INFLUENCE OF FOLIAR APPLICATIONS OF HUMIC ACIDS ON YIELD AND FRUIT QUALITY OF TABLE GRAPE CV. ITALIA

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Abstract

Aims: The responses in growth, yield and quality components of a *Vitis vinifera* cultivar (Italia) to the foliar applications of two humic acids extracted from a soil and a compost have been studied.

Methods and results: The foliar applications of the two humic acids were performed in two years and six different dates of the season. Both humic acids were tested at two different concentrations, 5 and 20 mg/L. Throughout the trial, different analyses were performed (SPAD, chlorophyll content, titrable acidity, soluble sugars, pH, yield). Grapevines treated with the two humic acids exhibited both significant increases in total chlorophyll content and reductions of the chlorophyll a/b ratio. Application of humic acids significantly decreased titrable acidity and increased °Brix/acidity ratio. Generally, the treatments with humic acids significantly increased berry size, and as a consequence the yield.

Conclusions: Humic acids exerted some positive effects (chlorophyll content, acidity, berry size) in Italia table grape. Better results were obtained when the compost humic acid was sprayed.

Significance and impact of study: This study gives new information about the positive effects of foliar application of humic acids, active components of soil and compost organic matter, on yield and fruit quality of table grape. In organic viticulture humic acids may find a valid and appropriate application for a technical and economical use.

Key words: compost, table grape, humic acid, yield, SPAD

Résumé

Objectifs : Les effets de l'application foliaire de deux acides humiques extraits d'un sol et d'un compost sur la croissance, la production et la qualité d'un cépage de *Vitis vinifera* (Italia) ont été analysés.

Méthodes et résultats : L'application foliaire des deux acides humiques a été effectuée pendant deux années, à six dates différentes. Deux concentrations différentes d'acides humiques ont été testées, à 5 et 20 mg/L. Pendant l'essai, plusieurs paramètres ont été évalués : le SPAD, la teneur en chlorophylle, l'acidité titrable, la teneur en sucres solubles, le pH et le rendement. Les raisins traités avec les deux acides humiques ont montré une augmentation significative de la teneur totale en chlorophylle et une réduction du rapport entre les chlorophylles a/b. L'application des acides humiques a réduit significativement l'acidité titrable et augmenté le rapport Brix/acidité. En général, le traitement avec des acides humiques a augmenté significativement la taille du grain, et, par conséquence, le rendement.

Conclusions : Les acides humiques exercent un effet positif (teneur en chlorophylle, acidité, taille du grain) sur le cépage de raisin de table Italia.

Importance et impact de l'étude : Cette étude a fourni de nouvelles informations sur les effets positifs de l'application foliaire des acides humiques, composants actifs de la matière organique présente dans le sol et dans le compost, sur la qualité et la production du raisin de table. Dans un contexte d'agriculture biologique, les acides humiques peuvent trouver une application valable et adéquate d'un point de vue technique et économique.

Mots clés : compost, raisin de table, acide humique, rendement, SPAD

manuscript received: 4 October 2007- revised manuscript received: 30 May 2008

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INTRODUCTION

Humic acids (HAs) are the main fractions of humic substances (HS) and the most active components of soil and compost organic matter. In the recent years, HS have been demonstrated to exert several direct and indirect biological effects on plants, including morphological, physiological, genetic and biochemical effects (Chen and Aviad, 1990; Clapp *et al.,* 2001; Ferrara *et al.*, 2001; Varanini and Pinton, 2001; Nardi *et al.*, 2002; Chen *et al.*, 2004). In particular, HS stimulate plant growth by accelerating respiration, by their effects on proteosynthesis, by increasing water and nutrient uptake, by affecting enzyme activities (Vaughan and Malcolm, 1985; Albuzio *et al.*, 1986; Concheri *et al.*, 1994; Nardi *et al.*, 1996). This action of HS is dose dependent and high concentrations of HS are inhibitory for nutrient accumulation (Chen and Aviad, 1990). The stimulation of growth, at least partially, seems to be related to the presence of plant hormone-like substances in the humic fractions. Recent papers demonstrated the high content of indolacetic acid in humic fraction isolated from forest soils (Muscolo *et al.*, 1998; Nardi *et al.*, 2000), and the general auxin-like and gibberellin-like activities as well as invertase and peroxidase activities of humic matter from silver fir forest (Pizzeghello *et al.*, 2002).

