechnology Benefits and Applications. Hamedan, Hegmataneh Environment Evaluators Association. http://www.civilica.com/Paper-NANOO01-NANOO01_033.html

Kok D., Bal E. 2016. Effects of foliar seaweed and humic acid treatments on monoterpene profile and biochemical properties of cv. Riesling Berry (*V. vinifera* L.) throughout the maturation period. Journal of Tekirdag Agricultural Faculty. 13(2): 67-74.

Latifi N., Mohammad Dost H. 1998. Effect of time and amount of nitrogen fertilizer on the yield of three wheat cultivars under dryland conditions. Journal of Agricultural Sciences and Natural Resources of Gorgan. 5(1-2):82-88.

Maccarthy P. 2001. The principles of humic substances. Soil Science. 166:738-751. https://doi.org/10.1097/00010694-200111000-00003

Mahdavi S., Karim, R., Valipouri Goudarzi A. 2022. Effect of nano zinc oxide, nano zinc chelated and zinc sulfate on vineyard soil Zn- availability and grapevines (*Vitis vinifera* L.) yield and quality. Journal of Plant Nutrition. 45(13): 1961-1976. https://doi.org/10.1080/01904167.2022.2046081

Manisalidis I., Stavropoulou E., Stavropoulou A., Bezirtzoglou E. 2020. Environmental and health impacts of air pollution. A Review. Frontiers in Public Health. 8: 14. https://doi.org/10.3389/fpubh.2020.00014

Martín P., Delgado R., Gonzalez M.R., Gallegos J.I. 2004. Colour of 'Tempranillo' grapes as affected by different nitrogen and potassium fertilization rates. Acta Horticulturae. 652:153-160. https://doi.org/10.17660/ActaHortic.2004.652.18

Mayhew L. 2004. Humic substances in biological agriculture. A scientific review. Part 1. Acres USA, 34(1):11-14.

Mekawy A.Y.H. 2012. Attempts for improving yield quantitively and qualitatively of Thompson seedless grapevines by application of some antioxidants with humic acid and farmyard manure extract. Ph. D. Thesis. Faculty of Agriculture Minia University, Egypt. 155 p.

Mostafa E.A.M., El-shamma M.S., Hagass L.F. 2006. Correction of boron deficiency in grape vines of Bez El-Anze cultivar. American-Eurasian Journalof Agricultural and Environmental Sciences. 1(3):301-305.

Mostashari M. 2012. Effect of some macro and micro elements of qualitative and quantitative properties of Currants grapes in Qazvin. Agricultural and Natural Resources Journal. 14(2):29-34.

Nikkhah R., Nafar H., Rastgoo S., Dorostkar M. 2013. Effect of foliar application of boron and zinc on qualitative and quantitative fruit characteristics of grapevine (*vitis vinifera* L.). International Journal of Agriculture and Crop Sciences 6(9):485-492

Noroozisharaf A., Kaviani M. 2018. Effect of soil application of humic acid on nutrients uptake, essential oil and chemical compositions of garden thyme (*Thymus vulgaris* L.) under greenhouse conditions. Physiology and Molecular Biology of Plants. 24(3):423-431. https://doi.org/10.1007/s12298-018-0510-y

Popescu G.C., Popescu. M. 2018.Yield, berry quality and physiological response of grapevine to foliar humic acid application. SciELO journals. https://doi.org/10.1590/1678-4499.2017030

Rabie A.M., Negm A.A. 2012. Effect of some organic treatments on some grapevine cultivars. Ph. D. Thesis. Faculty of Agriculture Cairo University Egypt. 125 pp.

Rahman K.M.A., Zhang D. 2018. Effects of fertilizer broadcasting on the excessive use of inorganic fertilizers and environmental sustainability. Sustainability. 10, 759. https://doi.org/10.3390/su10030759

Sabir A., Yazar K., Sabir F., Kara Z., Yazici M.A., Goksu N. 2014. Vine growth, yield, berry quality attributes and leaf nutrient content of grapevines as influenced by seaweed extract (Ascophyllum nodosum) and nanosize fertilizer pulverizations. Scientia Horticulturae. 175:1-8. https://doi.org/10.1016/j.scienta.2014.05.021

Saleh M.S., El- Ashry S., Gomaa A.M. 2006. Performance of Thompson seedless grapevines as influenced by organic fertilizer, humic acid and biofertilizers under sandy soil conditions. Research Journal of Agriculture and Biological Sciences 2 (6): 467 - 741.

