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EFFECT OF THE FOLIAR SPRAYING OF FULVIC ACID, FOLIC ACID, AND SEAWEED EXTRACT ON VEGETATIVE GROWTH, YIELD AND FRUIT QUALITY OF GRAPE CV. FLAME SEEDLESS

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ABSTRACT

This study was performed during 2019 and 2020 seasons on seven years old “Flame seedless” grape trees (*Vitis vinefera* L.). The trees were cultivated at 3 meters apart between rows and 2 meters between trees in the same row in a calcareous soil under drip irrigation system in a private orchard located at Nubaria, Beheira governorate, Egypt. The trees were sprayed three times, before flowering, during the full bloom and three weeks later with the following treatments: Control spray with water only, Fulvic acid at 1000, 1500 and 2000 ppm, Folic acid (vitamin B9) at 100, 150 and 200 ppm, Seaweed extract at 2000, 3000 and 4000 ppm. Besides, the combinations of 1000 ppm Fulvic acid +100 ppm Folic acid+ 2000 ppm Seaweed extract, 1500 ppm Fulvic acid + 150 ppm Folic acid + 3000 ppm Seaweed extract and 2000 ppm Fulvic acid + 200 ppm Folic acid + 4000 ppm Seaweed extract were also applied. The obtained results demonstrated that the foliar spray of Folic acid, Fulvic acid and Seaweed extract and their combinations improved weight, length, width, size and number of clusters. Furthermore, they also increased extremely weight of 100 berries and consequently the yield per vine in kg and the yield in ton per hectare, weight of juice, the percentages of total sugars, and total soluble solids as compared to control in the two seasons. The effect of Fulvic acid on the previous mentioned parameters was higher than the effect of Seaweed extractor Folic acid and its effect was better by the increasing the applied concentration where the best one was 2000 ppm, which gave the best results more than the other applied treatments in the two seasons. The best combination was Fulvic acid 2000 ppm + Folic acid at 200 ppm + Seaweed extract 4000 ppm.

Keywords: Fulvic acid, folic acid, seaweed extract, grape, yield

INTRODUCTION

Grape (*Vitis vinifera* L.) belongs to the family of Vitaceae, the cultivated area is 73351 and 6925972 hectare which produces 1626259 and 77137016tonnes in Egypt and in the world, respectively (FAO, 2019). Fulvic acid increases photosynthetic rate and reduce the opening of stomata and the transpiration rate, so, it can regulate the plant growth (Lu and Jaffe, 2001; Anjum *et al.,* 2011; Huang *et al.,* 2020). It also, enhances mineral elements absorption (Mackowiak *et al.,* 2001; Nardi *et al.,* 2002; Yang *et al.,* 2013; Justi *et al.,* 2019; Wang *et al.,* 2019), encourages the length of root (Canellas *et al.,* 2002). Besides, it improves transferring the minerals directly inside the cell of the plant sand fresh and dry weights of crop of plants (Chen *et al.,* 2004), and chelates mineral nutrients (Plaza *et al.,* 2005; Bocanegra *et al.,* 2006; Lotfi *et al.,* 2015; Malan, 2015). In addition, spraying fulvic acid significantly improved the average of size, weight, and shape index (length/ diameter) of fruit of table grape (Ferrara and Brunetti, 2010), SSC % and SSC/acidity ratio while it decreased the percentage of total acidity (Zhang *et al.,* 2013; Abd El-Hameed *et al.,* 2014; Suh *et al.,* 2014). As fulvic acid can enhance antioxidants, IAA, GA3 and Cytokines hormones and vitamins, it improves the vegetative growth in plants (Abd El-Hameed *et al.,* 2014).

Besides, fulvic acid significantly increased both leaf surface area and shoot length, fruit number/tree, fruit weight and fruit volume, soluble solid content, soluble solid content / acid ratio and total sugars and decreased specific gravity in fruits of apple cv. Anna (El-Boray *et al.,* (2015) and on apricot cv. Canino (Haggag *et al.,* 2016). It improved the contents of sucrose, sugars, crop yield and quality of beet sugar (El-Hassanin *et al.,* 2016), shoot length, leaf surface area, total chlorophyll and total protein in the canes, leaf content from N, P and K, enhancing yield per vine, cluster weight, berry weight, soluble solids content and total phenols. On contrary, it reduced total acidity, the percentages of cluster weight loss, berry shatter, and berry decay during storage shelf-life period of grapevines cv. Thompson seedless (El-kenawy, 2017), significantly increased the yield in red delicious (*Malus domestica* Borukh.) (Khan *et al.,* 2019).

It was reported by (Soliman *et al.,* 2000; Abd El-Mawgoud *et al.,* 2010; Prasad *et al.,* 2010; Marrez *et al.,* 2014) that because of the higher content of seaweed from mineral elements like N, P, K, Mg, Ca, S, Cu, Fe, Mn, B and Mo. Moreover, it contains a high amount from cytokinins, IAA and GA3, amino acids, vitamins, and antioxidants, so it could be considered as plant growth stimulators and has a good role in increasing the cell division. The foliar application of seaweed extract has been reported to influence growth, productivity, and fruit quality of grapes cvs. Thompson Seedless (Abd El-Ghany *et al.,* 2001), Red Roomy (Abada, 2002) and Superior (Abd El Moniem and Abd-Allah, 2008). The foliar application of seaweed extract has been reported to influence growth, productivity, and fruit quality of fruit trees (El-Sawy, 2005; Mahmoud, 2012; Oraby, 2013; Merwad *et al.,* 2019). Besides, spraying alga (*Ascophillum nodosum*) increased greatly chlorophyll content, which enhanced photosynthesis and respiration rates in apple cv. Fuji (Spinelli *et al.,* 2009), and peach trees cv. Peento (Al-Rawi *et al.,* 2016). Colavita *et al.,* (2010) found that the application of seaweed extract (*Ascophyllum nodosum*) on “William” pear cultivar (*Pyrus communis*) improved the fruit weight and fruit diameter. Besides, the foliar spray of seaweed at 2 % improved the vegetative growth, fruit set percentage and leaf mineral composition of N, P and K of “Fagri Kalan” mango (El-Sharony *et al.,* (2015). Spraying “Anna” apple trees with 4 ml/l Algae extract improved the fruit size (Al-Jumaily and Al-Esawi, 2016). Furthermore, the application of seaweed extracts at 2 or 4% on “Zaghloul” date palm were very effective on improving yield and fruit quality fruit weight, dimensions, total soluble solids, and sugar contents in comparison with control treatment (Badran, 2016). Using algae extract of 4g/l enhanced obviously shoot length, shoot girth, number of leaves per shoot, total chlorophyll and fruiting parameters, length, diameter, size, weight, Juice, volume, hardness of grapes (Stino *et al.,* 2017).

