



## Article

# Effect of Spraying Ethanol and Acetaldehyde, as secondary metabolites, on Growth and Productivity of three grapevines Cultivars

Hamdy I.M. Ibrahim<sup>1,\*</sup>; El-Sayed A.E. El-Sayed<sup>2</sup> and Hassan M. Abo El-Fadl<sup>1</sup>



1 Hort. Dept. Fac. of Agric. Minia Univ., Egypt.

2 Plant Pathology Dept., Fac. of Agric. Minia Univ., Egypt.

\*Corresponding author. [hamdy\\_france@yahoo.com](mailto:hamdy_france@yahoo.com)

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**Abstract.** The current study focused on the effect of spraying some plant secondary metabolic byproducts, namely. ethanol and acetaldehyde, as well as their potential use as growth promoters and to improve vegetative growth, nutritional status, and productivity of three grape cultivars recently introduced and adapted to the Egyptian climate (Superior, Red Globe, and Early Sweet cvs.). Three concentrations of each material were used. Ethanol at 3, 6, and 9% and Acetaldehyde at 0.5, 1.0, and 1.5%. The obtained results showed that spraying Ethanol shows more effective rather than spraying Acetaldehyde in this respect. Spraying Ethanol at 9% presented the best results. Under the conditions of cultivation in clay soils in Minia Governorate and similar conditions, we recommend by spraying the Superior, Red Globe and Early Sweet cultivars three times during the season with Ethanol at 9% in order to improve growth, nutritional status and yield quantity.

**Key words.** Grapevines, Ethanol, Acetaldehyde, Superior, Red Globe, Early Sweet.

## 1. Introduction

Botanically, grapevines (*Vitis vinifera* L.) belong to the family *Vitaceae*, Genus *Vitis*. It mainly cultivated for wine and table grape production, only the European *Euvitis* (namely true grapes), cultivated for produces table grape or fine wine (Reynier, 2000 and Doring *et al.*, 2015). Egypt considered as one of leading countries in producer of table grape in Africa and Arab counters. El-Minia Governorate is one of the leading areas in grapevines cultivation. Three cultivars were chosen for achieving this study. Superior is one of seedless grapevine cultivars, it is known as a popular cultivar in Egypt. Red Globe late maturing seeded table grape cultivar. It characterized by very large, firm, dark red, violet, and spheroidal berries. Early Sweet is a seedless whit cultivar. It has been popular to Egyptian consumer. It characterized by medium size of berry, cohesive pulp texture and good flavor.

Ethanol and acetaldehyde are small, volatile metabolites that occur naturally in plant tissues under a variety of physiological and stress conditions. These compounds are produced endogenously through

anaerobic metabolism when tissues experience oxygen deficiency (e.g., waterlogging, root hypoxia) and they also appear during fruit ripening and floral senescence (**Kimmerer, 1982 and Pesis, 2005**). Exogenous application of ethanol or acetaldehyde has therefore been investigated extensively for its physiological effects on plants, for potential postharvest benefits, and for its risks when applied at inappropriate concentrations.

This investigation focused on the response of growth, natural status, productivity and berry quality as well as histology of three grapevines cultivars namely Superior, Red Globe and Early Sweet to spraying ethanol and acetaldehyde, under El-Minia Governorate conditions.

## **2. Material and Methods**

This study was conducted during two seasons 2022 and 2023 on three grapevines cultivars namely. Superior, Red Globe, and Early Sweet. All these cultivars were grown in loamy clay soil, well drained water since water table depth is not less than two meters. The farm which the experiment was conducted was located at Abwan Village, Matay District El-Minia Governorate – Egypt. The vines were irrigated by using surface irrigation using Nile water. Twenty-one uniform vines in vigor were selected from each cultivar. Cane pruning system was followed. Vine loading was adjusted at 80 eyes per vine (8 fruiting canes X 8 eyes + 8 renewal spurs X 2 eyes). The chosen vines are subjected to regular horticulture practices commonly applied in vineyards.

### **2.1. Plant material**

The selected three cultivars Superior, Red Globe, and Early Sweet were 10 years old at the start of experiment. The chosen three cultivars were trained according to cane pruning system using gable shape supporting system. Vine load was adjusted to 80 eyes per vine (8 fruiting canes × 8 eyes plus 8 renewal spurs × 2 eyes).

### **2.2. Soil and water analysis**

The soil texture was loamy clay (table 2). A composite sample of soil was collected and subjected to Physical and chemical analysis according to the procedures outlined by **Wilde *et al.* (1985)**.

### **2.3. Experimental work**

In order to evaluate the response of growth, nutritional status and productivity of these three grapevines cultivars to spraying ethanol and acetaldehyde at different concentrations, seven treatments were performed for each cultivar as following. Control (untreated vines), spraying ethanol at 3%, spraying ethanol at 6%, spraying ethanol at 9%, spraying acetaldehyde at 0.5%, spraying acetaldehyde at 1.0%, spraying acetaldehyde at 1.5%.

All treatments were applied three times yearly. the first one after bud burst, the second one just after setting and the third one at one month later. Each treatment was replicated three times, one vine per each.

### **2.4. Experimental design and statistical analysis**

Treatments were arranged in a complete randomized block design (RCBD) in split plot design according to **Gomaz and Gomaz (1990)**. The obtained data were subjected to statistical analysis of variance (ANOVA), by using (MSTATC Program). Comparisons between means were made by using least significant differences (L.S.D) at  $P = 0.05$  (**Snedecore and Cochran, 1990**).