Samavat S., Malakoti M.J. 2005. The need for organic acids (humic acid and fulvic acid) to increase the quantity and quality of agricultural products. Technical publication 463. Soil and Water Research Institute. pp. 13.

Sefan R.F., El-Boray, M.S. 2019. Effect of potassium nano fertilizer on yield and berry qualities of 'flame seedless' grapevines. Journal of Plant Production. 10(11): 929-934. https://doi.org/10.21608/jpp.2019.68553

Singh R., Srivastava P., Verma P., Singh P., Bhadouria R., Singh V.K., Singh H., Raghubanshi A.S., 2020. Exploring soil responses to various organic amendments under dry tropical agroecosystems, Chapter 21 - Eds by Prasad, M.N.V. and Pietrzykowski, M. In Climate Change and Soil Interactions, Elsevier 583-611 https://doi.org/10.1016/B978-0-12-818032-7.00021-7

Uddin M.M., Zakee M.C.M., Zavahir J.S., Marikar F.M.M.T., Jahan I. 2021. Heavy metal accumulation in Rice and aquatic plants used as human food: A General Review. Toxics. 9: 360. https://doi.org/10.3390/toxics9120360

Vatankhah A., Mohammadkhani A., Hooshm S., Kiani S. 2016. Study the effect of humic acid and zinc on the quantity and quality of fruit, photosynthetic pigments and mineral concentrations of grapevine cv. 'Asgari', Journal of Crops Improvement 18 (2): 303-318. https://doi: 10.22059/jci.2016.56570

Vikram N., Sagar A., Gangwar C., Husain R., Kewat R.N. 2022. Properties of humic acid substances and their effect in soil quality and plant health. In: Makan, A., editor. Humus and Humic Substances - Recent Advances. London: IntechOpen. https://doi.org/10.5772/intechopen.105803

Yener H., Coban H., Cakıcı H., 2008. The effects of foliar potassium (K) applications on yield and N, P, K contents of leaves of Sultani Çekirdeksiz (*Vitis vinifera* L.). Ege Üniversity Agricultural Faculty Publication. 45: 21-25.

Zanin L, Tomasi N, Cesco S, Varanini Z and Pinton R., 2019. Humic substances contribute to plant iron nutrition acting as chelators and biostimulants. Frontiers in Plant Science. 10:675. https://doi.org/10.3389/fpls.2019.00675

Zaremanesh H., Akbari N., Eisvand H., Ismaili A., Feizian M. 2020. The Effect of humic acid on soil physicochemical and biological properties under salinity stress conditions in pot culture of Satureja khuzistanica Jamzad. Ecopersia 8(3):147-154.

Zhu Q., Xie, X., Xu Y., 2022. Fertilization regulates grape yield and quality in by altering soil nutrients and the microbial community. Sustainability 14, 10857. https://doi.org/10.3390/su141710857

Zlamalova T., Elbl J., Baron M., Belíkova H., Lampír L., Hlusek J., Losak T. 2015. Using foliar applications of magnesium and potassium to improve yields and some qualitative parameters of vine grapes (*Vitis vinifera* L.). Plant, Soil and Environment. 61(10): 451-457. https://doi.org/10.17221/437/2015-PSE

HOW TO CITE THIS ARTICLE

Arji I., Karimpour Kalehjoobi S., Nejatian M.A., Upadhyay T.K. 2022. Yield and Yield Components of Grapevines as Influenced by Mixed Nano Chelated Fertilizer, Humic Acid and Chemical Fertilizers. *Agrotechniques in Industrial Crops* 2(3): 156-165**.** 10.22126/ATIC.2023.8478.1076