Studies related to the effects of HS or HAs on plants have been generally conducted under laboratory experimental conditions, especially in the case of seedlings of various herbaceous species grown hydroponically (Malik and Azam, 1985; Lulakis and Petsas, 1995; Loffredo *et al.*, 1997; Ferrara *et al.*, 2001), or as applications to the soil in association with fertilizers in lemon (Sánchez-Sánchez *et al.*, 2002) and apple (Neilsen *et al.*, 2005). Only a limited number of reports concern with foliar applications of HS or HAs in the field and are limited to few species, such as olive (Fernández-Escobar *et al.*, 1996), strawberry (Neri *et al.*, 2002), rice (Tejada and Gonzalez, 2004) and durum wheat (Delfine *et al.*, 2005). In the case of the effects of HS or their fractions HAs in grape, the available literature is scarce and based on studies related to applications in wine grapes (Brownell *et al.*, 1987; Vercesi, 2000), table grape (Colapietra, 2000; Sánchez-Sánchez *et al.*, 2006) and grapevine rootstocks (Zachariakis *et al.*, 2001). A variability of results has been observed in all these studies, which can be attributed to both the variable sources of HS or HAs used and the different concentrations tested. In the particular case of HAs, optimal concentrations able to affect and stimulate shoot growth have been generally indicated in the range of 50-300 mg/L, but positive effects have been also exerted by lower concentrations (Chen *et al.*, 2004).

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

MATERIALS AND METHODS

1 - Humic substances origin and properties

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 experimental field located in Spinazzola (Bari province): a sandy loam soil (sand, 672 g/kg; silt, 160 g/kg; clay, 168 g/kg) classified as a Typic Haploxerept (Soil Survey Staff, 2003) or Haplic Calcaric Regosol (FAO/ISRIC/ISSS, 1998).

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. The principal chemical properties

Table 1 - Main chemical properties of the compost and degree of humification (DG), humification ratio (HR) and humification index (HI).

	Mean
pH (H_2O, 1:5)	7.8
Moisture (%)	33.3
EC_w (25 °C, 1:5, dS/m)	8.5
Ash (%)	39.5
$CaCO_3$ (g/kg)	168
Organic carbon (g/kg)	336
N_{tot}(g/kg)	26.6
C/N ratio	12.6
P (g/kg)	12.8
K (g/kg)	9.1
Mg (g/kg)	2.8
Fe (g/kg)	14.4
S (g/kg)	0.6
DH (%)	39.9
HR (%)	10.2
HI	1.5

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of compost were determined by conventional methods (Sparks *et al.*, 1996) and are reported in table 1.

The HA-like fractions of compost and soil HAs were isolated according to the method proposed by the International Humic Substances Society (IHSS) (MacCarthy and Rice, 1985). Briefly, a 0.1 M $Na_4P_2O_7$ and 0.1 M NaOH solution was added to each air-dried, 2-mm sieved compost or soil sample using a ratio extractant:sample = 10:1. The mixture was shaken mechanically in N_2 gas atmosphere for 24 h at room temperature (RT, 20 ± 2 °C). The supernatant solution was then separated from the residue by centrifugation at 9,600 g for 30 min. The extraction procedure was repeated three times on the residue that was finally discarded. The combined alkaline supernatants were acidified with 6 M HCl to pH~1, allowed to stand for 24 h in a refrigerator, and then centrifuged at 30,400 g for 20 min. The HA precipitates were purified by repeating three times the following steps: (a) dissolution in a minimal volume of the alkaline extractant; (b) centrifugation as above; (c) removal of the residue; (d) acidification of the recovered alkaline supernatant with 6 M HCl to a pH~1; (e) standing the suspension for 24 h at RT; and (f) final centrifugation as above. The centrifuged HAs were recovered with distilled water, and then dialyzed against distilled water using a membrane having a molecular weight cutoff of 6,000-8,000 Da, until the dialysis water gave a negative Cl^- ion test with $AgNO_3$. Finally, the dialyzed HAs were freeze-dried, and stored at RT in plastic vials placed in a desiccator containing P_2O_5. The two HAs were finally analyzed (Chen *et al.*, 1977; Brunetti *et al.*, 2007) and degree of humification (DH), the humification rate (HR) and humification index (HI) were calculated according to Sequi *et al.* (1986) and Ciavatta *et al.* (1988). Data of both HAs are shown in table 2. As expected, the elemental composition of sample CHA differs from that of sample SHA. In particular, sample CHA shows a slightly higher C, N and S contents, than sample SHA, whereas the opposite is true for O content and C/N, and O/C ratios. These results confirm previously reported data (Senesi and Brunetti, 1996) on the lower content of O-containing groups, higher content of N- and S-components and higher aliphatic character of compost HA, with respect to native soil HA.