### **2.5. Different measurements and determinations**

The following vegetative growth, leaves photosynthesis pigments, leaves macro nutrients contents (N, P, K, Mg), and yield and its component were achieved during the two experimental seasons (2022 and 2023).

### a- Vegetative growth

At the middle of April during 2022 and 2023 seasons, ten mature leaves from the opposite side to the basal clusters on the shoot were picked (according to **Ibrahim, 2010**), Leaf area (cm<sup>2</sup>) was estimated. Leaf area was measured by using the equation of **Ahmed and Morsy, 1999**. The average main shoot length (cm) was recorded, and then the average shoot length was calculated. Number of leaves per main shoot was recorded also.

### b- Measurements of leaf photosynthesis pigments

Samples of six adult fresh leaves from those leaves opposite of basal clusters were taken at the middle of April during the two seasons were taken, cut into small pieces and 0.5 g weight from each sample was taken, homogenized and extracted by 25% acetone in the presence of little amounts of Na<sub>2</sub>CO<sub>3</sub>. (according to **Ward and Johnston, 1962**).

$$\text{chlorophyll a} = (9.784 \times E_{662}) - (0.99 \times E_{644}) \quad \text{mg}/100\text{gFW}$$

$$\text{Chlorophyll b} = (21.426 \times E_{644}) - (4.65 \times E_{622}) \quad \text{mg}/100\text{gFW}$$

Where E = optical density at a given wavelength. Total chlorophyll was estimated by summation of chlorophyll a plus chlorophyll b (mg/ 100 g. F.W).

### c- Determination of leaves macro nutrients contents

The petioles only were used in different mineral nutrients determination. The petioles washed with distilled water, dried at oven, and grounded. 0.5 g of weight was digested, using H<sub>2</sub>SO<sub>4</sub> and H<sub>2</sub>O<sub>2</sub> until clear solution was obtained (**Martin-Preval *et al.*, 1984**). The digested solution was completed to 100 ml by using distilled water. Thereafter, contents of N, P, K, Mg, Fe, Zn, and Mn were determined as follows.

- Leaf Nitrogen content was determined by using modified microkjeldahl method (**Martin-Preval *et al.*, 1984**).

- Phosphorus determined colorimetricly by measuring the optical density of phosphor-molibdo-vanadate complex colour using Spectro-photometr at 430 nm wave length (**Wild *et al.*, 1985**).

- Potassium determined by flam photometrically method (according to **Martin-Préval *et al.*, 1984**).

**Yield and its component.** The clusters were harvested at ripening stage when T.S.S / Acid in the berries juice (check treatment) reached at 24 – 25 (**Winkler *et al.*, 1974 and Weaver, 1976**). The yield per vine was recorded in terms of weight (kg/vine) and number of clusters per vine and average cluster weight (g) were recorded.

## 3. Results and Discursion

### 3.1. Effect of Ethanol and Acetaldehyde on vegetative growth

#### 3.1.1. Effect on shoot length (cm)

The data presented in Table (1) showed the effect of spraying Ethanol and Acetaldehyde on shoot lengths of Superior, Red Globe and Early Sweet cultivars, this data demonstrate significant variations in shoot length among the three grapevine cultivars (Superior, Red Glob, and Early Sweet) in response to ethanol and acetaldehyde treatments during 2022 and 2023. The Superior cultivar exhibited the longest shoots, followed by Red Globe. While, Early Sweet showed the shortest shoots length. Among spraying ethanol at 9% proved most effective, producing shoots averaging 78.2 cm across both seasons, representing a notable enhancement compared to the control or other treatments. This finding aligns with research conducted by **Ben-Tal and Lavee (1976)** in their study titled Effect of ethylene treatment on ripening of grapes, which demonstrated that ethylene-related compounds can stimulate vegetative growth in grapevines. Similarly, **Weaver and Pool (1971)** in their comprehensive work Bloom delay and bloom

thinning in seedless grapes with gibberellic acid sprays, reported enhanced shoot elongation following growth regulator applications. Spraying acetaldehyde also showed positive effects, with the highest concentration (1.5 percent) yielding 70.6 cm mean shoot length. These results suggest that both ethanol and acetaldehyde can function as growth promoters in grapevines, possibly through their influence on ethylene biosynthesis pathways or their direct effects on cell expansion mechanisms. The consistent performance across both experimental seasons reinforces the reliability of these treatments. The interaction between cultivars and treatments (spraying ethanol and acetaldehyde) indicate that cultivar-specific responses exist, with Superior demonstrating greater responsiveness to the nine percent ethanol treatment, achieving 83.9 cm and 82.8 cm in the respective seasons.

