PRELIMINARY STUDY ON THE EFFECTS OF FOLIAR APPLICATIONS OF HUMIC ACIDS ON 'ITALIA' TABLE GRAPE

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Abstract
The effects of foliar applications of humic acids extracted from a soil and a compost on vegetative and qualitative parameters of 'Italia' table grape have been analyzed. Two humic acids were applied at two different concentrations, 5 and 20 mg/L. The grapevines treated with the humic acids exhibited a slight increase in shoot growth, increases in nitrogen and chlorophyll contents in the leaves and higher SPAD values. At harvest, the application of humic acids showed to have increased total soluble solids (°Brix), °Brix/acidity ratio and pH but decreased titratable acidity. Generally, treatments with humic acids significantly increased berry size, and as a consequence, a general increase in the yield was observed.

Introduction

Humic acids (HAs) are the main fractions of humic substances (HS) and the most active components of soil and compost organic matter. They exert indirect and direct effects on plants (CHEN *et al.* 2004), and this action of HS is dose dependent and high concentrations of HS are inhibitory for nutrient accumulation (CHEN and AVIAD 1990). Some plant hormone-like substances seem also to be present in the HS, thus exerting a possible stimulating effect on growth (PIZZEGHELLO *et al.* 2002).

Studies related to the effects of HS on plants have been generally conducted on herbaceous species under laboratory experimental conditions and only a limited number of reports concern with foliar applications of HS in the field and are limited to few species, such as asparagus (TEJADA and GONZALEZ 2003), creeping bentgrass (COOPER *et al.* 1998), olive (FERNÁNDEZ-ESCOBAR *et al.* 1996).

In the case of the effects of HS on *V. vinifera*, the available literature is scarce with few papers which generally investigated the effects of commercial HS products on wine grape (BROWNELL *et al.* 1987, VERCESI 2000) and table grape (COLAPIETRA 2000). A variability of results has been observed in all these studies which can be attributed to both the variable sources of HS used and the different concentrations tested.

Actually, responses of table grape cultivars to the foliar application of these compounds are still limited and unclear. The main objective of this work was to investigate the effects of foliar applications at low concentrations of two distinct HAs, chemically and physically characterized, both on vegetative growth and on quantitative and qualitative parameters of cv. Italia.

Materials and methods

Humic substances origin

Two HAs were used in this work: a soil humic acid (SHA) and a compost humic acid (CHA). The SHA sample was extracted from a soil sampled from an experiment field located in Spinazzola (Bari province) and the compost was obtained by subjecting to a conventional composting process a mixture of pruning residues, grape mark, exhausted olive pomace, fruit market residues at an equilibrate and appropriate ratio over a period of four months.

Field experiments

The experiment was carried out in Apulia (Southern Italy) in the year 2006. The trial was performed in a commercial table grape vineyard located near Castellaneta (Taranto province). 'Italia' grapevines were grafted onto 1103 P (*V. berlandieri* × *V. rupestris*), spaced 2.5 × 2.5 m, 'tendone' trained and drip irrigated (2000 m^3/ha). Fertilizers addition, pest control and other vineyard operations were consistent with commercially adopted practices in the region. Both SHA and CHA were tested at two concentrations, 5 and 20 mg/L, and a control (water) was also used. The vines were sprayed with the corresponding solutions from stage B of BAGGIOLINI (1952) onward at successive 21-day intervals for six foliar treatments throughout the season up to veraison

Vegetative growth was determined by measuring the length of four distal shoots per vine. The effect of HAs on chlorophyll content was determined in the field with a SPAD-502-meter (Minolta Camera Co., Osaka, Japan). The SPAD readings were performed on the 8th of June on the leaves of the primary shoots and on the 20th of July on the leaves of the lateral shoots.

Laboratory determinations

The same leaves used for the SPAD measurements were used for chlorophyll extraction and nitrogen (N) determination.

The berries collected in the field and carried to the lab were subjected to the following determinations: a) diameter, length and weight of each berry; b) total soluble solids (°Brix); c) pH; d) titratable acidity (as g tartaric acid per 100 ml juice) and the °Brix/acidity ratio was consequently calculated. At harvest, total yield per vine (kg) was finally measured.

Statistical analysis

Variance assumptions were verified (homogeneity of variance by the Levene's test, normal distribution by the Lillefors' test). Successively, analysis of variance and regression analysis were performed at the 0.05 P level and the mean values obtained for the different treatments were statistically compared to the control treatment by using the Dunnett's test.