It was noticed by many authors that folates are important factors in helping the transferring of carbon as doners and acceptors which can engaged in purines, pyrimidines, and amino acids synthesis (Scott *et al.,* 2000; Dhonukshe-Rutten *et al.,* 2009, and Blancquaert *et al.,* 2010). Moreover, Stakhova *et al.,* (2000) stated that the foliar spraying of folic acid enhanced the, photosynthetic rate in the leaves, seed weight and yield of pea (*Pisum sativum*). Exogenous spraying of folic acid positively influenced on soybean growth, yield and quality (Mahmoud, 2014) and strawberry (Li *et al.,* 2015). Javadi *et al.,* (2017) reported that the foliar spraying of folate on wheat enhanced the height of plant, flag leaf area, and tillers number and the grains number per spike and the yield of grains and grain composition of iron comparing with control. Using folic acid at 0, 20 and 40 mM on at strawberry cv. Paros improved the fruit quality, yield, weight of primary and secondary fruits and number of their achenes, total soluble solid, inducing sugar, titratable acidity, anthocyanin, phenol, and vitamin C (Raeisi-Vanani *et al.,* 2017).Youssif (2017) found that foliar spraying of potatoes cv. Valor with folic acid at 50, 100 or 150 ppm greatly enhanced the growth of potato plants, tuber yield and its components as well as chemical composition and total chlorophyll. Spraying pea plant (*Pisum sativum*, L. cv Master-B.) with 0, 10 and 20 mg/L from folic significantly increased obviously vegetative growth parameter, photosynthetic rate, yield and fruit quality, comparing with control and the application of 20 mg/L was superior and gave the best results over the other appliedFarouk *et al.,* (2018). The current study was performed to investigate the influence of the foliar spray of Fulvic acid, Folic acid, and Seaweed extracton vegetative growth parameters, yield and fruit quality of “Flame seedless” grape cultivar.

MATERIALS AND METHODS

This experiment was carried out on grape (*Vitis vinefera* L.) cv. Flame seedless during two successive seasons, 2019 and 2020. The trees under study were at the age of seven years old, planted at 3 meters apart between rows and 2 meters between trees in the same row and grown in a calcareous soil under drip irrigation in a private orchard located at Nubaria, Beheira governorate, Egypt. The analysis of physical and chemical analysis of the experimental soil was shown in Table 1 according to (Sparks *et al.,* 2016).

One hundred and four uniform trees were selected for this study and all of them were subjected to the same cultural practices in the two seasons and were sprayed before flowering, during full bloom and three weeks later. The applied treatments are control (water only), Fulvic acid 1000, 1500 and 2000 ppm, Folic acid (vitamin B9) at 100, 150 and 200 ppm, Seaweed extract 2000, 3000 ppm, and 4000 ppm. Besides, their combinations of Fulvic acid 1000 ppm + Folic acid at 100 ppm + Seaweed extract 2000 ppm, Fulvic acid 1500 ppm + Folic acid at 150 ppm +Seaweed extract 3000 ppm, Fulvic acid 2000 ppm + Folic acid at 200 ppm + Seaweed extract 4000 ppm were also applied to the trees. The previous applied treatments were arranged in a randomized complete block design where each treatment was composed from eight trees/replicates. The influence of the above-mentioned treatments was investigated on the following parameters:

Vegetative Parameters: Shoot length in cm and shoot thickness in cm by using a Vernier caliper was measured at the end of the growing seasons. Total chlorophyll was determined in the fresh leaves was determined as SPAD units by using Minolta chlorophyll meter (SPAD, 501).

Fruit yield: It was estimated per vine in kg by accounting the number of clusters per each vine, weight of each cluster and then the yield per vine in kg was calculated from this equation: number of clusters ×weight of clusters and then consequently the yield per hectare in ton was estimated.
Fruit Quality: At the time of harvesting, 100 berries from each vine/replicate were chosen randomly to determine their physical and chemical characteristics.

Fruit physical characteristics: cluster weight (g), size (cm^3), length and width (cm), 100 berries weight (g), size (cm^3) and their weight of juice(g), berry weight (g), length (mm) and width (mm). Fruit firmness (Ib/ inch2) using a Magness and Taylor pressure tester with 7/18-inchplunger.
Fruit Chemical Characteristics: Total soluble solids were determined using a hand refractometer and the result was expressed as a percentage. Percentage of titratable acidity in juice of 100 berries was determined according to (AOAC, 2005). Phenol and sulphuric acid were used calorimetrically

to estimate total sugar. The concentration of anthocyanin pigment was determined at the stage of coloration (mg/100 g fresh weight peel) according to Nangle *et al.,* (2015).

Leaf Chemical Composition: Samples of thirty leaves from the middle part of the shoots according to Arrobas *et al.,* (2018) were randomly selected from each vine/replicate after harvesting time in June to determine their content from N, P and K percentages. The leaf samples were washed with tap water, then with distilled water and dried at 70ºC until a constant weight, finally, they ground and acid digested using H_2SO_4 and H_2O_2 till the solution became clear. The digested solution was used for the determination of nitrogen using micro Kjeldhal method (Wang *et al.,* 2016), phosphorus by vanadomolybdo method (Weiwei *et al.,* 2017) and according to Mutalik *et al.,* (2011), flame photometer was used to estimate the concentration of potassium.

