ISPEC Tarım Bilimleri Dergisi, 7(2): 280-293, 2023
ISPEC Journal of Agricultural Sciences, 7(2): 280-293, 2023
DOI: https://doi.org/10.5281/zenodo.8020415

The Effects of Some Plant Nutrition Applications on the Bioactive Compounds of Grapevine (*Vitis vinifera* L.)

Elver AKCAN[1], Ethem Omer BAS[2], Ruhan Ilknur GAZIOGLU SENSOY[2*]
[1]Van Yuzuncu Yıl University, Horticultural Sciences, The Institute of Natural and Applied Sciences, Van
[2]Van Yuzuncu Yıl University, Horticulture Department, Agricultural Faculty, Van
[*]Sorumlu Yazar (Corresponding author): rigazioglu@yyu.edu.tr

Abstract
The basis of the study was formed by the application of Humic Acid (HA) and Rock Phosphate (RP), which are used in different doses as organic plant nutrition material, to the vineyard in early spring. As a plant material, the local variety Sepirze (Vitis vinifera L.), which is extensively produced in Mardin/Türkiye, is used for table consumption as well as being used for wine in small businesses. Analyzes were made to determine the effects of plant nutrition applications on acidity, pH, TSS and maturity index values, total phenolic content, and antioxidant activity in grape berries; The phenolic content and antioxidant activity were analyzed separately in the berry flesh, skin, and seed sections, and it was tried to determine which part of the fruit was more affected by the applications. When the physicochemical prosperities of the grains were evaluated, the TSS content was found to be significantly (P<0.01) varied among the applications. In addition, it was observed that plant nutrition applications had an increasing effect on the maturity index when compared to control vines without any application. Considering the different parts of the grape, phenolic and antioxidant amounts were found to be significantly (P<0.01) different. The highest phenolic and antioxidant ratios were determined in the seed, followed by skin and flesh. Plant nutrition applications increased the phenolic content in whole grape berries; Moreover, the antioxidant activity was found to be significantly varied among the applications.

Research Article

Article History
Received :28.12.2022
Accepted :31.01.2023

Keywords
Antioxidant
grapevine
humic acid
phenolic
rock phosphate

1. Introduction

As a productive economic plant with excellent agricultural qualities, the grape is one of the most important horticultural crops. It is mostly grown for the wine industry and processed into juice, wine, or raisins. The grape is a fruit that is gaining popularity and is a substantial source of nutritional antioxidants, including polyphenols and anthocyanins, as well as dietary elements that are biologically active (Orak, 2007). Antioxidants' main function is to prevent free radicals from starting or spreading oxidizing chain reactions, which delays the oxidation of other molecules and may lessen oxidative damage to the body. Some substances delay or inhibit the oxidation of free radicals in biological systems (Namiki, 1990). Such oxidative damage may play a major role in the onset of numerous chronic illnesses, including cancer and cardiovascular illnesses. Many epidemiological studies have revealed a link between the consumption of fruits and vegetables and several diseases (Papas, 1999). The term "phenolic compounds" refers to molecules that are naturally produced by microorganisms or plants that have a phenyl ring backbone with a hydroxyl group or another substitution and make up a significant portion of the phenolic material in grapes (Conde et al., 2007). The growing environment and seasonal conditions have the greatest impact on a grape cultivar's phenolic content. Particularly, light and temperature have a significant impact on the grape berry's phenolic content. Although various viticulture treatments, including strategic irrigation usage, cover crop use, row orientation, trellising, and other canopy alterations may improve plant interaction with light and temperature, these characteristics are the most challenging to control. Hence, one of the key issues in modern viticulture is the development of management systems for maximizing grapevine phenolic content in difficult situations. Another crucial study area that may lead to significant advancements in the future is the development and application of standardized instruments to evaluate the flavonoids in grape berries both quantitatively and qualitatively (Teixeira et al., 2013).

Phenolic and antioxidant substances in different parts of the grape berry were identified in different studies (Baysal and Yildiz, 2003; Aktas et al., 2014; Ozturk et al., 2014; Vural, 2011) and the proportions were as: seed> skin> fruit flesh. Studies investigating the effect of zinc on the biochemical properties of the fruit have been reported to cause a reduction in phenolic and antioxidant rates of application (Erdem and Ozturk, 2012). In a study investigating the effects of organic and inorganic fertilizer sources on phytochemical changes in melon production, it has been reported that the applications are not significantly different (Ozgen et al., 2014).

