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RESPONSE OF "WONDERFUL" POMEGRANATE CULTIVAR TO THE FOLIAR APPLICATION OF SOME BIOSTIMULANTS

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ABSTRACT

This experiment was carried out during 2019 and 2020 seasons on eight years old "Wonderful" pomegranate cultivar (*Punica granatum* L.) at Burg El-Arab, Alexandria governorate, Egypt. The experiment was performed on eighty trees, which were trained as vase shaped system on single-trunk with four branches, grown in a sandy soil under drip irrigation system and were grown at 4 m between trees and 5 m between rows. The trees were also similar in their size as possible and subjected to the same horticultural practiced in the orchard. They were sprayed at the beginning of flowering, full bloom and one month later three times by the following treatments: control (water only), humic acid at 0.2%, 0.3% and 0.4%, fulvic acid at 0.2%, 0.3% and 0.4%, yeast extract at 0.2%, 0.3% and 0.4%, moringa leaf extract at 0.2%, 0.4% and 0.6%. Moreover, the trees also sprayed by different combinations; 0.2% humic acid +0.2% fulvic acid + 0.2%yeast extract + 0.2%moringaleaf extract,0.3% humic acid + 0.3% fulvic acid + 0.3%yeast extract + 0.4%moringa leaf extract and 0.4% humic acid + 0.4% fulvic acid + 0.4% yeast extract+ 0.6% moringa leaf extract. The obtained results showed that the combination of 0.4% humic acid + 0.4% fulvic acid + 0.4% yeast extract+ 0.6% moringa leaf extract was the best treatment, which significantly improved shoot length, and diameter, leaf total chlorophyll content, fruit set percentage, weight, size, length, number and width of fruits, and fruit yield. Besides, it increased also the leaf mineral from N, P and K in the two seasons, as compared to control or the other treatments. Moreover, it also improved significantly fruit firmness, anthocyanin content, total soluble solids total and reducing sugars, TSS/acid ratio. On the other hand, the same combination decreased the percentages of fruit drop, cracking, sunburn and total acidity in the two seasons as compared to the control.

Keywords: Pomegranate; Fulvic acid; Yeast extract; Moringa; Yield; Fruit quality

INTRODUCTION

Pomegranate (*Punica granatum* L.) is cultivated in a wide range of arid and semi-arid regions in all parts of the world (Sarkhosh *et al*., 2006), is considered as an essential fruit for consumers, and has health benefits because of its high content from antioxidants, nutrients, and sugars (Holland *et al.,* 2009).

The application of humic acid exhibited significantly length of shoots, leaves of lateral shoots, leaf total chlorophyll, yield per vine, berry weight of 100 berries, cluster weight, length, and width, TSS and leaf chemical composition from N, P and Kof grape (Ferrara *et al*., 2007; Abd El-Moniem *et al*., 2008; Ferrara and Brunetti, 2008 and Asgharzade and Babaeian, 2012). Moreover, the foliar spraying of humic acid improved greatly the shoot length, diameter, leaf total chlorophyll, number of leaves per shoot, leaf area, the percentages of fruit set, and fruit retention, number of fruits per tree, weight, width and length of fruit, fruit chemical characteristics in terms of TSS, anthocyanin content, total carbohydrate, V.C. and leaf mineral composition from nitrogen, phosphorous, potassium and zinc as compared to control. Besides, it also was effective in reducing titratable acidity and tannins in mandarin (El-Mohamedy and Ahmed, 2009 and Abbas *et al*., 2013), pomegranate (Abd-Ella *et al*., 2010; Khattab *et al*., 2012 and Davarpanah *et al*., 2018), pear and apricot (Fathy *et al*., 2010), peach (Abd El-Razek *et al*., 2012), olive cv. Aggizy(El-Sayed (2013), strawberry (*Fragaria ananasa)* plant cv. Aromas (Farahi *et al*., 2013), mango (El Kheshin, 2016), orange (Samra *et al.,* 2017), apple (Hidayatulla *et al*., 2018) and *Annona squamosa* L. (Sindha *et al*., 2018).

Fulvic acid plays an important role in transporting the mineral nutrients directly to the sites of metabolism in the plant cells (Loveland, 2002 and Chen *et al*., 2004), and chelates mineral nutrients and increase their absorption (Bocanegra *et al*., 2006; Razavi and Parvar, 2007; Yang *et al*., 2013; Lotfi *et al*., 2015and Wang *et al*., 2019). It was noticed that the foliar application of fulvic acid was more effective in improving leaf area, shoot length, fruit set %, yield in kg per tree, fruit weight, fruit length and diameter, fruit firmness, soluble solids content, leaf mineral content from nitrogen, phosphorous, potassium, zinc, manganese, andiron as compared to control in apple (Pettit, 2004; El-Boray *et al*., 2015a; Taha *et al*., 2016 and Khan *et al*., 2019), citrus (Mahmoudi and Aryaee, 2015), apicot (Haggag *et al*.,

2016), persimmon trees (Abd El-Rheem *et al.,* 2017).Fulvic acid plays an important role in organizing the growth of plants by improving photosynthesis operation and minimizing the rate of transpiration (Li *et al*., 2005; Anjum *et al*., 2011and Huang *et al*., 2020). Besides, the effect of fulvic acid are similar to the effect of cytokinin, auxin and gerbilline (Abd El-Hameed *et al*., 2014; Samavat, 2014 and Khan *et al*., 2019).It was found by many authors that the foliar spraying of fulvic acid increased obviously total chlorophyll, the of average shoot length, diameter, leaf surface area and cluster weight, yield in kg per vine, total soluble solids, total soluble solids/ acid ratio**,** total carbohydrates, total nitrogen and C/N ratio in canes while it reduced titratable acidity percentage in grapevines cvs. Superior seedless (EL-Boray *et al*., 2015b), Thompson seedless (El-Kenawy, 2017), and King Ruby (Mostafa *et al.,* 2017).

Spraying yeast extract improved the shoot length, diameter, fruit yield, fruit weight, fruit length, width and firmness, TSS, total sugar, leaf mineral content from nitrogen, phosphorous, potassium, zinc, iron, and manganese and vitamin C while, it was very effective in decreasing the percentages of fruit drop and total acidity in pear trees cv. Le-Conte (Attala *et al.,* 2000 andHafez *et al*., 2018), papaya (Ismaeil and Bakry, 2005), Jaffa orange trees (Bakry, 2007), mango cv. Keitte (Abd El-Motty *et al*., 2010),Washington navel orange (Khafagy *et al*., 2010; Abd El-Motty and Orabi, 2013; El-Boray *et al*., 2015c and El-Shazly and Mustafa, 2015),olive (El-Sayed, 2013 and Mahmoud *et al*., 2015), mango (Abed El Hamied, 2014), orange trees (El-Tanany and Mohamed, 2016), apricot (Haggag *et al.,* 2016), Mandarin (Ahmed *et al.,* 2018 and Silem, 2020). Moreover, yeast helped the rate of leaf stomata opening, which increased the nutritional status of trees (Hassan, 2002).Additionally, yeast extract plays an important role in the availability of nutrients and increasing the levels from nitrogen, potassium, iron, zinc, phosphor and Manganese and it can also produce growth regulators like auxins, cytokinin, and gibberellins, or B vitamins that can be transferred to the plant (Eid, 2004; Mohamed and Hafez, 2004 and Abou El-Yazied and Maday, 2012). Marzouk*et al*. (2014) stated that because yeast extract contains a mixture of amino acids, peptides and B complex such as B1, B2, B6 and B12, carbohydrates, sugars, vitamins, enzymes and minerals so it could be used as bio stimulant.