2. Field experiments

The experiment was carried out in Apulia (Southern Italy) in the years 2006 and 2007. The trial was performed in a commercial table grape vineyard located near Castellaneta, in the Taranto province, on forty-five 3-year-old Italia table grape grapevines. All the grapevines were grafted onto 1103 P (*V. berlandieri* x *V. rupestris*), spaced 2.5 x 2.5 m, overhead system (tendone) trained and drip irrigated (2,000 m^3/ha). Fertilizers addition (N 140 kg/ha, P 60 kg/ha, K 170 kg/ha), pest control and other vineyard operations were consistent with commercially adopted practices in the area. The soil type was a sandy clay loam and the general properties are shown in table 3. A randomized block design was used with three blocks and five treatments, and each treatment in the block was of three grapevines. Each treatment consisted of: (a) H_2O, used as control; (b) SHA, or CHA at concentrations of 5 and 20 mg/L. The pH of all solutions used was about 7.2, as the water normally used in the vineyard for irrigation and pesticide applications. The forty-five vines were sprayed, with the corresponding solutions, at stage B of Baggiolini (1952) and at successive 21-day intervals for six foliar treatments throughout the season up to veraison. Foliar applications were performed using a manual pump with care to wet whole leaves and shoots.

Vegetative growth was determined by measuring the length of three shoots per vine, i.e., each last shoot of the

Table 2 - Elemental composition and atomic ratios, extraction yield, ash content, acidic functional group contents and E4/E6 ratios (ratio of absorbance at 465 and 665 nm) of the two HAs.

	SHA	CHA
C[a]	52.46	54.91
H[a]	5.77	4.91
N[a]	5.40	6.73
S[a]	0.70	0.78
O[a]	35.66	32.67
C/N	11.33	9.52
C/H	0.76	0.93
O/C	0.51	0.45
Yield[b] (%)	0.4	11.5
Ash[b] (%)	6.9	3.9
Total acidity[c]	5.0	8.2
Carboxyl (COOH)[c]	2.7	4.1
Phenolic OH[c]	2.2	4.0
E_4/E_6	7.4	5.4

[a] C, H, N, S, and O are the elemental composition in % (w/w) on a moisture- and ash-free basis; [b] On moisture-free basis.
[c] Carboxyl is the charge density (meq/g C) at pH 8.0; Phenolic is two times the change in charge density (meq/g C) between pH 8.0 and pH 10.0. On moisture- and ash-free basis.

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three canes per vine was tagged and measured throughout the growing season in different sampling dates.

A number of 90 berries per treatment were picked at every sampling date starting from 12 July, collected in plastic bags and stored in a portable ice box to be carried in the laboratory for the subsequent analyses.

The effect of HAs on chlorophyll content was determined in the field with a SPAD-502-meter (Minolta Camera Co., Osaka, Japan). For this determination, three fully-expanded leaves opposite to or above the first bunch of the middle shoots were used for each grapevine and nine SPAD readings were averaged for each leaf to represent one observation. The SPAD readings were performed in three dates, 7 June and 12 July on the leaves of the primary shoots, 20 July on the leaves of the lateral shoots.

Table 3 - Physical and chemical properties of the soil at the experimental field site.

Sand	Silt	Clay	$CaCO_{3\ active}$	pH_{H_2O}	EC
(g kg^{-1})					(dS m^{-1})
551.9	170.6	277.5	6.0	7.84	0.32
Cl^-	**CEC**	**C_{org}**	**OM**	**N_t**	**P_2O_5**
(g kg^{-1})	(cmol kg^{-1})		(g kg^{-1})		(mg kg^{-1})
0.19	10.84	5.7	8.74	0.61	78.28
Na	**K**	**Ca**	**Mg**	**C/N**	**K/Mg**
(cmol kg^{-1})					
0.82	1.17	12.40	3.75	8.25	1.01
Ca/Mg	**Mn_{ava}**	**B_{sol}**	**Cu_{ava}**	**Zn_{ava}**	**Fe_{ava}**
	(mg kg^{-1})				
5.46	11.07	0.67	4.22	1.72	4.60