In a study conducted by Bas (2018), the total amount of antioxidants in ten different local grape varieties grown in the Van region was examined, and it was determined that the total antioxidant rate was 91.89 mg g^{-1} in the Siyah kismis variety, and 42.23 mg g^{-1} in the Beyaz keçimemesi variety, the lowest. Gazioglu Sensoy et al. (2018) examined the total phenol content in some local grape forms and found that the total phenol amount was 73.60 mg 100 g^{-1} in the seed, 58.73 mg 100 g^{-1} in the skin and 40.52 mg 100 g^{-1} in grape must. Again this study examined the total antioxidant content of some local grape varieties, and the highest antioxidant average was 1009.58 μmol TE g^{-1} in the seed then 310.92 μmol TE g^{-1} in the skin, and the lowest in grape must 204.39 μmol TE g^{-1} was found. Duran (2014), in his study, examined the total antioxidant amount in the seeds and skins of different grape varieties and determined that the highest amount of antioxidants was in the seeds and that the total amount of antioxidants in grape skins was lower than in the seeds. Based on the Trolox Equivalent Antioxidant Capacity (TEAC) antioxidant activities, the antioxidant activities of different grape varieties were examined and they determined that the antioxidant ratios were between 2.29 mmol L^{-1} and 5.74 mmol L^{-1}. Gazioglu Sensoy (2012), in a study in which the phenolic content and antioxidant activity of some grape varieties were tried to be determined, Silfoni, Agin beyazı, Kis kirmizisi, Okuzgozu, and Ercis grape varieties were used, and the highest antioxidant activity was in cv. Kis kirmizisi (5.74 ± 2.38 TEAC mmol L^{-1}), but the lowest one was in cv. Ercis (2.78 ± 0.09 mg L^{-1}. Yegin and Uzun, (2018), the total phenolic content (mg GAE 100 g^{-1}) in the extracts obtained from the skin, seed, and berry pulp of 12 grapes (7 varieties, 5 wild types) genotypes grown in Türkiye were examined, and the highest total phenol content was determined as an average of 1390 mg GAE 100 g^{-1} was determined in the seed, 691 mg GAE 100 g^{-1} in the skin, and 333 mg GAE 100 g^{-1} in the grape flesh. Ozdemir et al. (2018), stated that 11 different fertilizers (green manure (ervil), green manure (barley), green manure (ervil+barley), farmyard manure, baktograd, NP, and three different organomineral quality fertilizers) were used in the Okuz gozu variety, and total phenolic, flavonoid, anthocyanin and antiradical activities were examined in grape berry flesh, skin, and seed. They detected the highest total phenol content (198.74 µg GAE mg^{-1}) in the seed. Perestrelo et al. (2018) tried to determine the potential of phenolics and antioxidants on grape ripening by spectrophotometric methods in the berries of Malvasia, Sercial, and Tinta negra grape varieties and they reported that the number of antioxidants decreased and the lowest amount of antioxidants was found at 56 days.

This study was carried out to determine whether or not some plant nutrition materials applied in different amounts would cause any changes in the total phenolic and antioxidant structure of the grape, and the different parts of grapes were handled concerning these materials. The effects of different nutritional applications (Humic acid and Rock phosphate) with different doses on the biochemical structure of different parts (grape berry flesh, skin, and seed) of the grapes in cv. Sepirze grapevine.

2.Materials and Methods

The experiment was carried out at Nusaybin town of Mardin province in Türkiye between latitudes 37° 02' and 37° 13' north and longitudes 41° 03' and 41° 45' east. There was a significant difference in average summer and winter temperatures in the region. From the beginning of April until the beginning of November, there are days with temperatures above 30 °C. In the summer, evaporation is accelerated by the low relative humidity. The low humidity contributes to the significant temperature difference between day and night. The soil characteristics of the vineyard region is given at Table 1.

A local grape variety called Sepirze was used as plant material (Figure 1). It is a cultivar with long, oval berries in a white-red (mottled) hue, an average fruit weight of 4.59 g, and a cluster weight of 241.17 g. It is regarded as a table grape and raisin in the area. The trial was carried out in Nusaybin town in the province of Mardin, at a private vineyard (Figure 2). The Rock phosphate (RP) used is a natural product belonging to the region and is supplied from Mount Mazi (Mardin), Türkiye.

Figure 1. Sepirze grape cultivar

Figure 2. Image from vineyard

Table 1. Soil characteristics of the vineyard area

pH	Total salt (µS cm^{-1})	Lime (%)	Org. Matter (%)	P (ppm)	N (ppm)
7.94	379.00	51.25	2.46	85.84	0.20
Cr (ppm)	**Cu (ppm)**	**Fe (ppm)**	**Mn (ppm)**	**Ni (ppm)**	**Pb (ppm)**
0.01	2.04	7.79	42.64	1.69	1.30
Zn (ppm)	**Ca (ppm)**	**Cd (ppm)**	**K (ppm)**	**Mg (ppm)**	**Na (ppm)**
1.43	3638.00	2.42	211.00	193.63	11.90

In the study, commercially packaged agricultural humic acid and commercially packaged rock phosphate were used. Although Humic acid is not used as the main fertilizer in plant nutrition, it is a plant nutrition product that has been observed to have a stimulating effect on the uptake of macroelements Na, P, and K and other secondary and trace elements by the plant. Because of this feature, it was used together with rock phosphate in the study, the chemical properties of humic acid used in the study are given below (Table 2).