Many authors reported that moringa leaf extract enhanced significantly plant growth, cell elongation and division, because it contains β carotene, amino acids, zeatin, ascorbic acid, phenolic compounds, profile of proteins, sugars, vitamins and minerals nutrients such as Ca, K, P, Mg, Mn, Zn,and Fe (Siddhuraju and Becker, 2003; Aslam *et al.,* 2005; Nagar *et al*., 2006; Anwar *et al*., 2007; Rizk-Alla *et al.,* 2011; Howladar, 2014 and Rady *et al*., 2015).The foliar spraying of moringa leaf extract increased the rate of photosynthesis, leaf area, and the yield of plants (Iqbal, 2014). Moringa leaf extract significantly enhanced the vegetative growth, leaf total chlorophyll, leaf mineral contents from nitrogen, potassium and phosphorous, fruit set, yield per tree, fruit weight, fruit length, diameter, and volume, pulp weight, yield, fruit firmness, TSS %, vitamin C, total, non-reducing, and reducing sugars, while it reduced the fruit drop, fruit weight loss and acidity percentages of grape cv. flame seedless (Bassiony and Ibrahim, 2016),mandarin cv. kinnow (Nasir *et al*., 2016), plum cv. Hollywood (Mahmoud *et al*., 2017),Washington navel orange (Abd Al Rhman *et al*., 2018), date palm cv. khadrawi (Moustafa *et al.,* 2018), Mango cv. zebda (Abd El-Razek *et al.,* 2019),olive cv. picual (Hassan *et al.,* 2019) and peach (Bakhsh *et al.,* 2020).

The purpose of the current study was to investigate the effect of the foliar application of humic and fulvic acids, yeast and moringa extracts as well as their combinations on vegetative growth parameters, yield, fruit quality characteristics and leaf mineral content of "Wonderful" Pomegranate cultivar.

MATERIALS AND METHODS

This study was carried out on eight years old "Wonderful" pomegranate cultivar (*Punica granatum* L.) grown at a private orchard of at Burg El-Arab, Alexandria Governorate, Egypt during the two successive seasons 2019 and 2020. The trees were cultivated at 4*5 meters apart and were trained as vase shaped system on single-trunk with four branches, grown in a sandy soil under drip irrigation system. During the entire seasons, eighty pomegranate trees that were similar in their shape and size as possible were chosen to perform this study. The selected trees were subjected to the same horticultural practices applied at the farm. The physiochemical analysis of experimental soil was indicated in Table 1 according to (Sparks *et al*., 2020).

Table 1 : Physiochemical analysis of the experimental soil

Depth(cm)	Textural class	pH	Total $CaCO_3$ (mg/L)	EC(ds/m)		O.M.(%)
0-45	Sandy Loam	7.89	39.51	1.74		1.43
Cations (meq/ 100 g soil)				Anions(**meq/ 100 g soil**)		
Na^+	**K^+**	**Ca^{2+}**	**Mg^{2+}**	HCO^{3-}	Cl^-	SO_4^{2-}
8.35	1.56	6.14	1.72	9.02	12.85	3.17

The trees were sprayed three times at the beginning of flowering, full bloom and one month later with the following treatments:

1. Control (water)
2. Humic acid at 0.2%
3. Humic acid at 0.3%
4. Humic acid at 0.4%
5. Fulvic acid at 0.2%
6. Fulvic acid at 0.3%
7. Fulvic acid at 0.4%
8. Yeast Extract at 0.2%
9. Yeast Extract at 0.3%
10. Yeast Extract at 0.4%
11. Moringa leaf extract at 0.2%
12. Moringaleaf extract at 0.4%
13. Moringaleaf extract at 0.6%
14. Combination1: 0.2% Humic acid +0.2% Fulvic acid + 0.2%Yeast extract + 0.2% Moringa leaf extract

15. Combination2: 0.3% Humic acid + 0.3% Fulvic acid + 0.3% Yeast extract + 0.4% Moringa leaf extract
16. Combination3: 0.4% Humic acid + 0.4% Fulvic acid + 0.4% Yeast extract+ 0.6% Moringa leaf extract.

The previous treatments were arranged in Randomized Complete Block Design (RCBD), where each one of them was composed from five replicates/ trees. The influence of the

A fore mentioned treatments was studied by evaluating their influence on the following parameters:

Vegetative Parameters

At the end of growing seasons, for the selected shoots length and thickness(cm) were measured. Total leaf chlorophyll content in fresh leaves was measured by using a chlorophyll meter (SPAD-502; Konica Minolta, Osaka, Japan) and the results were expressed in SPAD units.

Fruit Set, Fruit Drop, Fruit Cracking and Fruit Sunburn Percentage

Sixty days after flowering, final fruit set percentage was calculated according to this formula**(Westwood, 1988):**

$$\text{Fruit set (\%)} = \frac{No.\ of\ \ fruitlets}{No.\ of\ \ opened\ \ \ flowers} \text{ X } 100$$

Fruit drop % was calculated by counting the number of dropping fruits from the middle of June till the commercial harvesting time under experimental conditions, then expressed as a percentage according to this formula:

$$\text{Fruit drop (\%)} = \frac{\text{No.of dropped fruits}}{\text{No.of set fruits}} \times 100$$

The percentage of fruit cracking per tree was calculated before harvest time. The number of cracking (split) fruits was counted on each tree according to this equation:

$$\text{Fruit cracking (\%)} = \frac{\text{No.of cracking fruits}}{\text{total No.of fruits on tree}} \times 100$$

Fruit sun burn was visually estimated as the percentage of sunburned fruit on each tree relative to the total number of fruits on the tree just before harvest according to (Schupp *et al*., 2002) as:

$$\text{Sunburn (\%)} = \frac{\text{No. of fruit sunburnt}}{\text{total No. of fruits on tree}} \times 100$$

Yield (kg/tree): At harvest time in beginning of October, the number of fruits per tree in each treatment was counted and fruit yield (kg/tree) was calculated.

Fruit Quality: At harvest time, sample of five fruits per tree from each treatment was collected randomly for the determination of both physical and chemical characteristics.

Fruit Physical characteristics: Fruit weight (g), number of fruits per tree, fruit length and width (cm), fruit volume (cm^3). Fruit firmness ($Ib/inch^2$), which was determined by using Magness and Taylor pressure tester (mod. FT 327 (3-27 Ibs.Made in Italy)with a $^7/_{18}$-inch plunger.