Results and Discussion

Vegetative growth

The applications of both HAs generally increased the length of shoots (Table 1) and the highest effect was assessed when the treatment with CHA at 20 mg/L was applied, with an increase of about 14% with respect to the control. In general, CHA at 5 and 20 mg/L seemed to exert a light better effect on shoot length than SHA at the same corresponding doses. The increase in shoot length observed in the present research is in agreement with data reporting improved plant growth in the case of grapevine rootstocks treated with olive compost HS solutions (ZACHARIAKIS *et al.* 2001).

The two HAs also determined a light increase of N content both in the blade and in the petiole of the leaves (Table 1). In particular, the treatment with SHA at 20 mg/L significantly increased the N content in the petiole (about 26%) with respect to the control, but a limited increase was also observed in the case of all the other treatments. This increased N content as a consequence of HAs application was in agreement with data reported on wheat (MALIK and AZAM 1985), olive (TATTINI *et al.* 1990), tomato (DAVID *et al.* 1994), asparagus (TEJADA and GONZALEZ 2003) and rice (TEJADA and GONZALEZ 2004) using HS of different origin and concentration. However, the apparent not very consistent increase of both shoot length and N content following HAs applications may be explained by the fact that HS may have limited effects on growth when plants are adequately supplied with nutrients (CHEN and AVIAD 1990), as in the case of a well fertilized vineyard.

SPAD and chlorophyll measurements

A general increment of SPAD (Table 2) was observed as a consequence of HAs application, even in the case of the leaves of the lateral shoots (20 July). Both SHA and CHA also significantly increased total chlorophyll content (Table 2). In the case of the primary shoot (7 June), total chlorophyll content was significantly higher in all the HAs treatments (up to 48.6 $\mu g/cm^2$ in the case of CHA at 20 mg/L) with respect to the control (43.9 $\mu g/cm^2$). In the leaves of the lateral shoots significant increases of chlorophyll content were observed in the case of SHA and CHA at 5 mg/L.

Both a linear fit (R^2 = 0.61) and a nonlinear fit (R^2 = 0.65) provided a sufficiently good correlation between SPAD values and chlorophyll content expressed on area basis ($\mu g/cm^2$). A higher determination coefficient was found between N content in the blade and SPAD readings (R^2 = 0.87). PORRO *et al.* (2001) obtained decreasing determination coefficients (SPAD vs. chlorophyll content) from berry set (0.94) to harvest (0.37) in different leaves of ‘Chardonnay’ and the R^2 calculated were markedly influenced by various factors such as year, cultivar, phenological stage, leaf, fertilization.

Leaf N status is often well correlated with leaf chlorophyll content, and the higher SPAD values obtained in the leaves treated with both SHA and CHA at any concentration support the positive effect of HAs on chlorophyll (SPAD) in different types of leaves. Similar and persistent increases in the total chlorophyll content were observed in droughted wheat plants sprayed with a fulvic acid (XU 1986). Furthermore, in asparagus and rice, the highest total chlorophyll content was found in plants fertilized with HAs (TEJADA and GONZALEZ 2003, 2004). Increases in leaf chlorophyll content, as a consequence of HS application, were also detected in two grapevine rootstocks, 41B and 110 Richter (ZACHARIAKIS *et al.* 2001).

Yield and fruit quality

Foliar applications of CHA and SHA generally caused an increase in total soluble solids (°Brix) at harvest (Table 3). Both SHA and CHA at 20 mg/L induced a statistically significant decrease of the acidity (Table 3). The pH was slightly higher in all the HAs treatments (Table 3), irrespective of the concentration, with a mean value of 3.57. As a consequence of detected °Brix and acidity values, SHA and CHA at 20 mg/L significantly increased the °Brix/acidity ratio.

At harvest, total yield per vine and single bunch weight increased with both SHA and CHA spraying. In particular, SHA at 5 and 20 mg/L increased yield up to 32.2 and 29.9 kg/vine, respectively, with respect to the 28.2 kg/vine of the control treatment (Table 4). Significant increases in berry lengths were obtained by spraying with SHA at 20 mg/L, CHA at 5 and 20 mg/L (Table 4). With regards to berry width and weight, only CHA at 5 mg/L induced statistically different increases with respect to the control treatment(Table 4).

Data reported in the present paper showed that foliar applications of CHA and SHA slightly increased yield per vine in table grape. Our findings are in agreement with what reported for various wine grapes cultivars in California (BROWNELL *et al.* 1987), where applications of two leonardite extracts increased total yield from 3 up to 70%. Increases in berry size were also obtained in 'Italia' table grape after three soil treatments with commercial organic fertilizers containing small amounts of HAs (COLAPIETRA 2000). The increase in berry size may be partially ascribed to the possible hormone-like activity of HAs, and this action could be useful when applying these natural organic compounds in seedless table grape instead of synthetic hormones. The increase of °Brix and a reduction of acidity is another important aspect assessed in this trial, and HAs may be applied in order to hasten ripening and/or to obtain more uniformly ripened bunches. The improvement of quality parameters (°Brix, titratable acidity, size), especially by CHA, is in agreement with what reported in 'Chardonnay' and 'Barbera' (VERCESI 2000) and in table grape (COLAPIETRA 2000) with different HS.