Statistical Analysis

The obtained data were subjected to one-way ANOVA according to (Ott and Longnecker, 2015) and least significant difference (LSD) at 0.05% was used to compare between the means of the treatments.

RESULT AND DISCUSSION

Data in Table 2 showed that the foliar spraying of Fulvic acid at 1000, 1500 and 2000 increased greatly the shoot length and thickness as compared to Folic acid at 100, 150 and 200 ppm or seaweed extract at 2000, 3000 or4000 ppm and control in the two seasons. Moreover, they were also enhanced significantly by the application of 1500 ppm Fulvic acid + 150 ppm Folic acid + 3000 ppm Seaweed extract and 2000 ppm Fulvic acid + 200 ppm Folic acid + 4000 ppm Seaweed extract over control in both seasons. The foliar spraying of Fulvic acid at 2000 ppm was the best treatment, which gave the best results in terms of shoot length and thickness in the two seasons as compared to the other applied treatments. Leaf chlorophyll content was improved by the foliar spraying of Fulvic acid at 1500 and 2000 ppm and also by the foliar spraying of the combinations of Fulvic acid 1500 ppm + Folic acid 150 ppm + Seaweed extract 3000 ppm and Fulvic acid 2000 ppm + Folic acid 200 ppm + Seaweed extract 4000 ppm comparing with control in the two seasons. Moreover, the obtained results also showed that the spraying of seaweed extract at 4000 has a positive influence in improving the shoot length, and thickness and leaf content from total chlorophyll as compared to spraying Folic acid at 100, 150 and 200 ppm and control in both experimental seasons.

Data in Table 3 showed that the foliar spraying of Fulvic acid at 1000, 1500 and 2000, seaweed extractat 2000, 3000 and 4000 ppm, Folic acid at 100, 150 and 200 ppm increased significantly the cluster number, weight, yield in kg per vine and yield in ton per hectare as compared to control in the two seasons. The best results were obtained by the foliar spraying of Fulvic acid at 1500 or 2000 ppm and by the combinations of Fulvic acid 1500 ppm + Folic acid 150 ppm + seaweed extract 3000 ppm and Fulvic acid 2000 ppm + Folic acid 200 ppm + seaweed extract 4000 ppm as compared to the other applied treatments in both experimental seasons. The spraying of seaweed extract at 4000 ppm gave better results than seaweed at 2000 or 3000 ppm and also over the spraying of Folic acid at 100, 150 and 200 ppm in the two experimental seasons.

The results in Table 4 cleared that cluster size, length, and width were obviously increased by the foliar spray of Fulvic acid at 1500 and 2000 ppm. Besides, they also improved by the combination's of 1500 ppm Fulvic acid + 150 ppm Folic acid + 3000 ppm Seaweed extract and 2000 ppm Fulvic acid + 200 ppm Folic acid + 4000 ppm Seaweed extract more than the other applied treatments in the two seasons. The best results were obtained by the foliar application of Fulvic acid at 2000 followed by the combination of Fulvic acid 2000 ppm + Folic acid 200 ppm + Seaweed extract 4000 ppm, which gave the highest increment over the other applied treatments in the two seasons. Furthermore, the spraying of Seaweed extract at 4000 ppm increased significantly the cluster size, length and width as compared to seaweed extract at 2000 or 3000 ppm and control in both experimental seasons. The lowest significant influence was noticed by the spraying of Folic acid at 100, 150 and 200 ppm as compared to control in the two seasons.

The results in Table 5 demonstrated that the weight and size of 100 berries, length and width of berry were clearly improved by the foliar application of Fulvic acid at 1500 and 2000 ppm over control in the two seasons. Furthermore, they were also improved with the combination of Fulvic acid 1500 ppm + Folic acid 150 ppm + Seaweed extract 3000 ppm and Fulvic acid 2000 ppm + Folic acid 200 ppm + Seaweed extract 4000 ppm over the other applied treatments and control in both seasons. The best results were obtained by Fulvic acid at 2000 ppm and by the combination of Fulvic acid 2000 ppm + Folic acid 200 ppm + Seaweed extract 4000 ppm as compared to the rest treatments in the two seasons. It was noticed that Seaweed extract at 4000 ppm improved the weight and size of 100 berries, berry length and width more than 3000 or 2000 ppm in the two seasons. Besides, the foliar spray of Folic acid has lower effect than Fulvic acid or seaweed extract and the concentration of 200 ppm was better than 100 or 150 ppm in the two seasons.

Results in Table 6 showed that the juice weight, anthocyanin pigment concentration, and the percentages of TSS and total sugar were remarkably increased with spraying Fulvic acid at 1000, 1500 and 2000 ppm, Seaweed extract at 2000, 3000 and 4000 ppm, Folic acid at 100, 150 or 200 ppm. In addition, they raised obviously with the combinations of Fulvic acid 1000 ppm + Folic acid 100 ppm + Seaweed extract 2000 ppm, Fulvic acid 1500 ppm + Folic acid 150 ppm + Seaweed extract 3000 ppm and Fulvic acid 2000 ppm + Folic acid 200 ppm + Seaweed extract 4000 ppm as compared to control in the two seasons. The highest results were obtained by the foliar spraying of Fulvic acid at 2000 ppm and the combinations of Fulvic acid 1500 ppm + Folic acid 150 ppm + Seaweed extract 3000 ppm or Fulvic acid

Table 1. Physical and Chemical Properties of the Experiment Soil

Soil Depth (cm)	Texture	pH	* EC (dS/m)	N (%)	P (%)	K (%)	Fe (mg/L)	Zn (mg/L)	Mn (mg/L)
0 to 60	Sandy loam	8.3	4.54	86.00	4.82	308.00	0.85	0.11	0.27
	$CaCO_3$ (mg/L)		Cations (meq/100 g Soil)				O.M. (%)	Cl^-	HCO_3^-
	Na^+		K^+	Ca^{++}	Mg^{++}				
	-		7.80	2.28	32.89	7.32	0.2	5.08	1.89
* Note: EC = electrical conductivity									