**Table (1). Effect of spraying ethanol and acetaldehyde on Shoot length of Superior, Red Glob, and Early Sweet grapevines cultivars, during 2022 and 2023 seasons**

Shoot length (cm)							
Treatments	Superior (a1)		Red Globe (a2)		Early Sweet (a3)		Mean B
	2022	2023	2022	2023	2022	2023	
Control (b1)	75.3	70.2	65.5	70.3	61.3	63.3	<b>67.7</b>
Ethanol 3% (b2)	77.5	76.4	71.2	75.5	63.3	64.5	<b>71.4</b>
Ethanol 6% (b3)	78.3	77.3	73.3	75.7	62.5	69.6	<b>72.8</b>
Ethanol 9% (b4)	83.9	82.8	79.7	79.6	69.8	73.2	<b>78.2</b>
Acetaldehyde 0.5% (b5)	74.4	73.3	66.5	73.3	62.4	66.2	<b>69.4</b>
Acetaldehyde 1.0% (b6)	76.5	72.9	68.3	73.9	64.4	66.1	<b>70.4</b>
Acetaldehyde 1.5% (b7)	77.3	76.7	64.5	74.2	62.3	68.4	<b>70.6</b>
Mean A	<b>77.6</b>	<b>75.7</b>	<b>69.8</b>	<b>74.7</b>	<b>63.7</b>	<b>67.3</b>	
New LSD %	<b>A= 6.8 ; B= 6.1 ; AB= 8.8</b>						

### 3.1.2. Effect on the number of leaves per shoot

The statistical analysis indicated non-significant differences neither between the two cultivars nor between the treatments (Table 2). Furthermore, the interaction between the two factors (AB) was also non-significant. The absence of significant treatment effects on leaf number contrasts with findings reported by **Weaver (1976)**. However, this result is consistent with observations by **Korkutal *et al.*, (2008)**. The effects of shoot trimming on berry weight and main components of grape variety Semillon, published in African Journal of Agricultural Research, who found that leaf numbers remained relatively stable across different treatment regimens in mature grapevines. The non-significant response may be attributed to the inherent genetic regulation of leaf production in established vines, where leaf primordia development is primarily determined by cultivar characteristics rather than external chemical applications. **Morrison and Iodi (1990)** in their study Influence of ethylene on grape berry development and suggested that ethylene-related compounds have limited impact on organogenesis in woody perennials compared to herbaceous species.

### 3.1.3. Effect on leaf area (cm<sup>2</sup>)

The leaf area measurements presented in Table (3) demonstrate significant responses to both cultivar and treatment factors. Statistical analysis revealed significant differences among cultivars, treatments, and their interactions. 'Red Globe' exhibited the largest leaf area across both seasons, averaging 140.1 cm<sup>2</sup> in 2022 and 142.9 cm<sup>2</sup> in 2023, followed by Superior (138.2 and 137.9 cm<sup>2</sup>) and Early Sweet (132.1 and 132.9 cm<sup>2</sup>). The Ethanol and acetaldehyde treatments were particularly pronounced, with ethanol at 9% producing the highest mean leaf area of 144.9 cm<sup>2</sup>, representing a

substantial increase of 12.8 percent compared to the control treatment which averaged 128.5 cm<sup>2</sup>. Acetaldehyde treatments also enhanced leaf area development, with the 1.5 percent concentration achieving 139.9 cm<sup>2</sup>. These findings corroborate research by **Doring *et al.* (2015)**. Growth, canopy structure and gas exchange parameters of *Vitis vinifera* under different training systems, which demonstrated that chemical treatments affecting carbon assimilation pathways can significantly influence leaf expansion. The mechanism underlying this response may involve enhanced cell division and expansion promoted by ethylene-mediated signaling pathways, as described by **Koyama *et al.* (2018)** in their research on Ethylene and auxin interactions during grape berry development. The leaf area (cm<sup>2</sup>) observed with higher ethanol concentrations likely translates to increased photosynthetic capacity, which could positively impact overall vine productivity and fruit quality parameters.

**Table (2). Effect of spraying ethanol and acetaldehyde on number of leaves / Shoot of Superior, Red Globe, and Early Sweet grapevines cultivars, during 2022 and 2023**

Number of leaves per shoot							
Treatments	Superior (a1)		Red Globe (a2)		Early Sweet (a3)		Mean B
	2022	2023	2022	2023	2022	2023	
Control (b1)	13.5	11.9	12.3	14.5	13.2	13.5	13.5
Ethanol 3% (b2)	14.2	11.7	12.3	12.2	15.3	12.5	13.0
Ethanol 6% (b3)	13.3	13.3	13.5	13.1	13.6	13.1	13.3
Ethanol 9% (b4)	14.6	13.3	12.5	13.1	13.9	13.9	13.6
Acetaldehyde 0.5% (b5)	13.3	14.5	11.3	14.3	14.3	12.3	13.3
Acetaldehyde 1.0% (b6)	12.7	12.2	14.4	14.5	13.2	13.4	13.4
Acetaldehyde 1.5% (b7)	14.5	13.3	13.7	13.7	14.5	14.2	13.9
Mean A	13.7	12.9	12.9	13.6	14.0	13.2	
New LSD %	A= NS . B= NS ; AB= NS						

**Table (3). Effect of spraying ethanol and acetaldehyde on leaf area (cm<sup>2</sup>) of Superior, Red Globe, and Early Sweet grapevines Cvs, during 2022 and 2023 seasons**

Leaf area (cm <sup>2</sup> )							
Treatments	Superior (a1)		Red Globe (a2)		Early Sweet (a3)		Mean B
	2022	2023	2022	2023	2022	2023	
Control (b1)	130.1	128.9	132.5	136.7	122.4	120.5	128.5
Ethanol 3% (b2)	133.9	135.5	137.9	139.9	133.7	132.5	135.6
Ethanol 6% (b3)	142.1	144.7	142.3	145.5	134.6	137.5	141.1
Ethanol 9% (b4)	147.5	148.3	144.6	148.7	139.9	140.8	144.9
Acetaldehyde 0.5% (b5)	136.2	133.5	133.5	140.1	127.2	128.4	133.2
Acetaldehyde 1.0% (b6)	139.1	138.3	144.3	145.5	131.1	132.1	138.4
Acetaldehyde 1.5% (b7)	138.6	136.6	145.6	144.1	135.8	138.5	139.9
Mean A	138.2	137.9	140.1	142.9	132.1	132.9	
New LSD %	A= 4.6 ; B= 6.2 ; AB= 8.9						