Fruit Chemical Characteristics:

Total soluble solids percentage (TSS %) was measured by using a hand refractometer (ATAGO Co. LTD., Tokyo, Japan), from the fresh-cut pomegranate fruit and the result was expressed as percentage (%). Total and reducing sugars were estimated calorimetrically using Nelson arsenate – molybdate colorimetric method (Nielsen, 2010). Non-reducing sugars were estimated by the difference between total sugars and reducing sugars. Percentage of Titratable acidity in fruit juice was determined using an AOAC method (AOAC, 2005) where it was expressed as citric acid in gram/ 100 milliliters fruit juice. TSS/ acid ratio was counted by dividing the value of TSS over the value of titratable acidity. Ascorbic acid content of the juice (Vitamin C mg/ 100 mg juice) was estimated by titration with 2,6 dichloro phenol-indo-phenol (Nielsen, 2017) and calculated as milli-grams per 100 ml of juice. Anthocyanin content was determined at the stage of coloration (mg/100g) in seed of fruit according to Nangle *et al.* (2015).

Leaf Chemical Composition:

For the leaf chemical composition, samples of 30 leaves were chosen randomly from the middle of the shoots from each replicate after the harvest time in October to estimate their content in terms of percentages of nitrogen (N), phosphorus (P), and potassium (K) (Arrobas *et al.,* 2018). The leaf samples were washed first with tap water and then with distilled water and dried at 70 °C until a constant weight was obtained. Finally, the dried leaf samples were ground and acid digested using H_2SO_4 and H_2O_2 until the digested solution became clear. The digested solution was utilized for the estimation of nitrogen via the method of micro-Kjeldahl (Wang *et al.,* 2016), phosphorus by the method of vanadomolybdate (Weiwei *et al.,* 2017), and potassium by a flame photometer (Banerjee and Prasad 2020).

Statistical Analysis

Obtained results were analyzed by using one-way analysis of variance (Ott and Longnecker 2015). A least significant difference at 0.05% was utilized to compare between the means of the treatments and measured with CoHort Software (Pacific Grove, CA, USA).

RESULTS

Data Table 2 showed that the spraying of humic acid at 0.4% + fulvic acid at 0.4% + yeast extract 0.4% and moringa leaf extract 0.6% combination, moringa leaf extract at 0.4 and 0.6% and yeast extract at 0.3 and 0.4% significantly improved shoot length and thickness and leaf total chlorophyll content as compared to the other applied treatment in both seasons. Moreover, the best results were obtained by the application of humic acid at 0.4% + fulvic acid at 0.4% + yeast extract at 0.4% and moringa leaf extract at 0.6% combination followed by moringa leaf extract at 0.6% and yeast extract at 0.4% respectively, in the two experimental seasons. Besides, they were raised by spraying of fulvic acid at 0.4%, humic acid + 0.3% fulvic acid + 0.3% yeast extract+ 0.4% moringa leaf extract combination over control in the two seasons. Additionally, shoot length was also obviously enhanced by the foliar spraying of 0.2% moringa leaf extract, 0.3% humic acid, 0.3% yeast extract and 0.2 fulvic acid rather than control.

Results in Table 3 demonstrated that the fruit set percentage in pomegranate was significantly increased by the foliar applications of humic acid at 0.3 and 0.4%, fulvic acid at 0.3 and 0.4%, moringa leaf extract at 0.4 and 0.6, yeast extract at 0.3 and 0.4% and their combinations. The foliar applications of humic acid at 0.4% + fulvic acid at 0.4% + yeast extract at 0.4% + moringa leaf extract at 0.6% combination and fulvic acid at 0.4% gave the highest

increments in fruit set percentage, followed by fulvic acid at 0.3%, or 0.2%, and the combination of humic acid at 0.3% + fulvic acid at 0.3% + yeast extract 0.3% + moringa leaf extract at 0.4% comparing with control. The highest fruit drop percentage was obtained with control treatment, followed by the treatments of fulvic acid at 0.2% and yeast at 0.2% comparing with the other treatments during both experimental seasons. Besides, the lowest percentage of fruit drop was obtained by the application of moringa leaf extract at 0.6% and 0.4%,fulvic acid at 0.4% and humic acid at 0.4%,respectively in the two seasons. Fruit cracking and sunburn percentages were clearly minimized by the application of 0.2% humic acid, 0.2% fulvic acid and 0.3% humic acid as compared to control.

Data in Table 4 demonstrated that the foliar spray of humic and fulvic acids, moringa and yeast extracts and their combinations significantly increased number of fruits per tree, fruit weight and consequently the fruit yield comparing with control in the two seasons. Moreover, the best results were obtained by spraying humic acid at 0.4% + fulvic acid at 0.4 % + yeast extract at 0.4% + moringa leaf extract at 0.6% combination followed by moringa leaf extract at 0.6 %, yeast at 0.4% and fulvic acid at 0.4%, more than the other applied treatments in the two seasons. Additionally, they were also raised by the foliar application of fulvic acid at 0.3% orthe combination of humic acid at 0.3% + fulvic acid at 0.3% + yeast extract at 0.3% + moringa leaf extract at 0.4%. Furthermore, 0.4% moringa leaf extract, 0.4% humic acid and 0.3% yeast extract increased significantly number of fruits per tree, fruit weight and yield rather than control.

Data in Table 5 showed that the foliar spraying of humic and fulvic acids, moringa and yeast extracts and their combinations obviously increased fruit length, width and volume comparing with control in the two seasons. Moreover, the best results were obtained by spraying humic acid at 0.4% + fulvic acid at 0.4 % + yeast extract at 0.4% + moringa leaf extract at 0.6% combination followed by moringa leaf extract at 0.6 %, yeast at 0.4% and fulvic acid at 0.4%, more than the other applied treatments in the two seasons. The same trend was obtained by the usage of fulvic acid at 0.3% or the combination of humic acid at 0.3% + fulvic acid at 0.3% + yeast extract at 0.3% + moringa leaf extract at 0.4%**.** Furthermore, 0.4% moringa leaf extract, 0.4% humic acid and 0.3% yeast extract enhanced statistically fruit length, width and volume rather than control. Besides, it was noticed that the fruit firmness was highly raised by the foliar application of 0.2% humic acid, 0.2% fulvic acid, 0.3% humic acid, 0.2% moringa leaf extract and 0.2 yeast extract, respectively more than the other applied treatments or control. Additionally, fruit firmness was also increased by the foliar spraying of 0.3% moringa leaf extract, 0.3% fulvic acid and 0.3% yeast extract over control.