Table- 2: Influence of the foliar spraying of Fulvic acid, Folic acid, and Seaweed extract and their combinations on the shoot length, shoot thickness, and leaf total chlorophyll of grape cv. Flame seedless during 2019 and 2020 seasons

Treatment	shoot length (cm)		shoot thickness (mm)		Total Chlorophyll SPAD (µ Molm^{-2})	
	2019	2020	2019	2020	2019	2020
Control	103.20^{g}	112.60^{d}	6.30^{g}	7.42^{h}	33.30^{f}	34.56^{e}
Fulvic acid 1000 ppm	109.80^{bcd}	116.40^{abcd}	7.42^{cd}	8.70^{de}	39.52^{c}	4090^{c}
Fulvic acid 1500 ppm	111.60^{b}	117.80^{ab}	8.54^{ab}	9.21^{b}	42.52^{a}	42.85^{ab}
Fulvic acid 2000ppm	115.20^{a}	118.20^{a}	8.60^{a}	9.59^{a}	42.91^{a}	43.20^{a}
Folic acid 100 ppm	104.00^{fg}	112.80^{cd}	6.75^{f}	8.21^{g}	34.76^{e}	35.09^{e}
Folic acid 150 ppm	106.20^{efg}	114.00^{bcd}	6.94^{ef}	8.34^{fg}	37.2^{d}	38.02^{d}
Folic acid 200 ppm	107.20^{def}	116.80^{abc}	7.12^{def}	8.47^{efg}	37.29^{d}	38.29^{d}
Seaweed 2000 ppm	108.20^{cde}	115.80^{abcd}	7.17^{de}	8.55^{ef}	37.79^{d}	38.94^{d}
Seaweed 3000 ppm	109.00^{bcde}	116.40^{abcd}	7.41^{cd}	8.56^{ef}	38.04^{d}	39.14^{d}
Seaweed 4000 ppm	111.00^{bc}	116.60^{abcd}	7.62^{c}	8.87^{cd}	40.71^{bc}	42.30^{abc}
Fulvic acid 1000 ppm + Folic acid 100 ppm + Seaweed 2000 ppm	110.60^{bc}	115.40^{abcd}	7.41^{cd}	8.57^{ef}	40.35^{c}	41.57^{bc}
Fulvic acid 1500 ppm + Folic acid 150 ppm + Seaweed 3000 ppm	111.00^{bc}	117.00^{ab}	7.65^{c}	9.15^{bc}	41.79^{ab}	42.81^{ab}
Fulvic acid 2000 ppm + Folic acid 200 ppm + Seaweed 4000 ppm	112.00^{ab}	117.20^{ab}	8.16^{b}	9.16^{bc}	42.11^{a}	42.83^{ab}
$LSD_{0.05}$	3.32	4.08	0.4	0.3	1.25	1.51

Means not sharing the same letter(s) within each column, significantly different at 0.05 level of probability

2000 ppm + Folic acid 200 ppm + Seaweed extract 4000 ppm more than control in both seasons. The effect of Fulvic acid was better than the influence of Seaweed extract and Folic acid in the two seasons. Seaweed extract at 4000 ppm was better than Seaweed extract at 2000 or 3000 ppm in improving the juice weight, anthocyanin concentration and the percentages of TSS and total sugar in both study seasons. The impact of Folic acid was lower than the effect of Fulvic acid or Seaweed extract and the concentration of 200 ppm was better than 150 or 100 ppm in the two seasons. On contrary, total acidity was significantly minimized by the application of Fulvic acid at 1000, 1500 and 2000 ppm and by the combination of Fulvic acid 1500 ppm + Folic acid 150 ppm + Seaweed extract 3000 ppm or Fulvic acid 2000 ppm + Folic acid 200 ppm + Seaweed extract 4000 ppm as compared to control. Moreover, the foliar addition of seaweed extract or Folic acid negatively increased the fruit total acidity percentage as compared to the effect of Fulvic acid in both study seasons.

Results listed in Table 7 showed that leaf composition from N, P and K was greatly increased by the foliar spraying of Fulvic acid at 1000, 1500 and 2000 ppm, Seaweed extract at 2000, 3000, or 4000, Folic acid at 100, 150 or 200 ppm. Besides, they were also raised by the combinations of 1000 ppm Fulvic acid + 100 ppm Folic acid + 2000 ppm seaweed extract, 1500 ppm Fulvic acid + 150 ppm Folic acid + 3000 ppm seaweed extract or 2000 ppm Fulvic acid + 200 ppm Folic acid + 4000 ppm seaweed extract comparing with untreated trees in the two seasons. The best results were obtained by the usage of Fulvic acid at 2000 ppm and the combinations of 1500 ppm Fulvic acid + 150 ppm Folic acid + 3000 ppm Seaweed extract and 2000 ppm Fulvic acid + 200 ppm Folic acid + 4000 ppm Seaweed

Table- 3: Influence of the foliar spraying of Fulvic acid, Folic acid, and Seaweed extract and their combinations on numbers and weight of clusters per vine, yield in kg per vine and yield in ton per hectare of grape cv. Flame seedless during 2019 and 2020 seasons