Table 2. Chemical properties of Humic acid used in the study

pH	Organic Substance (%)	Salt (%)	Nitrogen (%)	Phosphorus (ppm)	K (%)	Ca (%)	Mg (%)	Mn (%)	Fe (ppm)
3.50	86.0	-	1.00	0.004	0.09	3.00	0.57	200	3.50

The rock phosphate used in the study is a natural source of the region and its source is located in Mazıdagı. The chemical properties of the rock phosphate used in the study are given below (Table 3).

Table 3. Chemical properties of Rock phosphate used in the study (%)

Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	K_2O	CaO	TiO	MnO	Fe_2O_3
0.6	0.2	0.4	2.8	31.9	<0.1	51.6	<0.1	<0.1	0.2

The study was planned as a randomized complete block design with 4 replications, 3 grapevines were used in each replicate. As a basic fertilizer, 80 gr Di-ammonium-phosphate per grapevine, 55 gr Nitrogen (urea) per grapevine, and 90 gr / Potassium (K_2SO_4) per grapevine were used, and also 55 gr Nitrogen (urea) was used 2 months before harvest.

Ten applications were applied to grapevines were as:

1. Control (no fertilizer)
2. Basic fertilizer (BF)
3. Rock phosphate (RP) (250g per grapevine) + BF
4. RP (500 g per grapevine) + BF
5. Humic acid (HA) (300 g per grapevine) + BF
6. HA (600 g per grapevine) + BF
7. RP (250 g per grapevine) + HA (300 g per grapevine) +BF
8. RP (250 g per grapevine) + HA (600 g per grapevine) +BF
9. RP (500 g per grapevine) + HA (300 g per grapevine) +BF
10. RP (500 g per grapevine) + HA (600 g per grapevine) +BF

2.1. Total phenolic content

Total phenolic content was determined by spectrophotometer by modifying the Folin-Ciocaltaeu calorimetric method (Swain and Hillis, 1959). About 50 g of grape berry flesh was fragmented and 1 ml of grape juice from each sample was transferred to centrifuge tubes. About 5 g of grape seed or skin samples were fragmented and 1 g from each sample was transferred to centrifuge tubes. Then, 5 ml of methanol was added and centrifuged at 10 000 rpm for 10 minutes, and the supernatant remaining on top was taken. 150 µl of supernatant is taken from the part, 2400 µl of distilled water, 150 µl of Folin cioucelta (1:10 solution) are added, 3-4 seconds vortex is made, 300 µl of 20% sodium carbonate is added, and it is kept in the dark at room temperature for 60 minutes, then the absorbance of the resulting solution was read spectrophotometrically at 725 nm wavelength and the total amount of phenolic substance was expressed as gallic acid equivalent (GAE) mg $100g^{-1}$ fresh weight (FW). The analyses were carried out in 3 replications for each cultivar.

2.2. Total antioxidant capacity

About 50 g of grape berry flesh was fragmented and 1 ml of grape juice from each sample was transferred to centrifuge tubes. About 5 g of grape seed or skin samples were fragmented and 1 g from each sample was transferred to centrifuge tubes. Then, 5 ml of methanol was added and centrifuged at 10 000 rpm for 10 minutes, and the supernatant remaining on top was taken. The FRAP (Ferric Reducing Antioxidant Power) reagent was prepared with a 300 mmol L^{-1} acetate buffer (pH 3.6), 20 mmol L^{-1} ferric chloride ($FeCl_3.6H_2O$), and 10 mmol L^{-1} TPTZ (2,4,6-tripyridyl-s-triazine in 40 mmol L^{-1} hydrochloric acid) at a ratio of 10:1:1. The mixture prepared for ABTS analysis with 2850 µl of FRAP reagent for samples was diluted 50 times with ethanol, then 150 µl of the sample was mixed and left at room temperature for 30 minutes. The resulting ferrus tripyridyltriazine complex was measured at 593 nm in the spectrophotometer and the results were reported as µmol Trolox equivalent (TE) g^{-1} FW (Lutz et al., 2011). 20 Trolox concentration range has been studied as 0-500 ppm.

2.3. Statistical analysis

The measurement, weighing, and laboratory analysis results obtained in the study were subjected to variance analysis (ANOVA) with the SPSS package program (IBM SPSS Statistics 21.0). Duncan's multiple comparison test was used to determine the differences between the means according to the P<0.01 and P<0.05 levels. Significance levels, mean values, and ± standard error values are indicated in the tables. To determine the correlation between the data, the Bivariate Correlations procedure computed Pearson's correlation coefficient (Eckstein, 2013).

