Foliar and Soil Drench Application of Humic Acid on Yield and Berry Properties of ‘Askari’ Grapevine

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ABSTRACT

In order to investigate two methods of Humic Acid (HA) application on the quantitative and qualitative traits of grape cv. ‘Askari’, an experiment was conducted in a randomized complete blocks design with seven treatments and three replications in a vineyard located in Sisakht, Yasouj, Iran. Treatments included control (0), soil and foliar application of HA at concentrations of 2.5, 5 and 7.5 g l−1 from green hum source (13% HA). Traits such as TSS, TA, pH, TSS/TA, weight of single cluster, yield per plant, length and weight of berry, berry volume, chlorophyll index (SPAD) and berry firmness were measured and evaluated during experiment. Results indicate that application of HA increases the qualitative and quantitative of ‘Askari’ grape compared to untreated plants. The highest cluster weight, chlorophyll index and TSS were obtained in plants that were treated with 2.5 g l−1 HA in soil application method. The firmness of berries was observed in soil application of 2.5 g l−1 HA. Therefore, use of HA in soil method is better than spray method in vineyards.

Keywords: Berry firmness, chlorophyll index, grape, SPAD, TSS.

Abbreviations:
HA: Humic Acid; TA%: Total Acid; TSS%: Total Soluble Solids.

INTRODUCTION

Grapevine is one of the most important horticultural crops in the world and Iran. It is full of vitamin A, B, and lots of sugar materials and it includes iron, calcium, phosphorus, magnesium, potassium and manganese. Based on 2012 statistics of FAO, cultivation area and the rate of grape production in the world are 6.96 million hectare and 67.1 million ton, respectively. While having 215000 hectare of culture area and 2.15 million tons of production, Iran holds the ninth rank in the world (FAO, 2012).

Nowadays organic fertilizers have found many supporters because of having less adverse effects on environment and better health. The results of studies have shown that very little amounts of organic acids have many beneficial effects on physical, chemical and biological properties of soil and besides that they increase yield and production of agricultural crops (Samavat and Malakoti, 2005). Different types of these materials such as compost, animal manure, and HA can cause increase plants growth. Humic compounds are the most abundant of the complex ligands, which are found in nature. In this regard, it is well known that the humic compounds improve soil structure, increase soil microbial population, increase soil cation exchange capacity and provide some specific materials for plant root indirectly by providing macro and micro minerals, leading to the increase of soil fertility (Tan, 2003; Timothy et al., 2010). HA has a useful effect on soil and plant. Liu and Cooper (2000) reported that there is a direct correlation between soil fertility and the organic fraction of the soil. HA effectively improves soil fertility and crop production especially in poor soils and alkaline-calcareous soils (Rajpar et al., 2011).

Previous studies reported a beneficial impact of this compound (HA) on plant growth and development (David et al., 1994; Adani et al., 1998; Nikbakht et al., 2008). HA improves the absorption of mineral elements such as N, P, K, Ca and Mg (Bohme and Thi-Lua, 1997; Atieyeh et al., 2002). The HA based fertilizers increase yield (Mohamed et al., 2009), simulation of plant enzymes and hormones and soil fertility (Mart, 2007; Sarir et al., 2005). Several research works have prominently
shown the positive benefits of application of HA on higher plants (Ashraf et al., 2005; Susilawati et al., 2009; Mackowiak et al., 2001). Hosseini Farahi et al. (2013) reported that application of HA had positive influence on fruit number, total yield of plant, TSS, fruit firmness and chlorophyll content of Strawberry cv ‘Aromas’ and suggested foliar application of HA is useful in improving the quantitative and qualitative characteristics of strawberry fruit in soilless cultures. Eshghi et al. (2013) reported that green hum and seaweeds extracts are capable of influencing vegetative and reproductive growth of strawberry cv. ‘Selva’. In a study, application of compost and HA caused to increase total yield of strawberry significantly in comparison with the mineral fertilizers (Shehata et al., 2011).

Zaki et al. (2006) observed the enhancement of shoot number, leaf area, total yield, fresh weight and phosphorus content by application of 1 gl⁻¹ HA as foliar application. In a research, all morphological traits such as plant height, number of leaf and stem in plant, fresh weight of leaf, yield and yield components of cucumber showed effective influences in response to high concentration of HA and Ecormon in comparison with other treatments. Foliar application of HA and bio-stimulators led to positive effects on plant growth, fruit set and improvement of cucumber production (El-Nemr et al., 2012). Ozdamar-Ullu et al. (2011) reported that soil and leaf application of HA increased fruit’s weight, pre maturation, total yield and increase the fruit quality of cucumber in comparison to untreated plants. Application of compost and HA cause increased total yield of strawberry significantly in comparison to fertilization elements (Shihata et al., 2011). Puzesh et al. (2011) showed that the most yield in grape cv ‘Paykani’ (up to 13.58 kg per vine) were obtained in vine treated with HA, zinc and acetic acid compared to control. Increase in leaf area, weight of primary and secondary fruits, number of achene, length of fruit, fresh and dry branches weight, fresh and dry root weight and yield of strawberry cv. ‘Selva’ with application of 3 ml⁻¹ HA was reported by Zare (2011). Brown et al. (1993) found that HA increases the average yield of tomato and cotton about 10 and 11 percent with regard to evidence and they also reported an increase in yield of different cultivars of grape from 3 to 7 percent as compare to untreated plants. In a study, effects of HA on three hybrids of watermelons were investigated. Results showed that use of HA up to 14.2 lh⁻¹ caused total yield of the three watermelon hybrids (Salman et al., 2005).