	Clusters number/ vine		Clusters weight (g/vine)		Yield (kg/vine)		Yield (ton/ hectare)	
	2019	2020	2019	2020	2019	2020	2019	2020
Control	33.20^{f}	33.80^{d}	440.40^{i}	452.80 ^{h}	14.60 ^{g}	15.40^{h}	23.39^{g}	24.48^{g}
Fulvic acid 1000 ppm	35.80^{cde}	37.20^{b}	642.60^{e}	647.60^{d}	23.00^{d}	24.20^{d}	36.81^{d}	38.54^{d}
Fulvic acid 1500 ppm	36.80^{bc}	37.20^{b}	698.60 ^{c}	723.8^{b}	25.60^{c}	27.00^{b}	41.13^{c}	43.08^{b}
Fulvic acid 2000ppm	40.60^{a}	39.80^{a}	721.80 ^{a}	729.80^{a}	29.20^{a}	29.00^{a}	46.89^{a}	46.48^{a}
Folic acid 100 ppm	34.00^{ef}	34.00^{d}	442.20^{i}	455.00^{h}	15.00^{g}	15.4^{h}	24.05^{g}	24.74^{g}
Folic acid 150 ppm	34.40^{def}	35.20^{cd}	475.00^{h}	481.60^{g}	16.60^{f}	16.80^{g}	26.14^{f}	27.13^{f}
Folic acid 200 ppm	35.00^{cdef}	35.40^{cd}	491.00^{g}	505.80^{f}	17.00^{f}	18.00^{f}	27.48^{f}	28.64^{f}
Seaweed 2000 ppm	35.40^{cde}	36.4^{bc}	557.2^{f}	575.80^{e}	19.60^{e}	21.00^{e}	31.56^{e}	33.53^{e}
Seaweed 3000 ppm	36.00^{cd}	36.00^{bc}	639.00^{e}	649.20^{d}	22.80^{d}	23.40^{d}	36.81^{d}	37.39^{d}
Seaweed 4000 ppm	36.80^{bc}	37.20^{b}	697^{cd}	700.00^{c}	25.80^{c}	26.40^{b}	41.04^{c}	41.65^{bc}
Fulvic acid 1000 ppm + Folic acid 100 ppm + Seaweed 2000 ppm	36.00^{cd}	36.40^{bc}	691.60^{d}	696.80 ^{c}	25.00^{c}	25.20^{c}	39.83^{c}	40.58^{c}
Fulvic acid 1500 ppm + Folic acid 150 ppm + Seaweed 3000 ppm	36.20 ^{cd}	37.20^{b}	714.20^{b}	720.20^{b}	25.80^{c}	26.80^{b}	41.37^{c}	42.87^{b}
Fulvic acid 2000 ppm + Folic acid 200 ppm + Seaweed 4000 ppm	38.20 ^{b}	39.20^{a}	718.40 ^{ab}	728.60 ^{a}	27.60 ^{b}	28.60^{a}	43.91^{b}	45.70^{a}
LSD $_{0.05}$	1.9	1.78	6.59	4.18	1.18	1.00	1.89	1.73

Means not sharing the same letter(s) within each column, significantly different at 0.05 level of probability

extract over the other applied treatments and control in the two seasons. From the obtained data, it was noticed that Folic acid at 200 ppm gave good results more than the concentrations of 100 or 150 in the two seasons, although their effect was lower than the influence of Fulvic acid or seaweed extract in both experimental seasons.

Discussion

The obtained results showed the positive effect of Fulvic acid in improving vegetative growth parameters, yield, fruit quality and leaf composition from nitrogen, phosphorous and potassium of "Flame seedless" grape cultivar. These results were previously explained by Plaza *et al.,* (2005), they noticed that the structure of fulvic acid and its chemical characteristics might be responsible for chelating mineral ions. Besides, Bocanegra *et al.,* (2006) reported that fulvic acid has the ability to chelate the nutrients like Fe and move them through the cell membranes. Furthermore, they added that it has total acidity, carboxyl groups number, adsorption and cation exchange capacities greater than humic acid, and perhaps it plays roles as natural chelators in the moving and transferring of micronutrients. Additionally, our obtained results are in the same trend with the findings of Anjum *et al.,* (2011). They reported that fulvic acid increased the leaf content of chlorophyll and water, photosynthetic rate, transpiration rate, CO_2 intercellular concentration but on contrary, it minimized the opening rate of stomata and transpiration, and water loss so, it led to increase the growth of maize. In another study, the same authors noticed that, fulvic acid is suitable for both acid and alkali medium. It encourages some physiological processes depending on plant species, and developing stage, where it enhanced the weight and diameter of fruit, pH of juice, and the content of vitamin C of lemon (*Citrus limon*). Fulvic acid increased greatly the percentages of total sugars in grapevines (El-Khawaga, 2011; Shaheen *et al.,* 2012). In the parallel to our findings, Zancani *et al.,* (2011) stated that fulvic acids can play a good role in the transporting of hormones inside the plants, and can raise the levels of intercellular ATP and glucose-6-phosphate that has a good relation with encouragement of cell cultures growth of cultures of Greek fir. In addition, fulvic acid is a good choice for the increment the availability of phosphorous and the physiochemical characteristics of the soil (Yang *et al.,* 2013). The usage of fulvic acid enhanced greatly SSC % and SSC/acidity ratio while it decreased the percentage of total acidity (Zhang *et al.,* 2013; Abd El-Hameed *et al.,* 2014; Suh *et al.,* 2014). As fulvic acid can enhance antioxidants, IAA, GA3 and Cytokines hormones and vitamins, it improves the vegetative growth in plants (Abd El-Hameed *et al.,* 2014). Besides, Priya *et al.,* (2014) reported that fulvic acid looks like the hormone of auxin in plant, which plays a good role in absorption of potassium and is responsible for the metabolism of starch. Fulvic acid can magnetize the molecules of water and facilitate the motion of nutrients like calcium, magnesium, iron, copper, and zinc to the roots of plants (Malan, 2015). The application of fulvic

Table -4: Influence of the foliar spraying of Fulvic acid, Folic acid, and Seaweed extract and their combinations on the size, length, and width of clusters of grape cv. Flame seedless during 2019 and 2020 seasons