3.Results and Discussion

3.1. Physicochemical traits

According to the applications, when pH, titratable acidity, TSS, and maturity index values are considered, Ph, Titratable Acidity, and Maturity Index were found to be insignificant. While TSS is found to be significant; The highest value was determined in 500 g RP+600 g HA+BF application and the lowest values were determined in the Control vines. While the Maturity Index was observed at the highest in the 600 g HA+BF application, the control application was again found to have the lowest maturity index value.

Table 4. Effect of some plant nutrition applications on the physicochemical traits of grapes

Applications	pH ^{ns}	Titratable	TSS**	Maturity
(1) Control	3.37±0.04	0.93±0.06	15.33±0.45 C	16.68±0.92
(2) Basic Fertilization (BF)	3.47±0.11	0.71±0.25	16.67±0.84 BC	17.78±1.61
(3) 250g of RP + BF	3.42±0.11	1.15±0.28	18.00±0.76 AB	17.79±3.19
(4) 500g of RP + BF	3.32±0.06	0.69±0.23	16.72±0.31 BC	18.29±0.57
(5) 300 g HA+BF	3.54±0.09	0.93±0.06	18.58±0.28 A	20.30±1.44
(6) 600 g HA+BF	3.36±0.03	0.95±0.10	19.13±0.77 A	20.86±2.68
(7) 250g RP+300g HA+BF	3.41±0.07	0.87±0.33	18.50±0.12 A	17.11±3.27
(8) 250g RP+ 600g HA+BF	3.49±0.09	1.02±0.18	18.75±0.42 A	19.65±2.54
(9) 500 g RP+300 g HA+BF	3.26±0.05	1.04±0.18	19.50±0.65 A	20.22±2.94
(10) 500 g RP+600 g HA+BF	3.49±0.04	1.04±0.13	19.54±0.54 A	20.08±3.54
Means	**3.41±0.02**	**0.93±0.06**	**18.14±0.27**	**18.97±0.74**

**(P<0.01) Values preceded by the same letter in the vertical do not differ significantly according to Duncan's multiple comparison test

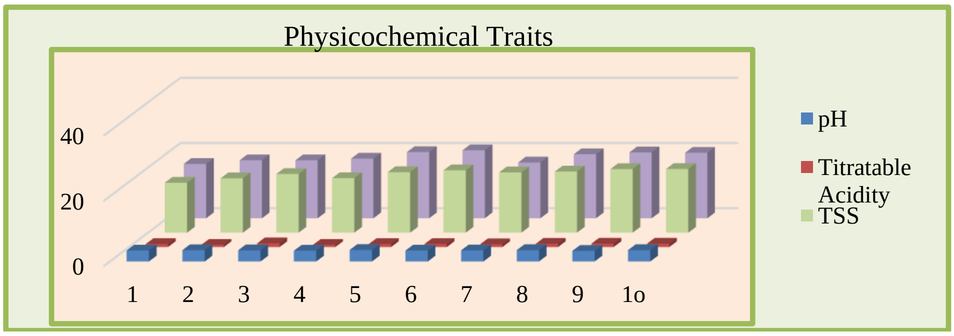

Figure 3. Physicochemical traits of grapes fertilized with different fertilizer combinations

3.2. Total phenolic capacity

Total phenolic content was found to be significantly different when the parts of the grape were evaluated over the averages (Table 5, Figure 4). While the highest phenolic content was found in the seeds in all applications, the least phenolic content was detected in the berry flesh. When the parts of the grape berry are considered based on applications, the order is again in the form of seed>skin>flesh; R.P. (500g per grapevine) + H.A. (300g per grapevine). were found to be significant (P<0.01) in all except for the application. When the rates were evaluated as %, a ratio of 54.05%>28.18>17.77 was formed for seed>skin>flesh. When evaluated in terms of applications, the highest phenolic content was found in grape berry flesh at R.P. (500g per grapevine) + H.A. (600g per grapevine) application, Humic acid (300g per grapevine) application in grape berry skin, and Rock Phosphate (500g per grapevine) application in grape seed.

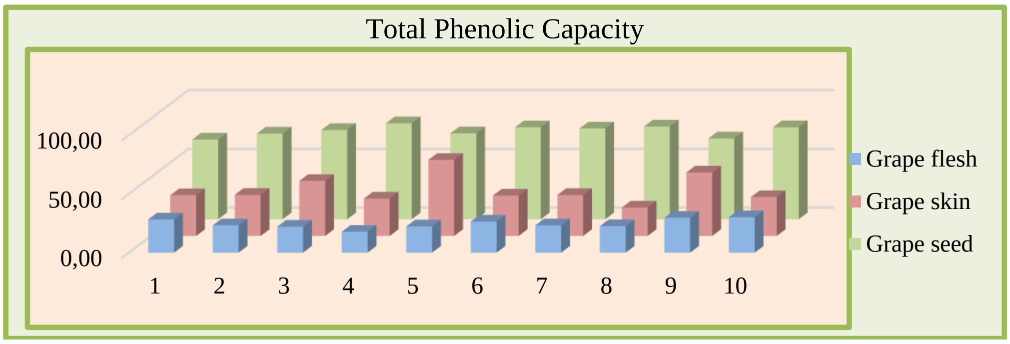

Figure 4. Total phenolic matter contents (mg 100 g^{-1} FW) in different parts of grapes fertilized with different fertilizer combinations