Data in Table 6 demonstrated that the foliar spraying of fulvic acid at 0.3%, humic acid at 0.4% + fulvic acid at 0.4% + yeast extract at 0.4% + moringa leaf extract at 0.6% combination, yeast extract at 0.2%, moringa leaf extract at 0.2% and yeast extract at 0.3% greatly raised total soluble solids % and TSS/acid ratio as compared to the other applied treatment in both seasons. The best results were noticed with the application of fulvic acid at 0.3% followed by0.4 % yeast extract, or the combinations of 0.3% humic acid + 0.3% fulvic acid + 0.3% yeast extract + 0.4% moringa leaf extract**,** and 0.4% humic acid + 0.4% fulvic acid + 0.4% yeast extract + 0.6% moringa leaf extract and yeast extract at 0.2% in the two experimental seasons. TSS percentage and TSS/ acid ratio were also enhanced by spraying of 0.2% fulvic acid and the combination of 0.2% humic acid + 0.2% fulvic acid + 0.2%yeast extract + 0.2% moringa leaf extract over control in the two seasons. Additionally, they were statistically enhanced by the foliar spraying of 0.4% fulvic acid, 0.4% moringa leaf extract and 0.6% moringa leaf extract rather than control. Regarding to the fruit acidity, it was remarkably decreased by the foliar application of humic or fulvic acids, yeast extract and moringa leaf extract or their different combinations. The best results were seen by the foliar spraying of fulvic acid at 0.3 or 0.4 % and yeast extract at 0.3% comparing with control in the two seasons. Spraying humic acid at 0.4%, fulvic acid at 0.3% and moringa leaf extract at 0.6% were improved considerably the percentage of vitamin C over the other applied treatments in both seasons. Furthermore, it was obviously enhanced also by the foliar spraying of yeast extract at 0.4%, moringa leaf extract at 0.4% and fulvic acid at 0.4%, and by the combinations of humic acid at 0.3% + fulvic acid at 0.3% + yeast extract at 0.3% + moringa leaf extract at 0.4% or humic acid at 0.2% + fulvic acid at 0.2% + yeast extract at 0.2%+ moringa leaf extract at 0.2% over control in the two seasons.

The results listed in Table 7 demonstrated that the effect of the foliar applications of humic and fulvic acids, moringa and yeast extracts and their combinations obviously improved total sugars percentage comparing with control in the two seasons. The application of the combinations of 0.3% humic acid + 0.3% fulvic acid + 0.3% yeast extract + 0.4% moringa leaf extract, 0.4% humic acid + 0.4% fulvic acid + 0.4% yeast extract+ 0.6% moringa leaf extract**,** moringa leaf extract at 0.4%, humic acid at 0.4% and fulvic acid at 0.2 gave a great increment in total sugars percentage over than control. Additionally, it was obviously enhanced by the foliar spraying of 0.3% humic acid, 0.4% fulvic acid, and 0.2% or 0.3% yeast extract as compared to control in the two seasons. Reducing sugars percentage was improved by the foliar spraying of humic acid at 0.3% + fulvic acid at 0.3% + yeast extract at 0.3% + moringa leaf extract 0.4% combination, humic acid at 0.4%, moringa leaf extract at 0.4%**,** fulvic acid at 0.2 or 0.4%, the combination of humic acid at 0.4% + fulvic acid at 0.4% + yeast extract at 0.4% + moringa leaf extract at 0.6% over control. Moreover, it was noticed that the spraying of leaf extract at 0.2, 0.4 and 0.6%, fulvic acid at 0.4% and combinations of 0.4% humic acid + 0.4% fulvic acid + 0.4% yeast extract+ 0.6% moringa leaf extract or humic acid at 0.3% + fulvic acid at 0.3% + yeast extract at 0.3% + moringa leaf extract 0.4% has a positive influence on improving non-reducing sugars percentage as compared to control in both experimental seasons. Besides, anthocyanin content was obviously raised by the foliar spraying of 0.2% humic acid +0.2% fulvic acid + 0.2% yeast extract + 0.2% moringa leaf extract combination followed by moringa leaf extract at 0.4% and fulvic acid at 0.4% comparing with control in the two seasons.

Data cleared in Table 8 showed the effect of the foliar applications with humic and fulvic acids, yeast extract, moringa leaf extract and their combinations obviously improved leaf mineral content from nitrogen, phosphorous and potassium as compared to control during both 2019 and 2020 seasons. The highest percentages were obtained with

the combination of 0.4% humic acid + 0.4% fulvic acid + 0.4% yeast extract+ 0.6% moringa leaf extract followed by 4% yeast extract and 0.6% moringa leaf extract over than the other applied treatments in the both seasons. Besides, spraying 0.4% or 0.2 % fulvic acid, 0.4% moringa leaf extract, 0.2% humic acid, 0.2% yeast extract and the combination of humic acid at 0.3% + fulvic acid at 0.3% + yeast extract 0.3% + moringa leaf extract at 0.4% gave better results over than control in the two seasons.

Table 2 : The influence of humic and fulvic acids, yeast extract and moringa leaf extract on shoot length, shoot thickness and leaf total chlorophyll of "Wonderful" pomegranate cultivar 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	53.75^{j}	63.50^{h}	5.58^{j}	5.83^{l}	53.38^{j}	56.75^{i}
Humic acid 0.2%	63.25^{i}	73.0^{g}	5.91^{i}	6.36^{k}	54.55^{j}	62.25^{h}
Humic acid 0.3%	70.50^{fg}	82.0^{df}	6.99^{f}	7.77^{g}	67.45^{fg}	74.90^{fg}
Humic acid 0.4%	72.75^{e-g}	84.5^{d}	7.01^{f}	7.86^{fg}	70.50^{ef}	78.75^{ef}
Fulvic acid 0.2%	64.00^{i}	74.50^{fg}	6.59^{h}	7.24^{j}	57.28^{ij}	63.75^{h}
Fulvic acid 0.3%	74.25^{ef}	85.50^{d}	7.29^{d}	7.96^{f}	76.40^{cd}	87.93^{cd}
Fulvic acid 0.4%	81.25^{d}	92.50^{c}	7.94^{c}	8.36^{d}	87.00^{ab}	95.90^{ab}
Yeast extract 0.2%	66.25^{hi}	77.00^{fg}	6.81^{g}	7.55^{h}	62.10^{hi}	70.75^{g}
Yeast extract 0.3%	73.00^{e-g}	84.75^{d}	7.16^{e}	7.87^{fg}	73.70^{de}	80.25^{e}
Yeast extract 0.4%	96.00^{b}	115.75^{b}	8.56^{b}	9.54^{b}	93.08^{a}	98.00^{a}
Moringaleaf extract%0.2	64.50^{i}	75.25^{fg}	6.64^{h}	7.43^{i}	58.20^{ij}	64.90^{h}
Moringaleaf extract0.4 %	73.50^{ef}	85.25^{d}	7.26^{de}	7.93^{f}	74.75^{de}	85.25^{d}
Moringaleaf extract%0.6	86.50^{c}	93.00^{c}	7.948^{c}	8.86^{c}	91.08^{ab}	97.75^{a}
Combination 1	69.00^{gh}	78.00^{ef}	6.94^{f}	7.58^{h}	63.88^{gh}	73.25^{g}
Combination 2	75.50^{e}	85.75^{d}	7.36^{d}	8.22^{e}	80.87^{c}	92.25^{bc}
Combination 3	115.50^{a}	131.75^{a}	9.88^{a}	11.20^{a}	95.68^{a}	98.85^{a}
LSD$_{0.05}$	4.22	4.03	0.10	0.12	5.14	4.71