Treatment	Cluster size (cm^3)		Cluster length (cm)		Cluster width (cm)	
	2019	2020	2019	2020	2019	2020
Control	423.40^{i}	436.60^{j}	14.86^{h}	15.42^{h}	8.82^{f}	9.57^{i}
Fulvic acid 1000 ppm	625.00^{e}	630.20^{f}	20.02^{d}	22.31^{de}	10.73^{c}	12.32^{ef}
Fulvic acid 1500 ppm	681.60^{cd}	707.60^{b}	21.16^{bc}	23.24^{cd}	11.51^{b}	13.06^{cd}
Fulvic acid 2000ppm	706.80^{a}	713.80^{a}	23.06^{a}	30.35^{a}	12.86^{a}	14.65^{a}
Folic acid 100 ppm	426.60^{i}	436.80^{j}	15.46^{gh}	15.66^{h}	7.68^{g}	9.49i
Folic acid 150 ppm	456.80^{h}	464.40^{i}	16.20^{g}	16.37^{h}	8.89^{f}	10.07^{i}
Folic acid 200 ppm	474.00^{g}	488.00^{h}	17.66^{f}	17.91^{g}	9.25^{ef}	10.92^{h}
Seaweed 2000 ppm	539.60^{f}	557.80^{g}	17.62^{f}	19.94^{f}	9.52^{e}	11.21^{gh}
Seaweed 3000 ppm	622.60^{e}	633^{f}	17.62^{f}	21.66^{e}	10.08^{d}	11.34^{gh}
Seaweed 4000 ppm	682.20^{c}	684.2^{d}	18.62^{e}	21.71^{e}	10.16^{d}	11.77^{fg}
Fulvic acid 1000 ppm + Folic acid 100 ppm + Seaweed 2000 ppm	675.40^{d}	677.80^{e}	20.68^{cd}	22.60^{cde}	10.80^{c}	12.61^{de}
Fulvic acid 1500 ppm + Folic acid 150 ppm + Seaweed 3000 ppm	696.40^{b}	701.80^{c}	21.80^{b}	23.52^{c}	12.03^{b}	13.46^{bc}
Fulvic acid 2000 ppm + Folic acid 200 ppm + Seaweed 4000 ppm	702.60^{ab}	710.60^{ab}	21.88^{b}	24.87^{b}	12.85^{a}	13.77^{b}
$LSD_{0.05}$	6.21	4.24	0.91	1.00	0.53	0.63

Means not sharing the same letter(s) within each column, significantly different at 0.05 level of probability

Table -5: Influence of the foliar spraying of Fulvic acid, Folic acid, and Seaweed extract and their combinations on weight, size, length, and width of 100 berries of grape cv. Flame seedless during 2019 and 2020 seasons

Treatment	Weight of 100 berries (g)		Size of 100 berries (cm^3)		Berry length (mm)		Berry width (mm)	
	2019	2020	2019	2020	2019	2020	2019	2020
Control	191.80^{h}	201.00^{i}	168.60^{i}	179.80^{i}	13.74^{g}	14.14^{k}	13.45^{g}	13.65^{g}
Fulvic acid 1000 ppm	253.80^{c}	265.40^{c}	231.60e	244.40^{c}	15.68^{d}	16.43^{de}	15.07^{d}	15.44c
Fulvic acid 1500 ppm	261.40^{b}	275.00^{b}	241.80^{bc}	257.6^{b}	16.24^{c}	16.55^{d}	15.40^{cd}	16.25^{b}
Fulvic acid 2000ppm	273.20^{a}	285.60^{a}	255.40^{a}	267.6^{a}	17.16^{a}	17.93^{a}	16.37^{a}	17.12^{a}
Folic acid 100 ppm	207.80^{g}	201.8^{h}	187.60^{h}	185.00^{h}	14.36^{f}	14.78^{j}	13.63^{g}	13.91^{fg}
Folic acid 150 ppm	212.40^{f}	214.40^{g}	192.20^{gh}	196.00^{g}	14.44^{f}	15.11^{i}	14.00^{f}	14.17^{f}
Folic acid 200 ppm	212.20f	225.00^{f}	195.4g	204.80^{f}	14.91^{e}	15.33^{h}	14.54^{e}	14.46^{e}
Seaweed 2000 ppm	241.20^{e}	250.00^{e}	220.00^{f}	230.80^{e}	15.32^{d}	15.49^{gh}	14.35^{ef}	14.70^{de}
Seaweed 3000 ppm	243.80^{de}	251.00^{de}	223.00^{f}	232.80^{e}	15.40^{d}	15.59^{fg}	14.42^{e}	14.87^{d}
Seaweed 4000 ppm	246.00^{d}	256.00^{d}	238.60^{cd}	239.4^{d}	15.51^{d}	15.79^{f}	14.52^{e}	15.32^{c}
Fulvic acid 1000 ppm + Folic acid 100 ppm + Seaweed 2000 ppm	259.20^{b}	264.60^{c}	235.60^{de}	247.60^{c}	16.16^{c}	16.28^{e}	15.35^{cd}	15.57^{c}
Fulvic acid 1500 ppm + Folic acid 150 ppm + Seaweed 3000 ppm	260.00^{b}	274.40^{b}	246.80^{b}	253.80^{b}	16.32^{bc}	16.96^{c}	15.69^{bc}	16.44^{b}
Fulvic acid 2000 ppm + Folic acid 200 ppm + Seaweed 4000 ppm	271.60^{a}	285.20^{a}	252.80^{a}	265.80^{a}	16.67^{b}	17.53^{b}	15.79^{b}	16.51^{b}
$LSD_{0.05}$	4.18	5.60	5.08	4.80	0.39	0.22	0.35	0.28

Means not sharing the same letter(s) within each column, significantly different at 0.05 level of probability

Table -6. Influence of the foliar spraying of Fulvic acid, Folic acid, and Seaweed extract and their combinations on the juice weight, anthocyanin pigment concentration, and the percentages of TSS, total sugar and total acidity of grape cv. Flame seedless during 2019 and 2020 seasons