Considering the beneficial effects of HA, this study was conducted to compare the effects of two methods of HA application (soil and foliar) on the qualitative and quantitative characteristics of ‘Askari’ grape and their improvement.

**MATERIALS AND METHODS**

**Treatment and Experimental Design:**

In order to study the effect of two methods of HA application on the quality and quantity of ‘Askari’ grape, an experiment was performed in randomized complete blocks design with seven treatments and three replications in a vineyard in Sisakht region, Yasouj, Iran. Applied treatments in this experiment consisted of soil and leaf spray application of HA in concentrations of 0, 2.5, 5 and 7.5 gl⁻¹. Applied HA in this study was made in green hum company of Italy (13 % HA).

At first, one soil sample of vineyard was taken based on standardized methods and sent to laboratory for measuring chemical and physical parameters of soil. Result of soil properties are shown in Table 1. Before treatment, during late winter, similar grape vines cv. ‘Askari’ were selected in a commercial vineyard in Sisakht, labelled and winter pruned. Treatments were done two weeks before blooming and its repetition was done two weeks after that. In order to prevent spilling of the drops, HA solution placed on soil before spilling solution under plastic bushes. All vineyard managements were done during growth season including irrigation, pests and diseases control based on standard conditions. During growth season, vineyards were observed regularly, and recorded as regards to considering attributes was done. Harvesting of fruits was done at the end of growth season and maturing of vine, and then it was analysed based on quantitative and qualitative attributes.

**Measurements:**

1. **Total Soluble Solid**

   TSS was measured by manual refractometer (model N52436, Netherlands) based on Brix%.

2. **Total Acid Percentage**

   TA% was measured by the NaOH titration method: in 10 ml of fruit juice, 5-6 droplets of phenolphthalein were added and then the mixture was titrated with 0.3 N NaOH until colour change to purple. Then following formula was used to calculate TA%:

   \[ \text{TA} \% = \frac{[\text{ml (NaOH) \times N (NaOH) \times acid}]}{\text{meq.factor/ml juice titrated}} \times 100. \]

3. **Fruit Juice pH**

   The pH of fruit juice was measured by digital pH meter (Jenway 3510, England).

4. **Cluster Weight**

   Cluster weight was calculated using digital balance (ACB Olus 600H, ADAM) with 0.001 accuracies.
5. Berry Size
Berry Length, width and average size was measured based on measuring average of 10 berries by digital calliper.

6. Chlorophyll Index
Chlorophyll Index which is an indicator of leaf chlorophyll rate was measured by a SPAD device (Minolta, Japan).

7. Berry Firmness
Berry firmness was measured by texture analyser.

Data Analysis:
Data were subjected to analysis of variance. All analyses were performed with MSTATC software. Mean comparisons were calculated using the Duncan’s at P < 0.05.

RESULTS
Yield and Other Quantitative Traits:
The highest cluster weight of 333.17 g was obtained in wines treated with soil application of 2.5 gl⁻¹ HA and the lowest single cluster weight with 287.87 g was observed in untreated wines (Fig. 1). Highest single berry weight (2.31 g) was related to 5 and 7.5 gl⁻¹ HA soil drench application (Fig. 2). Highest single berry width (1.45 cm) was obtained in 7.5 gl⁻¹ HA soil application and the least berry width of 1.36 cm was seen in 2.5 gl⁻¹ HA as foliar application and soil respectively (Fig. 3). But the longest berry length (1.85 cm) was seen in 7.5 gl⁻¹ HA soil drench and shortest (1.69 cm) belonged to 2.5 gl⁻¹ HA foliar application (Fig. 3). This was while the highest berry volume (2.2 cm³) was observed in 7.5 gl⁻¹ HA foliar application and least berry volume (1.8 cm³) was seen in 2.5 gl⁻¹ HA foliar application (Fig. 4).

Chlorophyll Index:
Data shown in Fig. 5 indicated that the highest leaf greenness index (43.13) was observed in 5 gl⁻¹ HA foliar application and the least (39.6) belonged to untreated vines (Fig. 5).