### 3.2. Effect on photosynthesis pigments

#### 3.2.1. Effect on chlorophyll a

Table (4) illustrates the chlorophyll a content in leaves of the three grapevine cultivars under different Ethanol and Acetaldehyde treatments. Significant differences were observed between cultivars, treatments, and their interaction. Superior cultivar consistently maintained the highest chlorophyll a levels compared to 'Red Globe' and 'Early Sweet'. Data revealed that Ethanol at 9% significantly enhanced chlorophyll a accumulation, achieving a mean of 5.5 mg/100g fresh weight, which represents a 31 percent increase over the control treatment. This substantial enhancement in chlorophyll content is consistent with findings reported by **Lichtenthaler (1987)** in his seminal work chlorophylls and carotenoids pigments, which established the relationship between growth promoting compounds and chlorophyll biosynthesis. Acetaldehyde treatments also showed positive effects, with the 1.5% producing 4.8 mg/100g fresh weight. The elevated chlorophyll a levels observed with ethanol treatments may be attributed to enhanced nitrogen metabolism and chloroplast development, as documented by **Perez *et al.* (2009)**. The interaction between Superior cultivar and 9% yielded the highest individual value, suggesting cultivar-specific optimization of photosynthetic pigment production under chemical regulation.

**Table (4). Effect of spraying ethanol and acetaldehyde on Chlorophyll a (mg/ 100g FW) of Superior, Red Globe, and Early Sweet grapevines cultivars, during 2022 and 2023 seasons**

Chlorophyll a (mg/100g FW)							
Treatments	Superior (a1)		Red Globe (a2)		Early Sweet (a3)		Mean B
	2022	2023	2022	2023	2022	2023	
Control (b1)	4.3	4.1	4.1	4.2	4.2	4.1	4.2
Ethanol 3% (b2)	4.8	4.7	4.6	4.8	4.3	4.4	4.6
Ethanol 6% (b3)	5.2	5.3	5.3	5.6	4.9	4.9	5.2
Ethanol 9% (b4)	5.6	5.9	5.5	5.8	5.2	5.1	5.5
Acetaldehyde 0.5% (b5)	4.5	4.7	4.4	4.6	4.4	4.3	4.5
Acetaldehyde 1.0% (b6)	4.6	4.7	4.5	4.7	4.6	4.5	4.6
Acetaldehyde 1.5% (b7)	4.9	4.9	4.8	4.9	4.7	4.8	4.8
Mean A	4.8	4.9	4.7	5.0	4.6	4.6	
New LSD %	A= 0.2 ; B= 0.3 ; AB= 0.4						

#### 3.2.2. Effect on chlorophyll b contents

Data presented in Table (5) reveals similar trends to chlorophyll a, with significant differences detected across cultivars, treatments, and their interactions. Superior cultivar exhibited the highest chlorophyll b concentrations, followed by Red Globe and Early Sweet. Spraying Ethanol at 9% treatment proved most effective in enhancing chlorophyll b levels, achieving a mean of 3.1 mg per 100-gram fresh weight compared to 2.3 milligrams in the control treatment. Acetaldehyde at 1.5% also demonstrated positive effects with 2.8 mg/100g fresh weight. These results align with research conducted by **Arnon (1949)** in his classical paper copper enzymes in isolated chloroplasts, which established the fundamental importance of chlorophyll b in light-harvesting complexes. The proportional increases in both chlorophylls a and chlorophyll b suggest that ethanol and acetaldehyde treatments promote balanced photosynthetic apparatus development rather than selective pigment accumulation. This finding is supported by work from **Taiz *et al.*, (2015)**, which explains the coordinated regulation of chlorophyll biosynthesis pathways. The enhanced chlorophyll b content likely contributes to improved light capture efficiency, particularly under varying light conditions, thereby supporting overall photosynthetic performance and carbon assimilation capacity in treated vines.

### 3.2.3. Effect on total chlorophyll contents

Total chlorophyll content, as presented in Table (6) showed a significant variation among cultivars, treatments, and their interaction. The Superior cultivar maintained the highest total chlorophyll levels in 2022 and 2023 seasons, surpassing ‘Red Globe’ and ‘Early Sweet’. Among treatments, spraying Ethanol at 9% achieved the highest total chlorophyll content of 8.6 milligrams per gram fresh weight, representing a 32.3 percent increase compared to the control (6.5 milligrams). Acetaldehyde treatments also enhanced total chlorophyll accumulation, with the 1.5% yielding 7.6 mg/100 g fresh weight. These findings are consistent with research by **Sairam *et al.*, (2002)** on homobrassinolide application on plant metabolism and grain yield under irrigated and moisture stress conditions, which demonstrated that growth promoting compounds can significantly enhance total chlorophyll content through multiple regulatory mechanisms. The substantial increases in total chlorophyll observed with Ethanol treatments suggest improved photosynthetic capacity, which would be expected to support enhanced carbohydrate production and overall vine vigor (**Kohli *et al.*, 2013**) on chlorophyll and carotenoid pigments.