Treatment	Juice weight (g)		Anthocyanin pigment concentration (mg/100 g)		TSS %		Total sugar %		Total acidity %	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Control	143.60^{h}	141.00^{j}	0.25^{g}	0.27^{f}	14.85^{f}	17.89^{cd}	12.87^{f}	13.26^{e}	0.70^{a}	0.72^{a}
Fulvic acid 1000 ppm	174.80^{d}	183.80^{e}	0.48^{cd}	0.5^{d}	15.83^{cde}	18.4^{abc}	14.90^{bcd}	14.82^{d}	0.45^{d}	0.51^{d}
Fulvic acid 1500 ppm	187.60^{c}	192.80^{cd}	0.50^{c}	0.57^{bc}	16.78^{ab}	15.98^{e}	15.53^{bc}	15.76^{bc}	0.43^{d}	0.44^{e}
Fulvic acid 2000ppm	212.20^{a}	222.40^{a}	0.63^{a}	0.67^{a}	17.23^{a}	18.90^{a}	17.13^{a}	17.12^{a}	0.32^{f}	0.33^{f}
Folic acid 100 ppm	146.60^{h}	153.20^{i}	0.29^{g}	0.44^{e}	13.50^{h}	16.02^{e}	13.06^{f}	13.28^{e}	0.64^{b}	0.65^{b}
Folic acid 150 ppm	148.00^{h}	166.80^{h}	0.39^{f}	0.48^{de}	13.90^{gh}	16.50^{e}	13.24^{f}	13.37^{e}	0.55^{c}	0.58^{c}
Folic acid 200 ppm	157.80^{g}	166.60^{h}	0.40^{ef}	0.50^{d}	14.53^{fg}	16.10^{e}	13.44^{f}	13.82^{e}	0.54^{c}	0.57^{c}
Seaweed 2000 ppm	163.40^{f}	173.20^{g}	0.41^{ef}	0.50^{d}	14.90^{ef}	16.49^{e}	13.64^{ef}	13.52^{e}	0.55^{c}	0.58^{c}
Seaweed 3000 ppm	166.40^{ef}	173.80^{g}	0.42^{ef}	0.50^{d}	14.90^{ef}	17.52^{d}	14.39^{de}	14.14^{de}	0.53^{c}	0.55^{cd}
Seaweed 4000 ppm	171.40^{de}	178.20^{f}	0.42^{ef}	0.51^{d}	15.40^{def}	17.73^{cd}	14.71^{cd}	14.96^{cd}	0.52^{c}	0.55^{cd}
Combination 1	183.80^{c}	190.60^{d}	0.44^{de}	0.56^{c}	16.03^{bcd}	18.08^{bcd}	15.21^{bcd}	15.74^{bc}	0.46^{d}	0.45^{e}
Combination 2	199.20^{b}	196.60^{c}	0.50^{c}	0.59^{bc}	16.73^{abc}	18.28^{abcd}	15.73^{b}	16.00^{b}	0.36^{e}	0.34^{f}
Combination 3	212.40^{a}	208.80^{b}	0.55^{b}	0.62^{b}	16.97^{a}	18.69^{ab}	17.00^{a}	16.24^{ab}	0.34^{ef}	0.34^{f}
$LSD_{0.05}$	5.04	3.94	0.04	0.05	0.93	0.79	0.84	0.89	0.03	0.04

Means not sharing the same letter(s) within each column, significantly different at 0.05 level of probability

Combination 1:Fulvic acid 1000 ppm + Folic acid 100 ppm + Seaweed 2000 ppm, Combination 2: Fulvic acid 1500 ppm + Folic acid 150 ppm + Seaweed 3000 ppm, Combination 3: Fulvic acid 2000 ppm + Folic acid 200 ppm + Seaweed 4000 ppm

acid at 500 ppm on grapevines cv. Thompson seedless was effective in improving shoot length, leaf surface area, total chlorophyll and total protein in the canes, leaf content from N, P and K, enhancing yield per vine, cluster weight, berry weight, soluble solids content and total phenols. On the opposite side, it reduced total acidity, the percentages of cluster weight loss, berry shatter, and berry decay during storage shelf-life period (El-kenawy, 2017). Wang *et al.,* (2019)observed that the foliar spraying of fulvic acid significantly facilitated nutrient elements transferring from root to shoot, especially the elements which are involved in photosynthesis such as iron, zinc, and manganese.

From the obtained results, it could be concluded that spraying seaweed extract improved the vegetative growth, yield, fruit quality and leaf composition of nitrogen, phosphorous and potassium as compared to control in the two seasons. These results were previously explained by Soliman *et al.,* (2000). They stated that because of, the higher content of seaweed from mineral elements like N, P, K, Mg, Ca, S, Cu, Fe, Mn, B and Mo and because of its higher content from cytokinins, IA A and GA3, amino acids, vitamins and antioxidants, it could be considered plant growth stimulators and has a good role in increasing the cell division. In the same trend with our obtained results, Ghalab and Salem (2001) stated that algae are a group of beneficial microorganisms that can fix the atmospheric N2 and can increase the growth, fresh and dry weight of roots, yield, photosynthetic rate and encourage the plant growth hormones. Moreover, the same authors added that algae contain cytokines, so they increase the plant growth, and photosynthetic rate. Furthermore, the advancing effect of seaweed extract on flowering time might be attributed to their essential role in balancing the ratio between carbohydrates and nitrogen to support the flowering(Neumann and Zur Nieden, 2001). Many authors reported that *Spirulina platensis* has high amounts from K, Ca, Cu, Fe, Mg, Mn, P and Zn, so it can improve the vegetative growth parameters, yield and yield components, leaf mineral composition of N, P, protein, chlorophyll content for a lot of crops grown under semi-arid and desert conditions (Abdel-Mawgoud *et al.,* 2010; Marrez *et al.,* 2014).Ali and Mohamed (2016) examined the effect of four concentrations,0.05, 0.1, 0.2 and 0.4% of seaweed extracton bud burst percentage, fruiting buds,