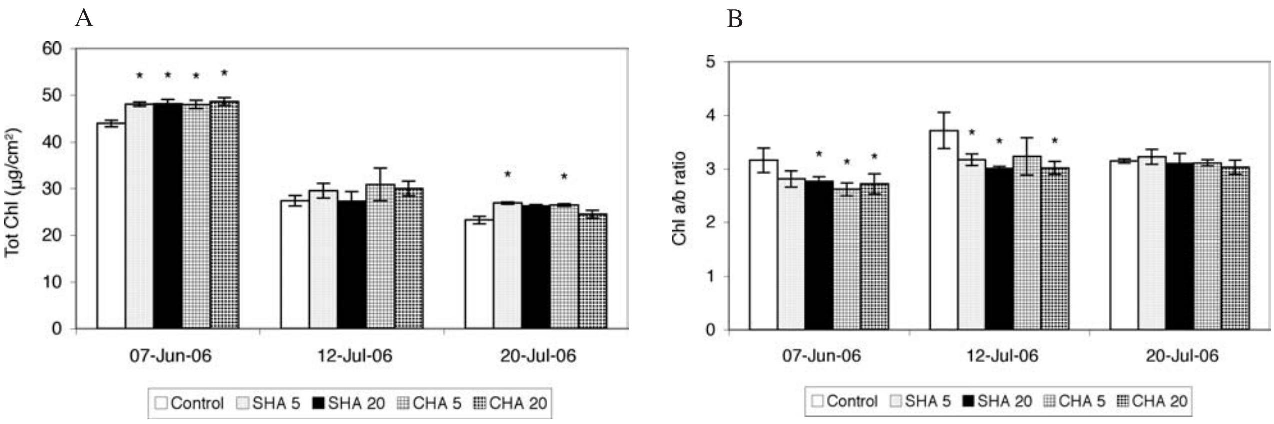

Fig. 1 - Effects of foliar sprays with a soil humic acid (SHA) and a compost humic acid (CHA) at two concentrations (5 mg/L, SHA 5 and CHA 5, 20 mg/L, SHA 20 and CHA 20) on total chlorophyll content (A) and chlorophyll a/b ratio (B).

Standard errors of the means are also indicated. * Statistically different at 0.05 P according to the Dunnett's test.

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3. Laboratory determinations

The same leaves used for the SPAD measurements were collected in plastic bags and stored in a portable ice box. Leaf chlorophylls were extracted from nine discs (each 0.94985 cm^2; approx. 120 mg total) using the dimethyl sulphoxide (DMSO) technique of Hiscox and Israelstam (1979). Chlorophyll a and chlorophyll b were calculated by the application of the equations of Arnon (1949), as also reported by Richardson *et al.* (2002). Regression between SPAD values and the spectrophotometric measurements was also calculated. The leaves and the petioles taken on 12 July for chlorophylls analysis were also used for nitrogen determination by using the Kjeldahl procedure.

The 90 berries collected in the field and carried to the lab were subjected to the following determinations, according to the A.O.A.C. (1990): 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 ratio °Brix/acidity was finally calculated.

A sample of 27 bunches per treatment (the mean of 9 bunches was considered as a replicate) was picked at harvest and the same above described parameters were measured. Yield per shoot (kg) and total yield per vine (kg) were finally calculated at harvest by counting and weighing the bunches in the laboratory.

4. 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

A similar pattern was observed for all the treatments in both years, 2006 and 2007 (data not shown) and for all the parameters examined (vegetative growth, chlorophyll, grape quality and yield).

1. Vegetative growth

The applications of both HAs generally increased the length of shoots, and the highest effect (239.7 cm) was assessed when the treatment with CHA at 20 mg/L was applied, with an increase of about 14 % with respect to the control (210.8 cm) on June 14, the last sampling date for shoot length.

The two HAs also determined a slight increase of N content both in the blade and in the petiole of the leaves. In particular, the treatment with SHA at 20 mg/L significantly increased the N content in the petiole (0.73 %) with respect to the control (0.58 %), with an increase around 26 %.