Table 5. Effect of some plant nutrition applications on total phenolic content

Applications	Total Phenolic Contents (mg 100 g-1 FW)						TOTAL
	Grape berry flesh**		Grape berry skin**		Grape Seed**		
	Mean	%	Mean	%	Mean	%	
(1) **	28.22±1.18 AB b	21.58	34.70±5.29 A b	26.54	67.85±6.36 B-D	51.88	130.77
(2) **	23.25±3.55 A-C b	17.73	35.00±7.73 B	26.69	72.87±5.66 A	55.58	131.11
(3) **	22.12±2.74 A-C b	15.26	46.83±16.13 A b	32.31	75.98±4.55 B-D	52.42	144.93
(4) **	17.75±1.10 C c	13.53	31.79±5.39 A b	24.23	81.66±1.48 AB a	62.24	131.20
(5) **	22.29±1.11 A b	13.92	64.70±16.30 A a	40.42	73.08±4.58 A-C	45.65	160.07
(6) **	26.50±5.78 BC b	19.05	34.32±3.96 B b	24.68	78.26±3.45 B-D	56.27	139.07
(7) **	23.19±3.02 AB c	17.14	34.88±3.23 A b	25.78	’7.23±2.26 D a	57.08	135.30
(8) **	22.54±2.91 A-C b	17.94	24.20±0.83 B b	19.27	78.88±6.40 B-D	62.79	125.62
(9) **	29.66±4.77 A	19.46	54.01±16.27 A	35.43	68.77±3.46 B-	45.11	152.43
(10) **	30.10±5.33 A b	21.28	33.07±2.01 A b	23.38	78.29±3.08 CD a	55.34	141.46
Means**	**24.80±1.1 c**	**17.7**	**39.32±3.23 b**	**28.1**	**75.42±1.43 a**	**54.05**	**139.53**

Values preceded by the same uppercase letter in the vertical do not differ significantly for fertilizer applications and values preceded by the same lowercase letter in the horizontal do not differ significantly for the grape parts according to Duncan's multiple comparison test (*p<0.05; ** p<0.01; ^{ns}: nonsignificant)

3.3. Total antioxidant activity

When the total antioxidant amounts were evaluated, the effect of the applications and the difference between the grain parts were found to be significant (P<0.01). While the highest antioxidant activity was found in the seeds in all applications, the least antioxidant activity was detected in the fruit flesh. When the parts of the grape are considered based on plant nutrition applications, the order is again in the form of grape seed>grape berry skin>grape berry flesh. When the rates were evaluated as %, a ratio of %91.64>8.25>0.11 was formed for grape seed>grape berry skin>grape berry flesh. When evaluated in terms of plant nutrition applications, the highest antioxidant activity value was found at R.P. (500 g per vine) + H.A. (600g per vine) application for grape flesh, at 250g of RP + BF application for grape berry skin, and at basic fertilizer application for grape seeds (Figure 5 and Table 6).

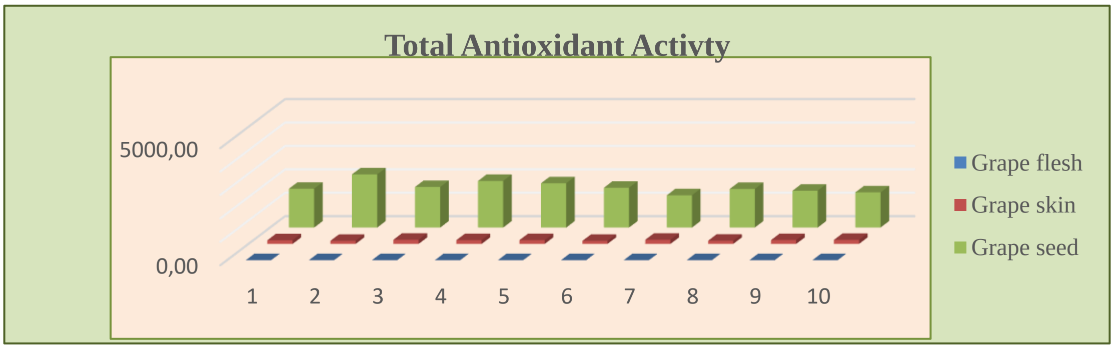

Figure 5. Total antioxidant contents (μmol TE g^{-1} FW) in different parts of grapes fertilized with different fertilizer combinations

Table 6. Effect of some plant nutrition applications on total antioxidant activity