**Table (5). Effect of spraying ethanol and acetaldehyde on Chlorophyll b of Superior, Red Globe, and Early Sweet grapevines cultivars, during 2022 and 2023 seasons**

Chlorophyll b (mg/100g FW)							
Treatments	Superior (a1)		Red Globe (a2)		Early Sweet (a3)		Mean B
	2022	2023	2022	2023	2022	2023	
Control (b1)	1.2	1.3	1.3	1.3	1.1	1.1	1.2
Ethanol 3% (b2)	1.4	1.5	1.4	1.5	1.3	1.3	1.4
Ethanol 6% (b3)	1.5	1.4	1.5	1.4	1.2	1.3	1.4
Ethanol 9% (b4)	1.7	1.8	1.5	1.5	1.4	1.4	1.6
Acetaldehyde 0.5% (b5)	1.2	1.4	1.3	1.2	1.1	1.2	1.2
Acetaldehyde 1.0% (b6)	1.3	1.3	1.4	1.4	1.3	1.3	1.3
Acetaldehyde 1.5% (b7)	1.4	1.5	1.5	1.6	1.4	1.4	1.5
Mean A	1.4	1.5	1.4	1.4	1.3	1.3	
New LSD %	A= NS ; B= 0.2 ; AB= 0.3						

**Table (6). Effect of spraying ethanol and acetaldehyde on total Chlorophyll of Superior, Red Globe, and Early Sweet grapevines cultivars, during 2022 and 2023 seasons**

Total chlorophyll (mg/100g FW)							
Treatments	Superior (a1)		Red Globe (a2)		Early Sweet (a3)		Mean B
	2022	2023	2022	2023	2022	2023	
Control (b1)	5.5	5.4	5.4	5.5	5.3	5.2	4.5
Ethanol 3% (b2)	6.2	6.2	6.0	6.3	5.6	5.7	6.0
Ethanol 6% (b3)	7.1	6.7	6.8	7.0	6.1	6.2	6.6
Ethanol 9% (b4)	6.3	7.7	7.0	7.3	6.6	6.5	6.9
Acetaldehyde 0.5% (b5)	6.7	6.1	5.7	5.8	5.5	5.5	5.9
Acetaldehyde 1.0% (b6)	5.9	6.0	5.9	6.1	5.7	5.8	5.9
Acetaldehyde 1.5% (b7)	6.3	6.4	6.3	6.7	6.1	6.2	6.3
Mean A	6.3	6.4	6.2	6.4	5.8	5.9	
New LSD %	A= 0.3 ; B= 0.5 ; AB= 0.7						

### 3.2.4. Effect on total carotenoids contents

The carotenoid content (Table 7) demonstrates significant differences among cultivars and treatments, as well as their interactions, during 2022 and 2023 seasons. Superior cultivar exhibited the highest carotenoid levels, followed by ‘Red Globe’ and ‘Early Sweet’. Treatment effects were particularly noteworthy, with Ethanol at 9% achieving the highest mean carotenoid content of 2.06 mg/100 g fresh weight, a 31.4 percent increase over the control treatment which averaged 1.57 mg. Spraying Acetaldehyde at 1.5% also showed positive effects with 1.86 mg/100 g fresh weight. These results are in agreement with findings by **Young (1991)** in the comprehensive review carotenoids in higher plant photosynthesis, which established the critical role of carotenoids in photo-protection and light harvesting. The enhanced carotenoid accumulation observed with ethanol treatments may be attributed to up-regulation of carotenoid biosynthesis genes, similar to mechanisms described by Hashimoto, Wada *et al.* (2008).

**Table (7). Effect of spraying ethanol and acetaldehyde on total carotenoids of Superior, Red Globe, and Early Sweet grapevines cultivars, during 2022 and 2023 seasons**

Total carotenoids (mg/100g FW)							
Treatments	Superior (a1)		Red Globe (a2)		Early Sweet (a3)		Mean B
	2022	2023	2022	2023	2022	2023	
Control (b1)	1.2	1.2	1.1	1.2	0.9	1.0	<b>1.1</b>
Ethanol 3% (b2)	1.6	1.9	1.5	1.7	1.1	1.1	<b>1.5</b>
Ethanol 6% (b3)	1.8	2.1	1.8	2.0	1.2	1.3	<b>1.7</b>
Ethanol 9% (b4)	2.2	2.3	2.1	2.1	1.4	1.5	<b>1.9</b>
Acetaldehyde 0.5% (b5)	1.6	1.6	1.5	1.7	1.2	1.3	<b>1.5</b>
Acetaldehyde 1.0% (b6)	1.7	1.8	1.4	1.8	1.3	1.4	<b>1.6</b>
Acetaldehyde 1.5% (b7)	1.9	2.1	1.9	2.0	1.5	1.5	<b>1.8</b>
Mean A	<b>1.7</b>	<b>1.8</b>	<b>1.6</b>	<b>1.8</b>	<b>1.2</b>	<b>1.3</b>	
New LSD %	A= 0.2 ; B= 0.3 ; AB= 0.5						