2. Chlorophyll content

Figure 1 shows the effect of spraying HAs on total chlorophyll content and chlorophyll a/b ratio, respectively. Both SHA and CHA increased total chlorophyll content (figure 1A) on 7 June (primary shoots) and 20 July (lateral shoots). In the case of the primary shoot, when mature and photosyntetically active leaves were analyzed (7 June), total chlorophyll content was significantly higher in all the HAs treatments (up to 48.6 µg/cm^2 in the case of CHA at 20 mg/L) with respect to the control (43.9 µg/cm^2). It is noticeable that the leaves of the lateral shoots showed an increase of chlorophyll content, significantly higher in the case of SHA at 5 mg/L (26.9 µg/cm^2) and CHA at 5 mg/L (26.4 µg/cm^2) with respect to the control (23.3 µg/cm^2). No differences have been observed between CHA and SHA, and both HAs seemed to delay chlorophyll degradation in the two different types of leaves, primary and lateral shoot leaves. Both HAs

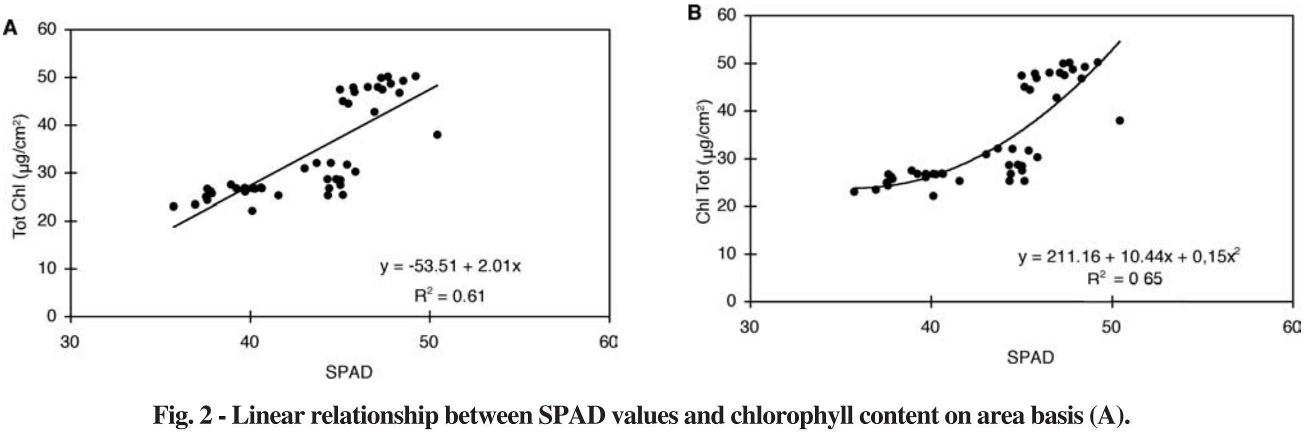

Fig. 2 - Linear relationship between SPAD values and chlorophyll content on area basis (A). Nonlinear relationship between SPAD values and chlorophyll content on area basis (B).

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significantly lowered the chlorophyll a/b ratio in the leaves of the primary shoot on the two sampling dates (figure 2B). In particular, on 12 July, the reduction was from 3.7 of the control down to 3.0 of both CHA and SHA at 20 mg/L.

Both a linear fit (figure 2A) and a nonlinear fit (figure 2B) provided a sufficiently good correlation (R^2= 0.61 and R^2 = 0.65 respectively, with P ≤ 0.0001,) between SPAD values and total chlorophyll content expressed on area basis (µg/cm^2). A higher coefficient of determination was found between N content in the blade and SPAD readings on 12 July (R^2 = 0.87). The coefficients of determination were not particularly high probably because a narrow range of leaf chlorophyll concentrations was selected, by using well-fertilized and generally dark green leaves, a normal condition in a well conducted table grape vineyard.

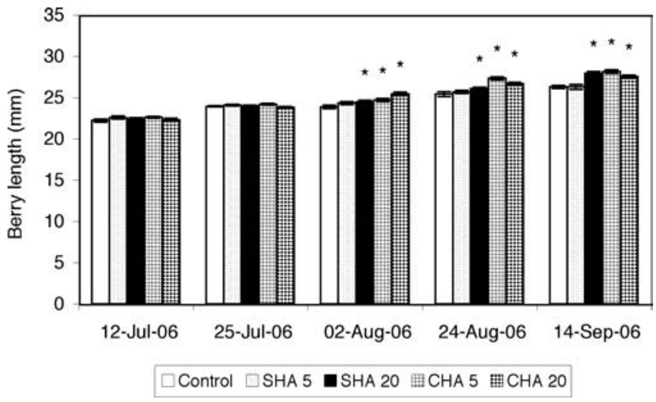

Fig. 3 - Effects of foliar sprays with a soil humic acid (SHA) and a compost humic acid (CHA) at two concentrations (5 mg/L, SHA 5 and CHA 5, 20 mg/L, SHA 20 and CHA 20) on berry length.
Standard errors of the means are also indicated. * Statistically different at 0.05 P according to the Dunnett's test.