Application	Total Antioxidant Activity (μmol TE g^{-1})						TOTAL
	Grape berry flesh**		Grape berry skin**		Grape Seed**		
	Mean	%	Mean	%	Mean	%	
(1) **	2.25±0.14 AB b	0.12	156.59±0.76 A b	8.62	1656.83±166.94 B-D a	91.25	**1815.67**
(2) **	2.10±0.27 A-C c	0.09	129.06±4.33 B b	5.37	2270.08±49.67 A a	94.54	**2401.24**
(3) **	1.93±0.13 A-C b	0.10	177.34±4.67 A b	9.27	1733.23±337.14 B-D a	90.63	**1912.50**
(4) **	1.38±0.11 C b	0.06	159.33±6.86 A b	7.41	1990.17±163.33 AB a	92.53	**2150.88**
(5) **	2.58±0.39 A c	0.13	160.03±2.17 A b	7.79	1891.00±73.10 A-C a	92.08	**2053.61**
(6) **	1.69±0.19 BC b	0.09	131.14±16.12 B b	7.15	1701.83±104.26 B-D a	92.76	**1834.66**
(7) **	2.25±0.21 AB c	0.14	174.58±1.97 A b	11.21	1380.22±23.53 D a	88.64	**1557.05**
(8) **	2.10±0.22 A-C b	0.12	136.69±6.67 B b	7.65	1648.50±137.39 B-D a	92.23	**1787.29**
(9) **	2.60±0.11 A c	0.15	162.52±2.17 A b	9.34	1574.34±8.70 B-B-D a	90.51	**1739.46**
(10) **	2.61±0.06 A b	0.16	169.19±8.61 A b	10.10	1503.50±110.04 CD a	89.75	**1675.30**
Means**	**2.17±0.09 c**	**0.11**	**156.36±3.45 b**	**8.25**	**1737.14±57.46 a**	**91.64**	**1895.67**

Values preceded by the same uppercase letter in the vertical do not differ significantly for fertilizer applications and values preceded by the same lowercase letter in the horizontal do not differ significantly for the grape parts according to Duncan's multiple comparison test (*p<0.05; ** p<0.01; ns: nonsignificant)

It was seen that the phytochemicals were synthesized at the highest rate in the seed part of the fruit, followed by the fruit skin. Phytochemicals in fruit flesh were found to be proportionally low compared to the other parts. Bunea et al. (2012) conducted a study to compare the total polyphenol content and antioxidant activity in the skins of some grape varieties grown with organic and conventional farming methods were determined between 1341.37 and 219.33 mg GAE kg^{-1} samples in organically grown varieties and between 1231.38 and 148.47 mg GAE kg^{-1} in conventionally grown varieties. In the same study, total antioxidant activity was found to be between 43.5 and 16.8 mg GAE kg^{-1} in organic products and between 40.4 and 14.7 mg GAE kg^{-1} in conventionally produced ones. In the present study, Total Phenol Content (mg 100 g^{-1}) varied from 23.48 to 51.35 according to the applications; Total Antioxidant Content (μmol TE g^{-1}) ranged from 62.00 to 105.57. Ozdemir (2018) stated that different treatments of organic and organo-mineral fertilizers had a significant effect on Bogazkere grape berry total phenolic (berry skin, pulp, seed), total flavonoid (berry skin, pulp, seed) and total anthocyanin (berry skin, pulp) profiles. The treatments of Bactolife Super Organo Power (OM4) and Bactolife High Organo 5-5-5 (OM3) were found more effective in producing total phenolic content of grape berry skin, pulp, and seed content than other treatments and control. The maximum total phenolic content at 126.69 µg GAE mg^{-1} of grape berry skin, 550.47 µg GAE mg^{-1} of berry pulp, at 346.22 µg GAE mg^{-1} of berry seed were recorded on organo-mineral fertilizer Bactolife Super Organo Power treatment. When the total amount of antioxidants in ten different local grape varieties grown in the Van region was considered, the highest rate was found in cv. Siyah kismis at 91.89 mg kg^{-1} but the lowest one was in cv. Beyaz kecimemesi at 42.23 mg kg^{-1} (Bas, 2018). In their study, Gazioglu Sensoy et al. (2018) reported the total phenolic matter content in some local grape cultivars as 73.60 mg 100 g^{-1} in the seed, 58.73 mg 100 g^{-1} in the fruit skin and 40.52 mg 100 g^{-1} in grape juice. In the same study, it was reported that the highest antioxidant content was 1009.58 µmol TE g^{-1} in the seed, then 310.92 µmol TE g^{-1} in the fruit skin, and 204.39 µmol TE g^{-1} in grape juice. When the total amount of antioxidants in the seeds and fruit skin of different grape varieties is examined, it has been found that the highest amount of antioxidants is in the seeds and the total antioxidant amount is lower in the grapefruit skin compared to the seeds (Duran, 2014). The antioxidant activities of different grape varieties were determined to be between 2.29 mmol L^{-1} and 5.74 mmol L^{-1} based on Trolox Equivalent Antioxidant Capacity (TEAC) (Gazioglu Sensoy, 2012).