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

Table 3: The influence of humic and fulvic acids, yeast extract and moringa leaf extract on the percentages of fruit set, drop, cracking and sunburn of "Wonderful" pomegranate cultivar during 2019 and 2020 seasons

Treatment	Fruit set (%)		Fruit drop (%)		Fruit cracking (%)		Sunburn (%)	
	2019	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**
Control	19.90^{m}	18.14^{o}	25.65^{a}	23.37^{a}	20.75^{a}	22.65^{a}	53.20^{a}	55.45^{a}
Humic acid 0.2%	23.78^{k}	22.20^{m}	11.40^{h}	11.00^{i}	10.60^{j}	11.90^{l}	18.30^{m}	23.70^{k}
Humic acid 0.3%	27.88^{i}	24.18^{k}	9.05^{k}	4.16^{o}	11.80^{h}	12.40^{k}	19.50^{k}	24.50^{i}
Humic acid 0.4%	33.31^{f}	27.84^{f}	10.62^{i}	9.13^{j}	12.10^{gh}	13.60^{h}	20.60^{i}	25.90^{f}
Fulvic acid 0.2%	39.94^{d}	36.86^{c}	18.98^{b}	15.78^{b}	11.10^{i}	12.40^{k}	19.80^{j}	26.70^{c}
Fulvic acid 0.3%	41.20^{c}	37.06^{c}	13.24^{f}	10.95^{i}	13.20^{de}	14.73^{f}	21.40^{g}	25.10^{g}
Fulvic acid 0.4%	42.23^{b}	39.59^{b}	13.08^{f}	7.14^{k}	14.70^{c}	15.90^{d}	22.80^{c}	26.20^{e}
Yeast extract 0.2%	22.39^{l}	20.93^{n}	17.07^{c}	15.30^{c}	12.80^{f}	12.80^{j}	19.10^{l}	23.20^{m}
Yeast extract 0.3%	30.44^{h}	26.33^{h}	16.84^{c}	12.39^{f}	11.90^{gh}	15.20^{e}	22.40^{d}	26.40^{d}
Yeast extract 0.4%	31.47^{g}	27.19^{g}	14.41^{e}	11.34^{h}	14.60^{c}	16.20^{c}	21.90^{f}	24.30^{j}
Moringa leaf extract 0.2%	24.00^{k}	22.53^{l}	16.22^{d}	14.31^{e}	11.90^{gh}	12.70^{j}	19.83^{j}	23.45^{l}
Moringa leaf extract 0.4 %	30.36^{h}	25.25^{i}	9.14^{k}	5.55^{m}	12.20^{g}	13.10^{i}	21.00^{h}	24.70^{h}
Moringa leaf extract 0.6%	33.86^{e}	31.31^{e}	7.30^{l}	5.21^{n}	13.50^{d}	16.40^{cb}	22.20^{de}	26.10^{e}
Combination 1	25.96^{j}	24.55^{j}	16.79^{c}	14.80^{d}	15.50^{b}	16.60^{b}	23.70^{b}	27.50^{b}
Combination 2	33.71^{e}	32.34^{d}	10.03^{j}	5.90^{l}	13.20^{de}	14.30^{g}	22.00^{ef}	25.80^{f}
Combination 3	43.05^{a}	40.68^{a}	12.22^{g}	11.89^{g}	12.90^{ef}	13.60^{h}	21.90^{f}	23.65^{k}
LSD $_{0.05}$	0.24	0.28	0.31	0.16	0.30	0.20	0.27	0.20

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

Table 4 : The influence of humic and fulvic acids, yeast extract and moringa leaf extract on fruit number, fruit weight and yield of "Wonderful" pomegranate cultivar during 2019 and 2020seasons

Treatment	Fruit number/tree		Fruit weight(g)		Yield seasons (kg/tree)	
	2019	2020	2019	2020	2019	2020
Control	26.25^{e}	24.50^{g}	304.75^{k}	309.75^{m}	8.375^{g}	9.91^{h}
Humic acid 0.2%	39.50^{d}	45.00^{f}	322.25^{j}	320.00^{l}	13.58^{f}	16.00^{g}
Humic acid 0.3%	42.50^{cd}	49.00^{d-f}	336.25^{hi}	363.00^{h}	14.69^{ef}	17.86^{fg}
Humic acid 0.4%	43.00^{cd}	49.00^{d-f}	341.25^{gh}	378.50^{g}	14.77^{d-f}	18.40^{ef}
Fulvic acid 0.2%	40.25^{d}	46.50^{ef}	323.00^{j}	340.75^{k}	14.28^{ef}	16.70^{fg}
Fulvic acid 0.3%	45.25^{c}	52.00^{b-e}	348.25^{e}	400.00^{e}	16.04^{b-e}	20.78^{cd}
Fulvic acid 0.4%	50.25^{b}	55.00^{bc}	365.50^{c}	430.00^{d}	16.79^{a-c}	21.76^{bc}
Yeast extract 0.2%	42.00^{cd}	48.00^{d-}f	332.00^{i}	351.50^{ij}	14.60^{ef}	17.05^{fg}
Yeast extract 0.3%	43.00^{cd}	49.25^{d-f}	342.75^{fg}	381.25^{g}	14.80^{c-f}	19.03^{d-f}
Yeast extract 0.4%	54.75^{a}	57.00^{ab}	425.00^{b}	483.50^{b}	17.82^{ab}	24.70^{a}
Moringa leaf extract 0.2%	41.00^{cd}	47.25^{ef}	331.75^{i}	351.00^{j}	14.58^{ef}	17.04^{fg}
Moringa leaf extract 0.4 %	45.00^{c}	50.00^{d-f}	347.50^{ef}	390.50^{f}	15.20^{c-f}	20.74^{c-e}
Moringa leaf extract 0.6%	52.75^{ab}	56.75^{ab}	369.00 ^{c}	449.00^{c}	18.10^{a}	23.47^{ab}
Combination 1	42.50^{cd}	48.25^{d-f}	336.00h^{i}	355.00^{i}	14.63^{ef}	17.60^{fg}
Combination 2	45.25^{c}	53.50^{b-d}	363.50^{d}	402.50^{e}	16.71^{a-d}	21.33^{b-d}
Combination 3	55.25^{a}	61.25^{a}	449.50^{a}	518.50^{a}	18.41^{a}	25.53^{a}
$LSD_{0.05}$	4.39	5.64	5.27	3.83	2.01	2.35

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

Table 5: The influence of humic and fulvic acids, yeast extract and moringa leaf extract on fruit length, width, volume and firmness of "Wonderful" pomegranate cultivar during 2019 and 2020 seasons