### 3.3. Effect on mineral status

#### 3.3.1. Effect on leaf N%

Table (8) illustrates the Nitrogen concentrations in adult leaves across the three cultivars under various Ethanol and Acetaldehyde treatments. Non-significant differences were observed between the three examined cultivars. Concerning the effect of spraying Ethanol and Acetaldehyde at different concentrations, it is clear that spraying the lowest concentration of Ethanol (3%) and Acetaldehyde (0.5%) failed to improve the leaf Nitrogen content neither in first season nor in the second season. Contrary, increasing the concentration of Ethanol from 3% to 9% and acetaldehyde from 0.5% to 1.5% was very effective in enhancing leaf Nitrogen %. This increment was parallel to increasing the concentration of each material. Regarding the interaction between the cultivars and spraying Ethanol and Acetaldehyde, it was significant in both experimental seasons. Furthermore, ‘Red Globe’ vines sprayed with Ethanol at 9% present the highest Nitrogen content (1.9% and 1.9%), during 2022 and 2023 seasons respectively. Contrary, untreated ‘Early Sweet’ vines presented the lowest Nitrogen content (1.1% and 1.2%), during the two experimental seasons respectively.

**Table (8). Effect of spraying ethanol and acetaldehyde on N% of Superior, Red Globe, and Early Sweet grapevines cultivars, during 2022 and 2023**

Adult leaves Nitrogen %							
Treatments	Superior (a1)		Red Globe (a2)		Early Sweet (a3)		Mean B
	2022	2023	2022	2023	2022	2023	
Control (b1)	1.3	1.2	1.4	1.4	1.2	1.1	1.3
Ethanol 3% (b2)	1.3	1.5	1.4	1.5	1.4	1.5	1.4
Ethanol 6% (b3)	1.7	1.7	1.8	1.7	1.5	1.6	1.7
Ethanol 9% (b4)	1.8	1.9	1.9	1.9	1.8	1.8	1.9
Acetaldehyde 0.5% (b5)	1.4	1.4	1.4	1.5	1.2	1.3	1.4
Acetaldehyde 1.0% (b6)	1.4	1.5	1.5	1.5	1.3	1.4	1.4
Acetaldehyde 1.5% (b7)	1.5	1.6	1.6	1.7	1.5	1.7	1.6
Mean A	1.5	1.5	1.6	1.6	1.4	1.5	
New LSD %	A= NS ; B= 0.3 ; AB= 0.4						

### 3.3.2. Effect on leaf P%

Data presented in Table (9) showed significant responses of the three cultivars, treatment, and interaction, in both experimental seasons. Early Sweet cultivar exhibited the highest leaf phosphorus %, followed by 'Red Globe' and 'Superior'. Treatment analysis revealed that spraying Ethanol at 9% was most effective, producing 0.25 %, which represents a 31.5 percent increase over the control treatment averaging, followed by spraying 6% Ethanol which produced 0.23%. In addition, spraying Acetaldehyde at 1.5% significantly improved the leaf phosphorus %. Regarding the interaction between the cultivars and treatments, it was significant in both seasons. Furthermore, the differences were clearer in the second season rather than those in the first one. Spraying 'Early Sweet' with 9% Ethanol presented the highest phosphorus % in 2023 (0.30%) followed by Superior cultivar. These results align with findings reported by **Mullins *et al.* (1992)** in their authoritative text *Biology of the grapevine*, which detailed phosphorus partitioning patterns in grapevines under various physiological conditions. The enhanced phosphorus accumulation in leaf following ethanol and acetaldehyde sprayings suggests improved translocation of photosynthesis products from leaves to growing tissues, a process critical for supporting vine growth and development. This interpretation is supported by **Loescher *et al.* (1990)**, which explained the mechanisms regulating of phosphorus distribution. The elevated leaf phosphorus content would be expected to provide metabolic substrates for cell division and expansion, thereby supporting the enhanced phosphorus contents.

### 3.3.3. Effect on leaf Potassium %

Data illustrated in Table (10) showed that Non-significant differences were observed between the three cultivars in both experimental seasons. Concerning the effect of spraying Ethanol and Acetaldehyde at different concentrations, it is clear that spraying the lowest concentrations of Ethanol (3%) and Acetaldehyde (0.5 and 1.0 %) failed to improve the leaf potassium content neither in first nor in the second season. Contrary, increasing the concentration of Ethanol from 3% to 9% and Acetaldehyde from 1.0% to 1.5% was very effective in enhancing leaf potassium %. However, the vines sprayed with 9% ethanol presented the highest K% in their leaves (1.8%). Regarding the interaction between the cultivars and treatments, it was significant in both experimental seasons. Furthermore, 'Red Globe' vines sprayed with Ethanol at 9% present the highest potassium content (1.9% and 1.9%), during 2022 and 2023 seasons respectively. Contrary, untreated 'Red Globe' vines presented the lowest potassium contents (1.3% and 1.2%) in both experimental seasons respectively.