Yegin and Uzun (2018) examined 12 grapes grown in Turkey (7 cultivars and 5 feral genotypes) for their total phenolic matter content capacity and the contents in the seed, fruit skin, and fruit flesh was determined as 1390 mg, 691 mg, and 333 mg Gallic acid equivalent (GAE) 100 g^{-1}, respectively. Ozdemir et al. (2018) used 11 different fertilizers [including green manure (vetch), green manure (barley), green manure (vetch + barley), manure, baktograd, NP, and three different organo-mineral quality fertilizers] for Okuzgozu grape cultivar and examined total phenolic, flavonoid, anthocyanin and antiradical activities. The total amount of phenolic matter content increased in all fertilizer applications compared to the control. The highest amount of phenolic matter was detected in the application of super organo-mineral quality fertilizer, as 105.17 µg GAE mg^{-1} in the grape skin, 785.49 µg GAE mg^{-1} in the grape, and 198.74 µg GAE mg^{-1} in the seed Perestrelo et al. (2018) determined the potentials of phenolic matters and antioxidants on grape ripening by spectrophotometric methods in Malvasia, Sercial, and Tinta Negra grape varieties. The antioxidant levels observed on different days were determined by the FRAP method, and the values on the 0th day were determined as 135.01 mg kg^{-1} (for cv. Malvasia), 651.12 mg kg^{-1} (for cv. Sercial), and 323.33 mg kg^{-1} (for cv. Tinta Negra). Then, as a result of repeated analyses on days 14, 28, 35, 42, and 56, it was reported that the number of antioxidants decreased gradually and the lowest antioxidant amount was determined on the 56th day.

In a study investigating the determination of total phenolic and flavonoid content of berry skin, pulp, and seed fractions of cv. Okuzgozu and cv.Bogazkere, Total phenolic content varied from 493.70 µg GAE mg^{-1} to 766.40 µg GAE mg^{-1} in Okuzgozu and Bogazkere grape berry pulp. The maximum amount of phenolic content was found in cv.Okuzgozu in 2013 (766.40 µg GAE mg^{-1}). The least amount was found in the Bogazkere grape variety in 2011 (493.70 µg GAE mg^{-1}). The average values in berry skin were found at 89.58 µg GAE mg^{-1} in cv. Okuzgozu and 523.43 µg GAE mg^{-1} in cv. Bogazkere. Total phenolic content varied from 157.60 µg GAE mg^{-1} to 340.40 µg GAE mg^{-1} in grapes berry seed. The average values in berry seed were found in 182.75 µg GAE mg^{-1} in cv.Okuzgozu and 329.45 µg GAE mg^{-1} in cv. Bogazkere. The highest amount of phenolic content was found in cv. Bogazkere in 2012 (340.40 µg GAE mg^{-1}) (Ozdemir et al., 2017).

In another study, total phenols in the grape seeds and skin were expressed as mg gallic acid equivalent (GAE) per g of dry matter (mg GAE g^{-1} DM), and in the pulp as mg GAE per g of fresh pulp. The results show that the highest content of phenolics was in seed extracts and the lowest was in pulp extracts. The total phenol content ranged from 251.46 ± 5.18 to 315.45 ± 7.17 mg GAE g^{-1} of dry seeds, from 74.04 ± 5.25 to 112.83 ± 4.27 mg GAE g^{-1} of dry skin, and from 21.21 ± 2.11 to 58.53 ± 3.77 mg GAE g^{-1} of fresh pulp (Andjelkovic et al., 2013).

Scientific studies based on plant nutrition in viticulture generally focus on yield. However, besides its many uses, it is also very important to reveal the changes in the content of the grape fruit, which has reached a very important added value with wine production, under the influence of various cultural processes. Kisaca and Gazioglu Sensoy (2023) reported that viticulture culture will gain more value and become widespread with the determination of the biochemical value of grape must and bringing the products made from must to the economy. Today, much effort is put into finding grape varieties with superior phenolic compositions, which are beneficial to human health. Thus, it is crucial to conduct comparison studies between commercial grape varieties and new grape types developed through breeding programs under comparable growing conditions (İzcara et al., 2021). When the correlation between the applications is evaluated (Table 7); it was seen that the linear correlation between the control group grapevines and pH and Maturity index was significant. While there was an inverse correlation between phenolic and antioxidant values in the control application in which no plant nutrition application was applied, provided that it was significant in four of the plant nutrition applications; This correlation was recorded as linear in all 9 treatment groups. When the maturity index value was compared with other traits, different degrees of importance and different negative/positive correlations were determined. It has been observed that the applications cause different reactions in fruits with this aspect.