Treatment	Fruit length (cm)		Fruit width (cm)		Fruit volume (cm^3)		Fruit firmness ($Ib/inch^2$)	
	2019	2020	2019	2020	2019	2020	2019	2020
Control	6.40^{j}	6.47^{m}	7.00^{l}	7.14^{m}	308.75^{k}	305.00^{m}	17.00^{j}	17.25^{i}
Humic acid 0.2%	7.33^{i}	7.540^{l}	8.43^{k}	8.44^{l}	326.50^{j}	351.50^{l}	28.00^{a}	38.00^{a}
Humic acid 0.3%	7.92^{f}	8.18^{i}	8.66h^{g}	8.86^{i}	363.00^{g}	393.50^{h}	24.75^{bc}	28.75^{cd}
Humic acid 0.4%	8.01^{ef}	8.28^{h}	8.68^{hg}	9.04^{h}	366.50^{g}	405.25^{g}	23.25^{c-e}	27.13^{de}
Fulvic acid 0.2%	7.55^{h}	7.70^{k}	8.52^{j}	8.59^{k}	342.50^{i}	357.75^{k}	25.75^{ab}	33.88^{b}
Fulvic acid 0.3%	8.20^{d}	8.65^{e}	8.85^{f}	9.39^{e}	382.00^{e}	420.75^{f}	22.00^{d-g}	23.50^{fg}
Fulvic acid 0.4%	8.25^{d}	8.95^{c}	9.12^{d}	9.61^{d}	387.50^{d}	473.25^{d}	20.50^{g-i}	21.50^{gh}
Yeast extract 0.2%	7.73^{gh}	7.91^{j}	8.60^{i}	8.74^{j}	356.00^{h}	364.00^{j}	23.75^{b-e}	30.13^{c}
Yeast extract 0.3%	8.13^{d}f	8.41^{g}	8.71^{g}	9.15^{g}	374.00^{f}	406.25^{g}	19.50^{hi}	21.25^{gh}
Yeast extract 0.4%	9.57^{b}	9.18^{b}	10.35^{b}	10.96^{b}	442.50^{b}	497.00^{b}	22.00^{d-g}	24.25^{f}
Moringa leaf extract 0.2%	7.69^{gh}	7.85^{j}	8.53^{j}	8.72^{j}	343.75^{i}	358.75^{k}	24.25^{b-d}	27.75^{cd}
Moringa leaf extract 0.4%	8.20^{d}	8.55^{f}	8.84^{f}	9.30^{f}	374.75^{f}	418.00^{f}	23.00^{c-f}	25.00^{fe}
Moringa leaf extract 0.6%	8.43^{c}	9.17^{b}	9.24^{c}	9.75^{c}	412.00^{c}	487.50^{c}	20.75^{f-i}	23.50^{fg}
Combination 1	7.83f^{g}	8.11^{i}	8.66^{h}	8.84^{i}	356.50^{h}	387.75^{i}	20.38^{g-i}	22.63^{f-h}
Combination 2	8.21^{d}	8.77^{d}	8.95^{e}	9.55^{d}	382.50^{e}	462.00^{e}	19.00^{ij}	20.25^{h}
Combination 3	9.74^{a}	10.45^{a}	10.46^{a}	11.31^{a}	462.50^{a}	536.25^{a}	21.50^{e-h}	20.38^{h}
$LSD_{0.05}$	0.18	0.07	0.05	0.07	3.74	3.59	2.43	2.66

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

Table 6 : The influence of humic and fulvic acids, yeast extract and moringa leaf extract on the percentages of TSS and acidity (%), TSS/acid and Vitamin C of "Wonderful" pomegranate fruit during 2019 and 2020 seasons

Treatment	TSS (%)		Acidity (%)		TSS/acid ratio		Vitamin C (mg/100 mL)	
	2019	2020	2019	2020	2019	2020	2019	2020
Control	14.33^{h}	14.68^{j}	1.11^{a}	1.03^{a}	12.90^{g}	14.22^{g}	9.46^{h}	11.21^{i}
Humic acid 0.2%	15.03^{g}	16.00^{fg}	0.96^{c}	0.88^{b}	15.66^{f}	18.28^{f}	11.63^{e}	13.57^{h}
Humic acid 0.3%	16.95^{b}	16.90^{c}	0.89^{de}	0.80^{de}	18.99^{b}	21.13^{c}	13.36^{b}	15.36^{ef}
Humic acid 0.4%	15.33^{f}	14.88^{j}	0.98^{b}	0.81^{d}	15.65^{f}	18.34^{f}	13.89^{a}	16.86^{a}
Fulvic acid 0.2%	16.08^{de}	16.15^{ef}	0.95^{c}	0.81^{d}	16.86^{e}	20.03^{d}	11.32^{f}	15.71^{de}
Fulvic acid 0.3%	17.28^{a}	16.28^{e}	0.83^{g}	0.73^{g}	20.77^{a}	22.26^{ab}	13.86^{a}	16.86^{a}
Fulvic acid 0.4%	15.98^{e}	15.40^{h}	0.84^{g}	0.70^{h}	18.99^{b}	21.97^{b}	13.00^{cd}	15.93^{cd}
Yeast extract 0.2%	16.23^{cd}	15.15^{i}	0.91^{d}	0.78^{ef}	17.86^{c}	19.33^{e}	11.34^{f}	15.07^{f}
Yeast extract 0.3%	16.23^{cde}	16.10^{ef}	0.85^{g}	0.81^{d}	18.99^{b}	20.01^{d}	12.85^{d}	16.21^{c}
Yeast extract 0.4%	16.88^{b}	17.12^{b}	0.97^{bc}	0.77^{f}	17.49^{cd}	22.30^{ab}	13.86^{a}	16.79^{ab}
Moringa leaf extract 0.2%	16.33^{c}	16.15^{ef}	0.98^{b}	0.77^{f}	16.67^{e}	20.90^{c}	13.21^{bc}	16.14^{cd}
Moringa leaf extract 0.4%	15.98^{e}	16.00^{g}	0.90^{d}	0.70^{h}	17.83^{c}	22.45^{ab}	11.06^{g}	14.50^{g}
Moringa leaf extract 0.6%	15.10^{fg}	16.23^{e}	0.91^{d}	0.72^{gh}	16.65^{e}	22.69^{a}	13.17^{bc}	14.93^{fg}
Combination 1	16.25^{cd}	16.60^{d}	0.95^{c}	0.85^{c}	17.04^{de}	19.73^{de}	13.81^{a}	15.71^{de}
Combination 2	16.78^{b}	16.70^{cd}	0.88^{ef}	0.80^{de}	19.10^{b}	21.01^{c}	12.78^{d}	16.71^{ab}
Combination 3	16.75^{b}	17.70^{a}	0.87^{f}	0.81^{d}	19.35^{b}	22.00^{b}	12.79^{d}	16.36^{bc}
$LSD_{0.05}$	0.25	0.22	0.02	0.02	0.45	0.54	0.24	0.49