3. Yield and fruit quality

At harvest, a single bunch weight and the total yield per vine 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. Some differences were observed in the case of bunch length and diameter, and both HAs generally reduced the length and increased the bunch diameter.

Foliar applications of HAs caused a significant increase in berry length in the three last sampling dates (figure 3). The highest berry lengths were obtained by spraying with SHA at 20 mg/L, CHA at 5 and 20 mg/L. With regards to berry width and weight, at harvest only CHA at 5 mg/L induced statistically different increases with respect to the control treatment (24.5 mm and 12.6 g, with respect to 23.8 mm and 10.6 g, respectively).

Foliar applications of CHA and SHA generally caused an increase in total soluble solids (°Brix) in almost all the samples. In the case of the titrable acidity, both SHA and CHA induced a statistically significant decrease of tartaric acid, and the lowest values were obtained by SHA and CHA at 20 mg/L with 3.7 g/L tartaric acid (figure 4A). Moreover, at harvest, SHA and CHA at 20 mg/L significantly increased the °Brix/acidity ratio (figure 4B). Finally, the pH was slightly higher in all the HAs treatments, irrespective of the concentration, with a mean value of 3.57 with respect to 3.50 of the control treatment.

DISCUSSION

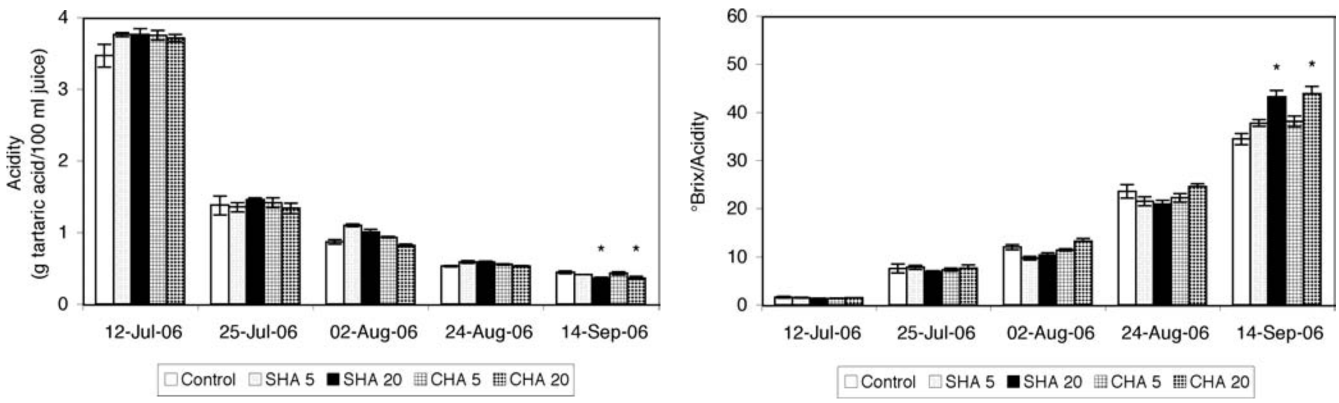

Fig. 4 - Effects of foliar sprays with a soil humic acid (SHA) and a compost humic acid (CHA) at two concentrations (5 mg/L, SHA 5 and CHA 5, 20 mg/L, SHA 20 and CHA 20) on titrable acidity (A) and °Brix/acidity ratio (B).
Standard errors of the means are also indicated. * Statistically different at 0.05 P according to the Dunnett's test.

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1. Vegetative growth

Data concerning foliar treatments with HAs of table grape cultivars are very scarce in the literature. In this study we did not observe any significant increase in shoot length, although improved growth of grapevine rootstocks treated with solutions of HS extracted from olive leaves compost has been already reported (Zachariakis *et al.*, 2001).