**Table (9). Effect of spraying Ethanol and Acetaldehyde on Phosphorus % of Superior, Red Glob, and Early Sweet grapevines cultivars, during 2022 and 2023 seasons**

Adult leaves Phosphorus %							
Treatments	Superior (a1)		Red Globe (a2)		Early Sweet (a3)		Mean B
	2022	2023	2022	2023	2022	2023	
Control (b1)	0.18	0.19	0.19	0.18	0.20	0.21	<b>0.19</b>
Ethanol 3% (b2)	0.20	0.24	0.19	0.21	0.21	0.23	<b>0.21</b>
Ethanol 6% (b3)	0.19	0.26	0.20	0.24	0.21	0.27	<b>0.23</b>
Ethanol 9% (b4)	0.20	0.27	0.22	0.26	0.22	0.30	<b>0.25</b>
Acetaldehyde 0.5% (b5)	0.19	0.19	0.18	0.19	0.19	0.22	<b>0.19</b>
Acetaldehyde 1.0% (b6)	0.19	0.20	0.18	0.19	0.22	0.24	<b>0.20</b>
Acetaldehyde 1.5% (b7)	0.20	0.21	0.21	0.22	0.22	0.26	<b>0.22</b>
Mean A	<b>0.19</b>	<b>0.22</b>	<b>0.20</b>	<b>0.22</b>	<b>0.22</b>	<b>0.25</b>	
New LSD %	A= 0.03 ; B= 0.04 ; AB= 0.06						

**Table (11). Effect of spraying Ethanol and Acetaldehyde on Potassium% of Superior, Red Globe, and Early Sweet grapevines cultivars**

Adult leaves Potassium %							
Treatments	Superior (a1)		Red Globe (a2)		Early Sweet (a3)		Mean B
	2022	2023	2022	2023	2022	2023	
Control (b1)	1.3	1.4	1.3	1.2	1.4	1.4	<b>1.3</b>
Ethanol 3% (b2)	1.4	1.6	1.4	1.3	1.4	1.5	<b>1.4</b>
Ethanol 6% (b3)	1.6	1.7	1.7	1.7	1.7	1.5	<b>1.6</b>
Ethanol 9% (b4)	1.8	1.7	1.7	1.8	1.9	1.9	<b>1.8</b>
Acetaldehyde 0.5% (b5)	1.4	1.4	1.4	1.4	1.5	1.6	<b>1.5</b>
Acetaldehyde 1.0% (b6)	1.5	1.6	1.4	1.5	1.5	1.6	<b>1.5</b>
Acetaldehyde 1.5% (b7)	1.5	1.6	1.6	1.7	1.7	1.7	<b>1.6</b>
Mean A	<b>1.5</b>	<b>1.6</b>	<b>1.5</b>	<b>1.5</b>	<b>1.6</b>	<b>1.6</b>	
New LSD %	A= NS ; B= 0.2 ; AB= 0.3						

### 3.4. Effect on yield and its component

#### 3.4.1. Effect on number of cluster per vine

Data in Table (11) showed the differences between the three examined cultivars in the number of clusters/vine as well the effect of spraying Ethanol and Acetaldehyde at different concentrations. Statistical analysis of obtained data revealed that non-significant differences were observed between the three cultivars. These non-significant differences between cultivars indicate similar cluster production capacity across the three varieties. Regarding the effect of spraying Ethanol and Acetaldehyde, ethanol at 9% achieved the highest cluster number/vine, followed closely by spraying Acetaldehyde 1.5%, and then spraying Ethanol at 6%. The control treatment produced the lowest number of clusters per vine. Concerning the interaction effects (AB), Superior vines treated with Acetaldehyde 1.5% in 2023 recorded the maximum number of clusters, followed by 'Superior' vines sprayed with Ethanol at 9% in 2023. The work of **Dry (2000)** on Canopy management for fruitfulness, demonstrated that treatments

affecting carbohydrate status during bud differentiation can significantly influence cluster initiation and development. The increased cluster numbers observed may result from enhanced bud fruitfulness in the previous season, as explained by **Conde *et al.* (2007)**.

**Table (11). Effect of spraying Ethanol and Acetaldehyde on number of cluster / vine of Superior, Red Globe, and Early Sweet grapevines cultivars, during 2022 and 2023**

Number of cluster per vine							
Treatments	Superior (a1)		Red Globe (a2)		Early Sweet (a3)		Mean B
	2022	2023	2022	2023	2022	2023	
Control (b1)	32.3	33.3	33.7	35.1	34.3	32.1	<b>33.5</b>
Ethanol 3% (b2)	31.7	36.2	36.9	39.4	33.2	34.9	<b>35.4</b>
Ethanol 6% (b3)	33.7	39.2	36.5	40.2	35.2	38.5	<b>37.2</b>
Ethanol 9% (b4)	34.5	41.4	35.4	40.5	34.1	40.6	<b>37.8</b>
Acetaldehyde 0.5% (b5)	33.8	33.5	33.7	35.2	33.7	33.7	<b>33.9</b>
Acetaldehyde 1.0% (b6)	33.7	40.3	32.4	37.1	35.4	39.9	<b>36.5</b>
Acetaldehyde 1.5% (b7)	34.5	42.7	35.2	38.2	36.2	39.4	<b>37.7</b>
Mean A	<b>33.5</b>	<b>38.1</b>	<b>34.8</b>	<b>37.9</b>	<b>34.6</b>	<b>37.1</b>	
New LSD %	A= NS ; B= 3.3 ; AB= 4.8						

### 3.4.2. Effect on cluster weight (g)

Table (12) presents cluster fresh weight data across the three cultivars under different treatment of ethanol and acetaldehyde. Statistical analysis revealed significant differences between the three cultivars, treatment, and their interaction. ‘Red Globe’ cultivar produced the heaviest clusters, surpassing ‘Superior’ and ‘Early Sweet’. Among treatments, spraying Ethanol at 9% achieved the highest cluster fresh weight. Spraying Acetaldehyde at 1.5% also showed beneficial effects. These findings are consistent with **Ferrara *et al.* (2013)**, which demonstrated that treatments enhancing photosynthetic capacity typically result in improved cluster weights through better carbohydrate supply to developing fruits. The mechanism underlying this response likely involves the enhanced photosynthetic pigment content and carbohydrate accumulation documented in previous tables, which would provide increased metabolic resources for fruit development. This interpretation is supported by the work of **Ollat and Gaudillere (1998 & 2000)** in their study the effect of limiting leaf area during stage I of berry growth on development and composition of berries of *Vitis vinifera*, which established the critical importance of source capacity for determining final cluster weights in grapevines.