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

Table 7: The influence of humic and fulvic acids, yeast extract and moringa leaf extract on total, reduced and non-reduced sugars percentages and anthocyanin of "Wonderful" pomegranate fruit during 2019 and 2020 seasons

Treatment	Total sugars (%)		Reducing sugars (%)		Non- reduce sugars (%)		Anthocyanin (mg/100 g fresh weight)	
	2019	2020	2019	2020	2019	2020	2019	2020
Control	7.77^{m}	8.24^{k}	6.49^{i}	7.46^{f-i}	1.28^{i}	0.79^{j}	0.32^{k}	0.27^{m}
Humic acid 0.2%	9.45^{j}	10.29^{h}	7.23^{gh}	8.42^{c-f}	2.22^{g}	1.87^{h}	0.52^{e}	0.56^{e}
Humic acid 0.3%	12.37^{de}	9.82^{i}	9.28^{c}	6.81^{h-j}	3.10^{c}	3.01^{d}	0.49^{f}	0.56^{e}
Humic acid 0.4%	13.44^{c}	10.85^{g}	10.71^{b}	7.63^{e-h}	2.73^{de}	3.22^{c}	0.36^{i}	0.44^{j}
Fulvic acid 0.2%	12.72^{d}	13.55^{b}	10.45^{b}	9.71^{ab}	2.27^{g}	2.50^{fg}	0.34^{j}	0.44^{ij}
Fulvic acid 0.3%	9.38^{j}	9.22^{j}	7.84^{f}	6.56^{ij}	1.54^{h}	2.66^{ef}	0.44^{g}	0.63^{d}
Fulvic acid 0.4%	11.34^{g}	12.22^{de}	7.68^{f}	9.77^{ab}	3.66^{a}	2.45^{g}	0.66^{c}	0.71^{c}
Yeast extract 0.2%	11.86^{f}	12.32^{d}	9.03^{c}	9.07^{bc}	2.83^{d}	3.26^{c}	0.45^{g}	0.39^{k}
Yeast extract 0.3%	11.23^{gh}	11.95^{e}	$8.56d^{e}$	9.56^{ab}	2.68^{de}	2.40^{g}	0.48^{f}	0.54^{f}
Yeast extract 0.4%	9.89^{i}	9.66^{i}	$7.58f^{g}$	7.82^{d-g}	2.31^{fg}	1.84^{h}	0.46^{g}	0.45^{h}
Moringa leaf extract 0.2%	8.82^{k}	9.71^{i}	5.06^{j}	6.06^{j}	3.76^{a}	3.66^{b}	0.44^{g}	0.47^{g}
Moringa leaf extract 0.4%	13.86^{b}	14.05^{a}	10.53^{b}	10.54^{a}	3.33^{bc}	3.52^{b}	0.75^{b}	0.75^{b}
Moringa leaf extract 0.6%	10.88^{h}	11.50^{f}	8.37^{e}	7.16^{g-i}	2.52^{ef}	4.34^{a}	0.42^{h}	0.45^{hi}
Combination 1	8.35^{l}	9.94^{i}	6.91^{h}	8.47^{c-e}	1.43^{hi}	1.47^{i}	0.77^{a}	0.79^{a}
Combination 2	14.31^{a}	13.06^{c}	11.71^{a}	8.80^{b-d}	2.60^{de}	4.25^{a}	0.55^{d}	0.63^{d}
Combination 3	12.27^{e}	12.97^{c}	8.87^{cd}	10.17^{a}	3.39^{b}	2.80^{e}	0.34^{j}	0.36^{l}
$LSD_{0.05}$	0.39	0.30	0.41	0.99	0.24	0.18	0.02	0.01

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

Table 8 : The influence of humic and fulvic acids, yeast extract and moringa leaf extract on leaf mineral composition from N, P and K of "Wonderful" pomegranate cultivar during 2019 and 2020 seasons

Treatment	N (%)		P (%)		K (%)	
	2019	2020	2019	2020	2019	2020
Control	1.33^{l}	1.05^{h}	0.25^{g}	0.25^{g}	0.81^{k}	0.74^{l}
Humic acid 0.2%	1.44^{k}	1.23^{g}	0.29^{g}	0.24^{f}	1.15j^{k}	1.23^{k}
Humic acid 0.3%	1.79^{fg}	1.78^{c-f}	0.5^{def}	0.59^{c}	1.26^{g-i}	1.56^{fg}
Humic acid 0.4%	1.80^{f}	1.79^{b-f}	0.52^{def}	0.63^{c}	1.32^{f-h}	1.57^{fg}
Fulvic acid 0.2%	1.59^{j}	1.73^{f}	0.29^{g}	0.44^{de}	1.17^{jk}	1.32^{j}
Fulvic acid 0.3%	1.84^{cd}	1.81^{b-e}	0.67^{b-d}	0.84^{ab}	1.42^{c-e}	1.64^{d}
Fulvic acid 0.4%	1.86^{bc}	1.83^{a-d}	0.70^{b-d}	0.86^{ab}	1.46^{b-d}	1.72^{c}
Yeast extract 0.2%	1.75^{h}	1.75^{ef}	0.44^{fg}	0.46^{de}	1.23^{h-k}	1.48^{h}
Yeast extract 0.3%	1.81^{ef}	1.80^{b-e}	0.54^{d-f}	0.77^{b}	1.33^{e-g}	1.59^{de}
Yeast extract 0.4%	1.88^{b}	1.85^{ab}	0.87^{ab}	0.91^{a}	1.54^{b}	1.82^{b}
Moringa leaf extract 0.2%	1.71^{i}	1.73^{f}	0.37^{fg}	0.44^{de}	1.21^{i-k}	1.44^{i}
Moringa leaf extract 0.4%	1.82^{de}	1.80^{b-e}	0.64^{c-e}	0.79^{ab}	1.39^{d-f}	1.62^{de}
Moringa leaf extract 0.6%	1.88^{b}	1.85^{a-c}	0.83^{a-c}	0.87^{ab}	1.50^{bc}	1.73^{c}
Combination 1	1.77^{gh}	1.78^{d-f}	0.44^{e-g}	0.57^{cd}	1.24^{h-j}	1.53^{g}
Combination 2	1.85^{c}	1.81^{be}	0.69^{b-d}	0.84^{ab}	1.46^{b-d}	1.64^{d}
Combination 3	1.91^{a}	1.89^{a}	0.91^{a}	0.91^{a}	1.65^{a}	1.94^{a}
$LSD_{0.05}$	0.02	0.07	0.20	0.13	0.10	0.04