Table -7: Influence of the foliar spraying of Fulvic acid, Folic acid, and Seaweed extract and their combinations on leaf composition from N, P and K of grape cv. Flame seedless during 2019 and 2020 seasons

Treatment	N %		P %		K %	
	2019	2020	2019	2020	2019	2020
Control	0.21h	0.26h	0.19j	0.21h	3.26h	3.82j
Fulvic acid 1000 ppm	0.35ef	0.36efg	0.34f	0.34f	4.89d	5.15g
Fulvic acid 1500 ppm	0.41c	0.40d	0.45d	0.48c	5.25abc	6.17c
Fulvic acid 2000ppm	0.53a	0.53a	0.87a	0.84a	5.32a	7.25a
Folic acid 100 ppm	0.24g	0.35fg	0.20ij	0.22h	3.5g	4.26i
Folic acid 150 ppm	0.32f	0.35fg	0.23hi	0.24h	3.58g	4.31i
Folic acid 200 ppm	0.34ef	0.36efg	0.24gh	0.27g	4.22f	4.53h
Seaweed 2000 ppm	0.33f	0.34g	0.27g	0.27g	4.34f	5.31f
Seaweed 3000 ppm	0.34ef	0.36efg	0.34f	0.37e	4.62e	5.44e
Seaweed 4000 ppm	0.37d	0.38de	0.39e	0.43d	5.18c	5.92d
Fulvic acid 1000 ppm + Folic acid 100 ppm + Seaweed 2000 ppm	0.36de	0.37ef	0.36f	0.41d	5.17bc	5.50e
Fulvic acid 1500 ppm + Folic acid 150 ppm + Seaweed 3000 ppm	0.42c	0.47c	0.54c	0.57b	5.28abc	6.25bc
Fulvic acid 2000 ppm + Folic acid 200 ppm + Seaweed 4000 ppm	0.45b	0.50b	0.80b	0.82a	5.31ab	6.30b
$LSD_{0.05}$	0.02	0.02	0.03	0.03	0.13	0.12

Means not sharing the same letter(s) within each column, significantly different at 0.05 level of probability

growth, nutritional status of vine, yield and berries quality of grape cv. Early sweet under the environmental conditions of Minia region. The obtained results proved that foliar application of seaweed extract at 0.05% to 0.4% resulted in stimulating all the investigated characteristics. Al-Musawi (2018) performed this study on local sour orange trees to see the expected effect of spraying of algae extracts at 0, 1, 2 and 3% on some physical and chemical characteristics of fruit. They found that spraying the trees twice, after fruit-set increased the length, width and size of fruit, fruit fresh weight, peel thickness, fruit moisture and juice, fruit peel and its moisture, ascorbic acid and total soluble solid. On the opposite side, they minimized the acidity and carotene content. Treatments had significant effects in comparison with the control, especially with at 3%, which gave the best results for the study.

Folic acid especially the concentration of 200 ppm was effective in improving the vegetative growth, yield, and fruit quality and leaf mineral composition from N, P and K over control in both experimental seasons. These results wereclearly illustrated by Popova *et al.,*(1995), they stated that folic acid plays an important role in synthesis of glutamic acid which can organize a lot of systems of enzymes. Andrew *et al.,* (2000) sated that Folic acid is the highest distinguished vitamin in the group of B complex although it is very important biochemical role in the synthesis metabolism of amino and nucleic acids. Spraying folic acid on pea and barley enhanced the seed yield, weight and quality (Stakhova *et al.,* 2000). It was reported by (Hanson and Roje, 2001;Jabrin *et al.,* 2003) that Folic acid is the basic factor which involved in the reaction of transferring of carbon which involved in a lot of reactions in the cell like the synthesis of purines, amino acids metabolism, converting glycine to serine, methionine synthesis and lignin formation, chlorophyll and in the cycle of respiration. Folic acid has an essential role in photosynthesis (Grunert *et al.,* 2002), in the process of nitrogen, carbon and sulfur biochemical transformation, in the synthesis of amino acids and glycine as coenzymes (Metzler, 2003) and nucleic acids (Litwack, 2008). Furthermore, by increasing the level of folic acid may be enhanced the synthesis rate of methionine will increase (Dahl *et al.,* 2008). The foliar spraying of folic acid at 20 mg. L^{-1} has the ability to encourage the vegetative growth, yield and the quality of the seeds of pea (*Pisum sativum* L.) (Farouk and Qados, 2018). Moreover, the obtained results are in parallel with the findings of Al-Maliky *et al.,*(2019). They examined the effect of the foliar spraying of folic acid at 0, 10, 20 and 30 mg. L- on faba bean (*Vicia faba* cv. Luz de otono). They found that using folic acid improved significantly the shoot height, the weight of dry and shoots, leaf mineral composition from N, P, K, leaf total chlorophyll, yield in terms of green pods and fresh seeds per plant. The best results were obtained with the spraying of 30 mg. L^{-1} as compared to control. The obtained results are in harmony with the findings of (Ibrahim *et al.,* 2021). They stated that the spraying of snap beans (*Phaseolus vulgaris* L.) with folic acid at the concentrations of 50, 100 and 150 µM/l raised obviously the yield, total soluble solids, protein, proline, free amino acids, total soluble sugars, antioxidant enzymes. Besides, it was demonstrated that the concentration of 150 µM was the best one in the previous mentioned parameters more than the other applied treatments and control. These results showed that folic acid plays an effective role in alleviating the effects of drought.

CONCLUSIONS

• The foliar spray of Fulvic acid, Folic acid and seaweed extract and their combinations improved vegetative growth, yield and fruit quality as compared to control in the two seasons and their positive effect increased by raising the used concentration from each one of them.

• The effect of Fulvic acid was better than the influence of Folic acid and seaweed extract in both experimental seasons.

• 00The best concentration was Fulvic acid at 2000 ppm, which gave the best results more than the other applied treatments in the two seasons.

• The best combination was Fulvic acid 2000 ppm + Folic acid at 200 ppm + Seaweed extract 4000 ppm.

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