### 3.4.3. Effect on yield (kg/vine)

Table (13) illustrates the yield per vine (kg) across the three cultivars under various treatment regimens. Significant differences were detected for cultivar effects, treatment effects, and interaction cultivar treatments. Red Globe cultivar produced the highest yield per vine with means of 22.33 kg/vine and 24.8 kg, surpassing ‘Superior’ (12.44 and 14.18 kg/vine) and ‘Early Sweet’ (11.92 and 13.04 kg), during 2022 and 2023 respectively. Spraying Ethanol at 9% achieved the highest yield. Spraying Acetaldehyde at 1.5% also demonstrated positive effects on yield/vine of the three cvs. These findings align with research conducted by **Coombe and Mc-Carthy (2000)**. The enhanced of yield and observed with Ethanol treatments likely result from multiple factors including improved cell division during the initial phase of berry development and enhanced cell expansion during subsequent growth phases, both supported by the increased carbohydrate contents. This interpretation is consistent with findings by **Matthews *et al.* (1990)**, which demonstrated the importance of metabolic substrate availability for berry sizing.

**Table (12). Effect of spraying Ethanol and Acetaldehyde cluster weight (g) (ppm) of Superior, Red Globe, and Early Sweet grapevines cultivars, during 2022 and 2023 seasons**

Cluster weight (g)							
Treatments	Superior (a1)		Red Globe (a2)		Early Sweet (a3)		Mean B
	2022	2023	2022	2023	2022	2023	
Control (b1)	355.3	350.2	577.4	570.5	321.2	329.5	<b>417.4</b>
Ethanol 3% (b2)	367.4	368.9	670.5	672.9	339.5	344.2	<b>460.6</b>
Ethanol 6% (b3)	377.5	379.5	687.3	692.5	348.7	355.3	<b>473.5</b>
Ethanol 9% (b4)	394.2	401.2	692.1	714.7	357.1	371.5	<b>488.5</b>
Acetaldehyde 0.5% (b5)	362.1	360.4	594.4	612.2	340.2	342.1	<b>435.2</b>
Acetaldehyde 1.0% (b6)	370.3	369.5	642.3	632.3	349.5	354.3	<b>453.0</b>
Acetaldehyde 1.5% (b7)	374.1	370.1	655.9	661.7	355.9	361.2	<b>463.2</b>
Mean A	<b>371.6</b>	<b>371.4</b>	<b>645.7</b>	<b>650.9</b>	<b>344.6</b>	<b>349.4</b>	
New LSD %	A= 35.3 ; B= 21.7 ; AB= 31.5						

**Table (13). Effect of spraying Ethanol and Acetaldehyde on Yield (kg/vine) of Superior, Red Globe, and Early Sweet grapevines cultivars, during 2022 and 2023 seasons**

Yield (kg/vine)							
Treatments	Superior (a1)		Red Globe (a2)		Early Sweet (a3)		Mean B
	2022	2023	2022	2023	2022	2023	
Control (b1)	11.48	11.66	19.45	20.02	11.02	10.58	<b>12.37</b>
Ethanol 3% (b2)	11.65	13.35	24.74	26.51	11.27	12.01	<b>14.59</b>
Ethanol 6% (b3)	12.72	14.88	25.09	27.84	12.27	13.68	<b>17.75</b>
Ethanol 9% (b4)	13.60	16.61	23.12	28.94	12.18	15.08	<b>18.26</b>
Acetaldehyde 0.5% (b5)	12.24	12.07	20.03	21.55	11.46	11.53	<b>14.82</b>
Acetaldehyde 1.0% (b6)	12.48	14.89	20.81	23.46	12.37	14.14	<b>16.36</b>
Acetaldehyde 1.5% (b7)	12.91	15.80	23.09	25.28	12.88	14.23	<b>17.37</b>
Mean A	<b>12.44</b>	<b>14.18</b>	<b>22.33</b>	<b>24.8</b>	<b>11.92</b>	<b>13.04</b>	
New LSD %	A= 2.8 ; B= 3.2 ; AB= 4.7						

#### 4. Conclusion

Based on the results of this study, the response to spraying Ethanol and Acetaldehyde varied significant according the cultivar. Treated the vines of the three examined cvs. with Ethanol and Acetaldehyde at different concentrations had a significant effect on improving vegetative growth characteristics, mineral content, and vine yield (kg/vine). However, spraying Ethanol shows more effective rather than spraying Acetaldehyde in this respect. Spraying Ethanol at 9% presented the best results. Under the conditions of cultivation in clay soils in Minia Governorate and similar conditions, we recommend by spraying the Superior, Red Globe and Early Sweet cultivars three times during the season with Ethanol at 9% in order to improve growth, nutritional status and yield quantity.

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