Conclusions

Results obtained in the present work showed that HAs are able to produce positive effects on the growth, quality and yield of cv. Italia. The lack of a stronger effect of HAs may probably support the hypothesis of CHEN and AVIAD (1990) that humic substances have limited effects on plants adequately supplied with nutrients and maybe higher concentrations could be more efficient for foliar treatments (CHEN *et al.* 2004). In a sustainable or organic viticulture the application of organic products can be a noteworthy alternative to chemicals and foliar spray applications of these products can have prospects for a possible economical use.

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Tables

Table 1. Effects of foliar sprays with a soil humic acid (SHA) and a compost humic acid (CHA) at two concentrations on shoot length and nitrogen (N). Values are means ± SD. * Statistically different at 0.05 P according to the Dunnett's test.

Treatment	Shoot length (cm)	N content (% d.w.)	
		Blade	Petiole
Control	210.8 ± 53.0	2.34 ± 0.09	0.58 ± 0.02
SHA 5 mg/L	212.6 ± 45.6	2.50 ± 0.11	0.67 ± 0.02
SHA 20 mg/L	217.0 ± 52.1	2.48 ± 0.10	0.73 ± 0.09*
CHA 5 mg/L	216.4 ± 39.1	2.46 ± 0.06	0.67 ± 0.04
CHA 20 mg/L	239.7 ± 59.6	2.36 ± 0.03	0.62 ± 0.02

Table 2. Effects of foliar sprays with a soil humic acid (SHA) and a compost humic acid (CHA) at two concentrations on SPAD and total chlorophyll. Values are means ± SD. * Statistically different at 0.05 P according to the Dunnett's test.

Treatment	SPAD		Chlorophyll content (μg/cm^2)	
	7 June	20 July	7 June	20 July
Control	45.9 ± 3.0	37.8 ± 3.8	43.9 ± 1.2	23.3 ± 1.4
SHA 5 mg/L	47.7 ± 4.2	39.8 ± 3.3	48.1 ± 0.9*	26.9 ± 0.4*
SHA 20 mg/L	46.7 ± 2.7	38.6 ± 3.5	48.2 ± 1.6*	26.2 ± 0.6
CHA 5 mg/L	47.2 ± 2.5	39.9 ± 3.1	48.0 ± 1.6*	26.4 ± 0.4*
CHA 20 mg/L	47.4 ± 2.8	37.5 ± 4.2	48.6 ± 1.4*	24.5 ± 1.4

Table 3. Effects of foliar sprays with a soil humic acid (SHA) and a compost humic acid (CHA) at two concentrations on some qualitative parameters. Values are means ± SD. * Statistically different at 0.05 P according to the Dunnett's test.

Treatment	°Brix	Acidity (g tartaric acid/100 ml juice)	°Brix/Acidity	pH
Control	15.3 ± 0.5	0.45 ± 0.03	34.5 ± 2.0	3.50 ± 0.10
SHA 5 mg/L	15.7 ± 0.2	0.42 ± 0.01	37.8 ± 1.2	3.57 ± 0.03
SHA 20 mg/L	15.7 ± 0.3	0.37 ± 0.02*	43.2 ± 2.3*	3.56 ± 0.04
CHA 5 mg/L	16.3 ± 0.8	0.43 ± 0.04	38.1 ± 1.9	3.57 ± 0.02
CHA 20 mg/L	16.0 ± 0.8	0.37 ± 0.04*	43.9 ± 2.5*	3.57 ± 0.03

Table 4. Effects of foliar sprays with a soil humic acid (SHA) and a compost humic acid (CHA) at two concentrations on berry and yield. Values are means ± SD. * Statistically different at 0.05 P according to the Dunnett's test.

Treatment	Berry			Yield (kg/vine)
	Length (mm)	Width (mm)	Weight (g)	
Control	26.3 ± 1.8	23.8 ± 2.0	10.6 ± 2.0	28.2 ± 5.9
SHA 5 mg/L	26.3 ± 2.4	23.3 ± 1.5	10.5 ± 2.1	32.2 ± 8.7
SHA 20 mg/L	27.9 ± 2.2*	23.8 ± 1.6	11.8 ± 2.0	29.9 ± 9.4
CHA 5 mg/L	28.1 ± 2.0*	24.5 ± 1.5*	12.6 ± 2.3*	29.6 ± 7.0
CHA 20 mg/L	27.5 ± 2.2*	24.3 ± 1.7	12.1 ± 2.7	29.6 ± 6.3