Quality Properties:
Results of this study showed that the highest TSS (20.39 Brix %) was observed in 2.5 gl⁻¹ HA treatment in soil application and least of them (18.5% Brix) in 5 gl⁻¹ litter HA foliar application treatment (Fig. 6). Results showed that there was significant difference between different levels of HA treatment for total acid. The highest of total acid (0.85 %) was seen in 5 gl⁻¹ HA treatment in form of soil application and least of it (0.6%) was observed in untreated vine (Fig. 7). The results of means comparison showed that there was not a significant difference among different levels of HA treatment on juice pH, but the highest fruit juice pH (3.01) was observed in control treatment and least of it (2.94) was seen in 2.5 gl⁻¹ HA treatment in the form of soil drench (Fig. 8). Results shown in Fig. 9 indicate that the highest TSS/TA (33.1) was obtained in grapes of untreated vines and the least of it (1.89 cm³) was seen in 5 gl⁻¹ HA soil drench treatment (Fig. 9).

Berry Firmness:
The results of means comparison showed that highest berry firmness was obtained in wines that were treated with 2.5 gl⁻¹ HA (642.81 gr) in soil application method and the least of it was observed in untreated plants (377.90 gr) (Fig. 10).

DISCUSSION
In this study the application of HA increased the quantitative characteristics and yield of ‘Askari’ grape. Increasing quantitative and qualitative characteristics by using HA have been reported by many researchers (Zaki et al., 2006; Ferrara and Brunetti, 2010; Pousheshi et al., 2011; Shihata et al., 2011; Ozdamar-Ullu et al., 2011; Kamari-Shahmaleki et al., 2012). Formation of complex between HA and mineral ions, catalysis of HA by the enzymes in plant, influence of HA on respiration and photosynthesis, stimulation of nucleic acid metabolism and hormonal activity of HA are amongst effective assumptions that has been expressed to describe the effect of HA on plants growth parameters (Turkmen et al., 2004).

Activation of ATPase and proton pumps in the root cellular membrane is one of the primary responses to HA application (Pinton et al., 1999). Enhancing the quantitative and qualitative characteristics as a result of increased respiration, photosynthesis and total protein in the plants, due to HA and folic acid application has also been reported by Nardi et al. (2002). Sayyedbagheri (2010) reported humics substance have direct and indirect effects in synthesis of protein, hormone–like activity, photosynthesis stimulating, variation in enzymes” activity, absorption of macro and micro elements reduction of toxic element, and increase in microbial population of soil. Liu et al. (1998)
showed that 400 mg l⁻¹ of HA increased photosynthesis rate and root development in bent grass.

Increasing leaf area, weight of first and second fruits, achene's number, fruit length, shoot fresh and dry weight, root fresh and dry weight and yield of strawberry cv 'Selva' by using HA has been reported by Zare (2011), which is agree with our results. Some researchers (Atiyeh et al., 2002) reported that the reason behind the effectiveness of HA on plant growth and development is the existence of plant growth regulators such as IAA, GAs and CKs. Moreover, some investigators attributed the positive effects of HA due to its influence on plants root (Adani et al., 1998; Atiyeh et al., 2002; Turkmen et al., 2004; Yildrim, 2007 and Ozdamar-Ullu et al., 2011).

![Fig. 1. Effect of HA on cluster weight of 'Askari' grapes.](image1)

![Fig. 2. Effect of HA on single berry weight of 'Askari' grapes.](image2)

![Fig. 3. Effect of HA on berry length and width of 'Askari' grapes.](image3)

![Fig. 4. Effect of HA on berry size of 'Askari' grapes.](image4)

![Fig. 5. Effect of HA on chlorophyll content of 'Askari' grapes.](image5)

![Fig. 6. Effect of HA on TSS % of 'Askari' grapes.](image6)
Cangi et al. (2006) indicated that foliar spraying of HA and amino acids on Asparagus plants increase uptake of macro and micro elements in shoot and rhizome has increased carbohydrates production, chlorophyll and carotenoids in edible stems.

Nikbakht et al. (2008) concluded that HA might increase the plant growth by improving the minerals nutrition uptake. Gibberellins and cytokinin-like activities have been reported for HA (Zhang and Ervin, 2004). Atiyeh et al. (2002) reported 250 mg/l of HA caused increment of tomato fruits, they included hormone like activity of this compound as one the reasons responsible for bigger fruits. Results of this study showed that HA causes increase in qualitative properties of fruit such as TSS %, pH and TA %. Significant positive effects of HA on qualitative traits of fruit such as TSS %, Vitamin C, total sugar, reduced and non-reduced sugars was reported by Abassi et al. (2013). Khan et al. (2012) reported that soil application of HA increased significantly chlorophyll content, carotenoid and sugar in pea. In this study application of HA causes increased berry firmness. Increase in fruit firmness by use of HA reported by some researchers. Application of HA to creating favourable conditions to facilitate nutrient uptake by roots, cause increase in calcium and fruit firmness (El-Nemir, 2012). Nikbakht et al. (2008) concluded that HA might increase the plant growth by improving the minerals nutrition uptake.

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