Effect of Humic Acid Applications on Yield, Fruit Characteristics and Nutrient Uptake in Ercis Grape (*V. vinifera* L.) Cultivar

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The effects of humic acid applications on the yield, fruit characteristics and nutrient uptake of Ercis grape cultivar (*V. vinifera* L.) in Van in the east of Turkey were examined during two growing seasons in 2003-2004. Solid form of humic acid (55% humic acid, 30% fulvic acid and 8% K_2O) were applied from soil in the amount of 100, 200, 300 kg/ha and 10, 20, 30 kg/ha from leaves. There was no significant effects of humic acid application on the yield and mean bunch weight (MBW) but there was significant effect on soluble solid contents (SSC) and total acid statistically. SSC content was increased with humic acid applications, but total acid was decreased with treatment. As a result of this study, yield, MBW, SSC total acid ranged between 6650 and 14580 kg/ha, 123.3 and 249.5 g, 12.3 and 18.0%, 1.28 and 2.05 g/L, as years and applications, respecuvely. In the result of leaf analysis, humic acid affected the N content (each two years), P, Fe and Zn contens of leaves (at first year), but K, Cu and Mn contents were not affected statistically. N and K content of leaves were increased with humic acid applications as compared with control. As a result, SSC, total acid, N and Fe contents of leaves of grape vines were affected by humic acid application. In cool ecology, such as Van province, increase in SSC by humic acid application will contribute to ripening of grapes before autumn frost.

Key Words: Humic acid, Ercis cultivar, Yield, Plant nutrition.

INTRODUCTION

Several organic matters, in addition to farmyard and green manure, are used to compensate the deficiency of organic matter in soil. Humic matters are the most widely distributed organic products of biosynthesis on the face of the earth and they are used in various areas of agriculture[1–4]. The benefits of humic substances in agricultural soils are well established[5]. It has been reported that humic substances have benefical effects on plant growth, nutrient uptake by plants, root initiation, yield, seed germination, plant photosynthesis[1, 2, 6–10]. Likewise, in the previous studies, humic matters were stated to increase dry matter in grape[6], tomato[11], corn[12] and strawbery[13].

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There were a lot of studies on relationship of fruit sugar contents with organic fertilizer application[13–16]. Different studies on the relationships between plant nutrients of soil with fruit sugar and fruit sugar contents of strawberry have shown significant effects of humic acid on sugar contents[13, 15, 16]. Wang *et al.*[16] noted that sugar content of grapes on humic acid application was higher than the sugar content of grapes grown under chemical fertilization. In grape production for wines, these complex sugars produce much higher quality vintage. Besides improving the sweetness, the humic acid plays an important role in immune system of the plant.

A long growing season is required for grape berry; maturation growing period must be 180 d for economical production. The time required for grapes to reach maturity is determined mainly by the total amount of heat received. The effective heat summation for grapes must be at least 900 degree-days. Temperature, especially during the ripening period, greatly influence, the sugar or acid content of grapes and thus affects their quality for various uses. Cool weather fosters a high degree of acidity, a low pH and a good colour. Low summations of heat during ripening cause a low ratio of sugar to acid in the fruits[17, 18].

Ercis grape is a local cultivar grown in Van province stiuated in Eastern Anatolia. Generally, this region has hard continental climate and climatic conditions impose strict limits on viticulture, but viticulture in this province has been done in restricted are as for centuries. The length of growth period in Van province is 160 days; effective heat summation in Van is 974 degree-days above 10°C[19, 20]. These values are lower limits for grapes. Therefore, in some years, the fruit quality of grapes grown in the Van region could become insufficient.

This study was aimed at the determination of effects of humic acid applications from soil and foliar at different levels on yield, some fruit characters and nutrient uptake in Van ecology.

EXPERIMENTAL

This research was carried out on Ercis grape variety in vineyards in Van province (latitude 39°01′26″, longitude 43°21′42″, altitude 1720 m.) in eastern Turkey during 2003–2004. Ercis grapes cultivar (*V. vinifera* L.) is a table and wine variety cultivar whose ampeleographic characters were determined[21]. The vines were Goble-trained situated and planted at 2 × 1 m growing in Van ecological conditions. The vines were pruned in winter pruning as canes on 10 bud/vine levels (50000 buds/ha), 2 noded, separately in March. It was applied net N (80 kg/ha) and P_2O_5 (150 kg/ha) as basic fertilizer in trial vineyard.

Some characteristics of the soil were as follows (30 cm depth): texture sandy clay loam, organic matter 1.10%, lime 7.10%, pH 7.5, total salt 0.087%, total nitrogen 0.11%, available P 5.55 mg kg^{-1}, exchangeable K 1.50 $cmol_c$ kg^{-1}. The available Fe, Cu, Zn and Mn contents of soil were 6.0, 0.60, 0.64 and 8.38 mg kg^{-1}, respectively.