Table 7. Correlation analysis of some plant nutrition applications on some studied traits

		Antioxidant	Acidity	pH	TSS	Maturity İndex
Control	Phenolic	-0.498	0.026	0.553	0.932	0.480
	Antioxidant		0.802	-0.889	-0.160	-0.918
	Acidity			-0.800	0.326	-0.858
	pH				0.305	0.994**
	TSS					0.206
Basic Fertilizer	Phenolic	0.783	-0.780	0.980	0.180	0.997*
	Antioxidant		-0.221	0.890	0.753	0.735
	Acidity			-0.642	0.475	-0.824
	pH				0.370	0.964
	TSS					0.108
RP (250g)	Phenolic	1.000**	-0.923	0.782	-0.905	0.695
	Antioxidant		-0.991	0.948	-0.873	0.991
	Acidity			-0.920	0.656	-0.912
	pH				-0.383	0.899
	TSS					-0.321
RP (500g)	Phenolic	0.998*	-0.981	-0.007	-1.000**	-1.000**
	Antioxidant		-0.992	0.061	-1.000**	-1.000**
	Acidity			0.057	-0.631	-0.883
	pH				0.291	-0.104
	TSS					0.921
HA (600g)	Phenolic	1.000*	-0.956	0.897	0.731	0.993
	Antioxidant		-0.806	0.536	0.495	0.778
	Acidity			-0.779	-0.652	-0.983*
	pH				0.976*	0.881
	TSS					0.781
HA (600g)	Phenolic	0.998*	0.408	0.701	0.991	-0.158
	Antioxidant		0.349	0.654	0.998*	-0.095
	Acidity			0.531	0.129	-0.897
	pH				0.897	-0.123
	TSS					0.317
R.P.(250g) +H.A.(300g)	Phenolic	0.995	-0.708	0.062	-0.736	-0.011
	Antioxidant		-0.566	1.000**	-0.932	-1.00**
	Acidity			0.968	0.175	-0.979
	pH				-0.801	-0.999*
	TSS					0.769
R.P.(250g) +H.A.(600g)	Phenolic	0.425	-0.176	-0.799	0.856	0.236
	Antioxidant		-0.966	0.205	-0.105	0.980
	Acidity			-0.485	0.063	-0.997**
	pH				-0.457	0.441
	TSS					0.017
R.P.(500ge) +H.A.(300g)	Phenolic	0.976	0.664	-0.802	0.817	-0.790
	Antioxidant		0.812	-0.913	0.923	-0.905
	Acidity			-0.956*	0.734	-0.983*
	pH				-0.878	0.978*
	TSS					-0.758
R.P.(500g) +H.A.(600g)	Phenolic	0.588	0.410	-0.180	0.164	-0.425
	Antioxidant		0.315	0.213	-0.079	-0.243
	Acidity			0.734	-0.793	-0.999**
	pH				-0.988*	-0.703
	TSS					0.769

**(P<0.01); *(P<0.05)

4.Conclusion

In the present study conducted in Nusaybin/Mardin ecological conditions in Sepirze, a local grape variety, the effect of plant nutrition practices on TSS value, and total phenolic and total antioxidant contents were found to be significantly different among the applications. Considering the applications made in terms of the maturity index value, it was concluded that plant nutrition applications could affect plant phenology and precipitate maturity. When the study was evaluated in terms of phenolic content, it was observed that plant nutrition applications tended to increase in general compared to the control. When the total antioxidant amount was evaluated, it was observed that the combined applications of Humic acid and Rock phosphate caused a significant decrease in the total antioxidant amount. The reason for this decrease is thought to be that adequate nutrient intake reduces the stress in the plant and thus slows down the plant's production of antioxidative enzymes. Considering the total antioxidant content and phenolic contents for different parts of the fruit, the differences were found significant ($P<0.01$). The total antioxidant and total phenolic contents of grape seeds were significantly the highest, followed by grape berry skin and grape berry flesh. Thus, the richness of the grape seed in terms of nutritional content has been demonstrated once again. One of the most important mistakes made while consuming grapes is the habit of not consuming the seeds or turning to seedless varieties in the consumption of table grapes and raisins depriving people of this important nutritional supplement.

Declaration of Conflicts of Interest

All authors declare that there is no conflict of interest related to this article.

Declaration of Author Contributions

The authors declare that they have contributed equally to the article. All authors declare that they have seen/read and approved the final version of the article ready for publication.

Acknowledgments

This study was a part of M.Sc. thesis of first author and it was funded by Van Yuzuncu Yil University Scientific Research Projects Coordination Unit as project numbered 2014-FBE-YL-158.

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To Cite	Akcan, E., Bas, E.O., Gazioglu Sensoy, R.I., 2023. The Effects of Some Plant Nutrition Applications on the Bioactive Compounds of Grapevine (*Vitis vinifera* L.). *ISPEC Journal of Agricultural Sciences*, 7(2): 280-293. DOI: https://doi.org/10.5281/zenodo.8020415.