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

DISCUSSION

The obtained results showed the foliar spraying of humic acid improved the vegetative growth parameters, leaf total chlorophyll, yield, physical and chemical fruit characteristics and leaf mineral content from macro and micronutrients of pomegranate. These results were earlier confirmed by the findings of (Nardi *et al*., 2002; Turkmen *et al.,* 2004 and Muscolo *et al*., 2007). They mentioned that humic acid can increase the efficacy of nutrients uptake and gas soil exchange and has also the ability to organize the rate of stomata opening and consequently increases photosynthesis in the plant. Moreover, it can stimulate plant growth and thus yield by acting on mechanisms involved in cell respiration, photosynthesis, protein synthesis, water and nutrient uptake, enzyme activities (Chen *et al*., 2004; Salman *et al*., 2005; Nardi *et al*., 2007; Carletti *et al*., 2008; Saruhan *et al*., 2011and Canellas *et al.* 2015). Furthermore, humic acid contains also many elements that help boosting the soil fertility and the provision of many nutrients (Yildirim, 2007). Moreover, it can also chelate metal ions under alkaline soil conditions and improves the absorption of nutrients (Zhang *et al*., 2010 and Rajpar *et al.,* 2011). Besides, humic acid has the ability to improve soil structure and change physical soil characteristics by enhancing the chelation of many elements and making them available to plants and therefore improves the growth and productivity of plants (Szczepanek and Wilczewski, 2011; Khattab *et al*., 2012; Cavalcante *et al.,* 2013; Mosa *et al*., 2015and Shiva *et al*., 2015). Additionally, humic acid has the ability to improve the resistance of plants to biotic stresses, activate enzymes, increase the synthesis of chlorophyll and thus photosynthesis, the metabolism of sugars and amino acids, boost the thickness of cell wall and extend the time of fruit storage (Abd El-Razek *et al*., 2012; Haggag *et al*., 2013 and Ngullie *et al*., 2014). Kołodziej *et al*. (2013) reported that humic substances have a positive effect on soil fertility, nutrients availability and their absorbing by plant. In addition, humic acid increases the micro flora in the soil (Puglisi *et al*., 2013), raises the efficacy of fertilizers and soil ventilation, so it can improve the growth of plant (Canellas *et al*., 2015). Khan *et al.* (2019) stated that humic acid stimulated growth, development of plants and yield because of its stimulatory activity, which is similar to plant growth hormones such as cytokinin and auxin and gibberellin.

Our results obviously showed a positive effect of fulvic acid in improving vegetative growth parameters, yield and fruit quality of pomegranate. These findings were previously explained by the findings of (Varanini and Pinton, 2001; Razavi and Parvar, 2007; Yang *et al*., 2013; Justi *et al*., 2019 and Wang *et al*., 2019). They stated that as fulvic acid increases the absorption of elements, it may encourage the growth and development of plants. Fulvic acid could be considered as plant growth regulator, because it can help transporting the nutrients in the plant cells, increasing chlorophyll content, photosynthetic rate and reducing the opening of stomata and the transpiration rate (Chen *et al*., 2004; Li *et al*., 2005; Anjum *et al*., 2011 and Huang *et al*., 2020). Besides, 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 (Bocanegra *et al*., 2006 and Canellas *et al*., 2015). In addition, Abd El-Hameed *et al*. (2014) stated that fulvic acid can enhance antioxidants, IAA, GA_3 and Cytokines hormones and vitamins, so it improves the vegetative growth in plants. Moreover, 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. 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.

According to our results, the foliar spraying of yeast extract increased the vegetative growth parameters, leaf total chlorophyll, yield, physical and chemical fruit characteristics and leaf mineral content from macro and micronutrients of pomegranate. These results were in harmony with the findings of Amin *et al*. (2000) and Abd El-Galil *et al*. (2003).

They mentioned that yeast extract has a good effect on improving vegetative growth parameters, yield and fruit chemical characteristics of grape cv. King Ruby because it has related to the synthesis of photosynthesis and its influence is similar to the effect of cytokines. In the same trend Omran (2000) stated that yeast extract plays an important role in raising the endogenous content of cytokines, IAA and GA_3. Additionally, yeast extract is very beneficial and essential for the synthesis of amino-linolenic acid, which is necessary for the formation of protoporphyrin, aids in activating photosynthesis process by releasing of CO_2 (El- Shammaa, 2001; Mostafa and El-Hosseiny, 2001; Ahmed *et al*., 2003; Abdelaal *et al*., 2012 and Hassan *et al*., 2012). Besides, it had a primary and secondary effect as plant growth regulators and vitamins that enhance the cell division and metabolism, as well as photosynthetic rate, where it increased the formation of protoplasm and the importing of RNA and DNA to the cell (Hashem *et al*., 2008).

In the current experiment, moringa leaf extract has apositive influence on increasing the vegetative growth parameters, leaf total chlorophyll, yield, physical and chemical fruit characteristics and leaf mineral content from macro of pomegranate. These results were explained by the prior results of many authors (Makkar *et al*., 2007; Phiri, 2010;Sivakumar and Ponnusami, 2011; Emongor, 2012; Nouman *et al*., 2012 and Azra *et al*., 2013). They stated that moringa leaf extract is considered a natural, good and environmentally friendly plant growth promoter because it contains high percentages from calcium, magnesium, iron, phosphorus and potassium, proteins, vitamins: A, B1, B2, B3, C and E, carotene, amino acids phenolic compounds, sugars, several flavonoid pigments, ascorbates, phenolics and cytokinin in the form of zeatin, carotene, antioxidants, proteins, ascorbates and phytohormones. Moreover, our results are in the same line with the findings of many authors, they reported that moringa leaf extract improved leaf total chlorophyll, shoot length, shoot diameter, fruit set percentage, fruit yield, fruit weight, length, width and size, TSS %, TSS/acid ratio, total sugar and vitamin C and leaf mineral composition from N, P and K, while it reduced the percentage of fruit acidity in "Le-Conte" pear (Abd El-Hamied and El-Amary, 2015), "Washington" navel orange (AboEl-Enien *et al*., 2015), and "Manfalouty" pomegranate cultivar (Kamel, 2015), and peach (Bakhsh *et al.,* 2020).

CONCLUSION

The foliar application of of humic and fulvic acids, yeast and leaf moringa extracts, had a positive effect on improving shoot length, diameter, leaf total chlorophyll, fruit set percentage, yield, fruit physical and chemical characteristics and leaf chemical composition from nitrogen, phosphorous and potassium of "wonderful" pomegranate cultivar. The obtained results showed that the combination of 0.4% humic acid + 0.4% fulvic acid + 0.4% yeast extract+ 0.6% moringa leaf extract was the best treatment, which significantly raised shoot length, and diameter, leaf total chlorophyll content, fruit set percentage, weight, size, length, number and width of fruits, and fruit yield. Besides, it increased also the leaf mineral from N, P and K in the two seasons, as compared to control or the other treatments. Moreover, it increased obviously fruit firmness, anthocyanin content, total soluble solids and TSS/acid ratio as well as total and reducing sugars. On the other hand, the same combination decreased statistically the percentages of fruit drop, cracking, sunburn and total acidity in the two seasons as compared to the control and the other applied treatments in the two experimental seasons.

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