For the analyses of soil, texture was determined by Bouyoucu[22] hydrometric method, pH by Jackson[23] 1 : 2.5 soil-water suspension method, lime with 4 replicates by calcimetric method[24], organic matter by modified Walkley-Black method[25], salt by Richards method[26], total nitrogen by Kjeldahl method[27], available P by the methods of Olsen *et al.*[28], exchangable K[29], available Fe, Cu, Zn and Mn by the methods of Lindsay and Norvell[30]. P after being dried with HNO_3[31]; K, copper, zinc, manganese and iron were measured by atomic absorption spectrometry[32].

Treatments and plant analyses

In the research, solid humic acid (polymeric polyhydroxy acid), commercial name "Humipower", was used (55% humic acid, 30% fulvic acid, 8% K_2O). Humic acid (HA) was applied from soil and foliar at different levels. HA applications were made from soil (0–100–200–300 kg/ha) and leaves (0–10–20–30 kg/ha) in young shoot stage; foliar application was done at 3 different stages (before blossoming, after set fruit, veraison stage).

Treatments:

1. Control (C_0); 2. Foliar application 10 kg/ha(F_{10}); 3. Foliar application 20 kg/ha (F_{20}); 4. Foliar application 30 kg/ha (F_{30}) 5. Soil application 100 kg/ha (S_{100}); 6. Soil application 200 kg/ha (S_{200}); 7. Soil application 300 kg/ha (S_{300}).

Leaf samples for analyses, blades from leaves opposite basal bunches were collected in two years. The leaves was collected at varaison stage in first year, and it was collected before two weeks from ripening in second year.

In trial vineyard, grapes were harvested on 15 September 2003 and 20 September 2004. Yield (kg/ha), MBW (g); soluble solid contents, SSC (%) and total acid (titratable acidity) as tartaric acid (g/L) in juice samples were determined in harvest stage.

Experimental design was randomized block design with 3 replicates. The data for all variables were analyzed by analysis of variance within each experiment and year. To calculate significant differences between treatments the least significant difference (LSD) test was used and calculated at 5% level of probability.

RESULTS AND DISCUSSION

HA applications did not affect yield and MBW. Amount of yield and MBW changed from 6665 to 14580 kg/ha; from 123.3 to 249.4 g, respectively. The highest MBW was recorded in the treatments S_{100} and S_{200}(249.5–197.5 as years). The highest yield was obtained from S_{100} application (14580–13665 kg/ha) (Table-1). The yield reduced linearly with increasing HA doses in the soil treatments. The typical growth response curves that have been reported as a result of treating plants with humic substances, show progressively increasing growth with increasing concentrations of humic substances, but there was a decrease in growth at higher concentrations of these materials[2]. These results are in agreement with other reports for strawberry[2, 15, 16, 33].

Significant differences among HA treatments were observed for SSC and total acid (Table-1). SSC values and total acid values are medium SSC and low acid group according to ampelographic criteria[34]. The highest SSC were obtained from

F_{20} treatment in each year. The lowest SSC were obtained from control treatment, but the highest total acid was determined from control treatment. Humic acid application had a positive effect on SSC ratio but negative effect the total acid in berry juice. These positive effects on fruit quality are likely due to an indirect positive physiological effect of the humic acid foliar applications on the whole plant and may not relate to any curative action. It can be concluded from the results of this study that F_{20} and S_{200} doses of HA ripened berries earlier. These results are closely in agreement with the findings obtained by others, for example, in grape[6], tomato[11], corn[12] and strawberry[13, 15].

Sometimes sugar accumulation will cease due to unfavourable environmental conditions such as very high or low temperatures but resume once the conditions have changed[35]. Temperature, especially during the ripening period, greatly influences the sugar or acid content of grapes. Cool weather fosters a high degree of acidity, a low pH and a good colour. Low summations of heat during ripening cause a low ratio of sugar to acid in the fruits[17, 18]. Thus, in cool ecology, such as in Van province, increase in SSC by HA application will conribute to ripening of grapes before autumn frost.

TABLE-1
EFFECTS ON YIELD, MBW, SSC AND TOTAL ACID OF DIFFERENT HUMIC ACID APPLICATION IN ERCIS GRAPE VARIETY

Treatments (HA kg/ha)	Yield (kg/ha)		Mean bunch weight (g)		Soluble solid content (%)		Total acid (g/L)	
	1 year	2 year	1 year	2 year	1 year	2 year	1 year	2 year
C_0	8585	7250	184.7	151.6	13.67 e	12.33 c	2.02 a	2.05
F_{10}	10535	8400	218.1	145.7	15.97 bc	16.77 ab	1.50 cd	1.73
F_{20}	12385	9085	236.4	138.7	18.00 a	17.50 a	1.44 cd	1.57
F_{30}	7165	6750	164.0	123.3	17.00 ab	16.00 ab	1.50 cd	1.78
S_{100}	14580	13665	249.4	186.3	14.00 de	17.33 a	1.91 ab	1.28
S_{200}	12330	8250	214.6	197.5	15.30 cd	15.47 b	1.67 bc	1.73
S_{300}	8665	6665	171.2	166.1	15.67 bc	15.27 b	1.35 d	1.76
F-test	ns	ns	ns	ns	*	*	*	ns
LSD (P = 0.05)	—	—	—	—	1.345	1.833	0.275	—

*and **significant at $P < 0.05$ and $P < 0.01$ F level, respectively. ns: not significant.
Means followed by the same letter are not significantly different (LSD Test, $P < 0.05$)

Christiensen *et al.*[36] stated that the required adequate limit values in grape leaves were between 2.2–4.0% for N, 0.15–0.30% for P, 0.8–1.6% for K. In consideration of these values, the amount of N was inadequate in first year and of K was adequate in leaf samples, but the amount of P was adequate in C_0, F_{30} and S_{100} treatments (Table-2).