The significant increased N content in the leaf petiole as a consequence of HAs application was in agreement with data reported in cucumber (Rauthan and Schnitzer, 1981), 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 or HAs of different origins and various concentrations. Probably, foliar applications of HAs may have influenced nutrient availability (i.e., N supplement) by acting as complementary organic fertilizers. It has also been reported (Chen and Aviad, 1990) that HS may have limited effects on growth when plants are adequately supplied with nutrients, as in the case of a well fertilized vineyard. The beneficial effects of HS and HAs have been showed by many studies but more on root growth than on shoot growth (Chen *et al.*, 2004).

2. Chlorophyll content

With regards to the spectrophotometric chlorophyll content, similar and persistent increases 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). Strawberries treated with HAs in various dates presented higher chlorophyll a and b concentrations and a greater photosynthetic efficiency (Neri *et al.*, 2002). Increase in leaf chlorophyll content and decrease in chlorophyll a/b ratio were also detected in two grapevine rootstocks, 41B and 110 Richter (Zachariakis *et al.*, 2001). The decreased chlorophyll a/b ratio in the leaves means an extension of the absorption band of mixed pigments towards the green part of the system (Ramadan and Omran, 2005) and is generally found at high chlorophyll levels (Terry and Zayed, 1995). The foliar treatment with HAs may have stimulated chlorophyll synthesis (Vaughan and Malcolm, 1985; Nardi *et al.*, 1996) or probably delayed chlorophyll degradation in the treated grapevines.

The coefficients of determination (SPAD vs. chlorophyll content) calculated in this experiment are lower than the ones reported for some potted grapevines (Bavaresco, 1995) and in a Cabernet-Sauvignon vineyard (Baldy *et al.*, 1996), but the conditions of the experiments are not comparable (climate, soil, nutritional status, training system, cultivar, rootstock, etc.). However, Porro *et al.* (2001) obtained decreasing coefficients of determination (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. Moreover, in our experimental conditions, grapevines were covered with a plastic sheet and various factors (light scattering, leaf surface reflectivity, pigment distribution in the leaf) may have affected the *in vivo*/*in vitro* chlorophyll relationship. On the other hand, the correlation between SPAD and N content in leaf blade was characterized by a higher R^2, similarly to what reported for Chardonnay at berry set (Porro *et al.*, 2001).

3. Yield and fruit quality

Data reported in the present paper showed that foliar applications of CHA and SHA slightly increased yield per vine in table grape. Larger increments have been 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 %. However, no details on the chemical properties of the two extracts used were indicated in the mentioned paper. The increase in berry size (length) may be potentially ascribed to the possible hormone-like activity of HAs (i.e., auxin, gibberellin- and cytokinin-like activity), and this action could be useful when applying these natural organic compounds in seedless table grape instead of synthetic hormones. The slight increase of °Brix and the statistically significant reduction of acidity are noteworthy, 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 and HAs.

4. Structure-activity relationships

The stimulating activities of the two HAs samples used can be partially related to their compositional, structural and functional properties (table 2). Sample CHA features smaller O and H contents, similar or larger C, N and S contents, and much larger total acidity and carboxyl and phenolic group contents than SHA sample. A general more positive growth and quality effects exerted by CHA with respect to SHA can be related to the greater content of carboxyl groups and acidity. These findings agree with the generally greater biological activity found for HS rich in carboxylic and phenolic groups and of small molecular weight detected in previous works on plants (Chen and Aviad, 1990; Piccolo *et al.*, 1992; Nardi *et al.*, 2002; Ferrara *et al.*, 2004). The low molecular weight components present a larger number of functional groups thus possessing a higher metal binding capacity and consequently improving nutrient assimilation and a general plant metabolism (Nardi *et al.*, 2002).

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CONCLUSIONS

Results obtained in the present work showed that two HAs, one extracted from a compost and the other from a native soil, were able to produce some positive effects on the general quality of table grape cv. Italia. In particular, a significant increase in berry size and a significant reduction of titrable acidity have been observed. Actually, new experiments are running in order to verify the effects of higher concentrations and less purified HAs.

Acknowledgments: This research was financially supported by Fondi di Ateneo Project (ex 60 %) of the University of Bari. We wish to thank Dr. Andrea Pacifico and Mr. Pasquale Simeone for support both in the field and in the lab. We are also indebted to Dr. Tony Romanazzi for the use of a section of his vineyard. The precious comments of Dr. Matthew Fidelibus to the manuscript have been greatly considered.

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