N concentration in grape leaves according to control (C_0) was affected by the treatments and increased with HA applications (Table-2). These results have been confirmed by some other studies reporting that humic acid applications increased N content in strawbery[13], tomato[37], corn[38] and bean[39].

TABLE-2
EFFECTS ON N, P AND K UPTAKE OF DIFFERENT HA APPLICATIONS IN ERCIS GRAPE VARIETY

Treatments (HA kg/ha)	N (%)		P (%)		K (%)	
	1 year	2 year	1 year	2 year	1 year	2 year
C_0	1.80 c	2.13	0.156 ab	0.159	0.83	0.85
F_{10}	1.91 bc	2.30	0.132 cd	0.135	1.26	0.93
F_{20}	1.97 abc	2.30	0.122 d	0.142	0.95	0.89
F_{30}	2.16 a	2.48	0.156 ab	0.163	1.03	1.00
S_{100}	2.04 ab	2.26	0.165 a	0.153	0.77	0.84
S_{200}	2.06 ab	2.37	0.147 abc	0.135	0.85	0.91
S_{300}	2.04 ab	2.26	0.143 bc	0.153	0.94	0.98
F-test	**	*	*	ns	ns	ns
LSD (P = 0.05)	0.192	0.194	0.020	—	—	—

* and **significant at $P < 0.05$ and $P < 0.01$ F level, respectively. ns: not significant.
Means followed by the same letter are not significantly different (LSD test, $P < 0.05$)

P concentration in leaves was affected by the treatments in first year. There are some reports on the positive effect P uptake of HA applications in different crops[37, 40]. In contrast to these reports, other researchers have stated that there was no relation between HA applications and P uptake in kiwifruit[41] and spinach[42]. The stimulatory effects of humic substances have been directly correlated with enhanced uptake of macronutrients, such as nitrogen, phosphorus, sulfur and micronutrients, *i.e.*, Fe, Zn, Cu and Mn[2].

Similar results related to interaction between HA application and K concentration were reported in tomato[37], kiwifruit[41], spinach[42] and grapes[43], but in other studies, it was reported that K concentrations were not affected in corn[44] and lettuce[44].

TABLE-3
EFFECTS ON Fe, Cu Mn AND Zn UPTAKE OF DIFFERENT HUMIC ACID APPLICATIONS IN ERCIS GRAPE VARIETY

Treatments (HA kg/ha)	Fe (mg kg^{-1})		Cu (mg kg^{-1})		Mn (mg kg^{-1})		Zn (mg kg^{-1})	
	1 year	2 year	1 year	2 year	1 year	2 year	1 year	2 year
C_0	149.267 b	77.200	9.200	5.567	51.467	144.30	68.400 b	14.467
F_{10}	181.333 a	84.267	4.933	5.933	42.867	156.40	131.000 a	10.700
F_{20}	142.167 b	79.567	7.100	3.133	37.000	154.80	105.367 ab	9.333
F_{30}	140.000 b	78.267	6.833	8.400	40.733	141.90	89.133 ab	10.367
S_{100}	147.567 b	79.000	5.100	5.300	50.900	225.13	103.900 ab	11.933
S_{200}	192.400 a	85.333	7.300	7.533	60.233	185.80	115.400 ab	11.233
S_{300}	179.667 a	87.867	5.000	5.567	58.733	125.30	124.167 ab	7.200
F-test	**	ns	ns	ns	ns	ns	**	ns
LSD (P = 0.05)	28.166	—	—	—	—	—	58.871	—

Christiensen et al.[36] stated that the required adequate limit values in grapes were between 40.0–100.0 mg kg^{-1} for Fe, 10.0–100.0 mg kg^{-1} for Cu, 25.0–200.0 mg kg^{-1} for Mn and 35.6–60.0 mg kg^{-1} for Zn. In consideration of these values, the amounts of Fe and Mn were adequate in samples, but the amount of Cu was inadequate; the amount of Zn was adequate in first year treatments.

HA applications affected for Fe and Zn contents in first year, however, no significant difference was observed for Cu and Mn contents. Many researchers have stated that Fe affects uptake of HA[38]; in addition HA applications have improved Fe uptake in corn[12], spinach[42] and grapes[43]. Dormaar[39] reported that humic acid application in bean did not affect P, K, Mg and Ca uptake.

In this experiment, it has been shown that humic acid increased SSC of berry by affecting some nutrient element uptake. From the results, it can be concluded that 20 kg/ha of humic acid application to leaf or 100 kg/ha to soil appeared as optimum dose.

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