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APPROACH FOR MINIMIZING THE AMOUNT OF MINERAL FERTILIZERS FOR MANFALOTY POMEGRANATE TREES USING MYCORRHIZA AND YEAST EXTRACT

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ABSTRACT: A field experiment was carried out on 6-year-old Manfaloty pomegranate trees grown in sandy soil at 3 × 5 m under drip irrigation system in Abo-Hamad Distrect, Sharkia Governorate, Egypt, during the two successive seasons of 2015 and 2016. Thirty-three trees were subjected to 11 mineral fertilization treatments with or without mycorrhiza or yeast extract. Control trees fertigated by 100% mineral NPK without mycorrhiza or yeast extract addition. Other combinations were 75, 50 and 25% mineral NPK with or without 30 g mycorrhiza or yeast extract. The mineral fertilizer and died yeast applied by fertigation in ten doses during the season, while mycorrhiza was applied to the soil in the wet region under the drippers at the first season (late of February) in the two seasons. The obtained results showed that the highest yield (38.85 and 24.76 kg/tree), average fruit weight (462.70 and 462.10 g), fruit firmness (759.90 and 765.50 g/cm^2), number of grains/fruit (630.70 and 484.20 grain) and grains weight (227.70 and 213.50 g) were gained by trees fertilized by 25 % mineral NPK + 30 g mycorrhiza/tree in the both seasons, respectively. The produced fruits on trees of this treatment contained higher TSS/acid ratio and total anthocyanin content. The trees fertilized by 75% mineral NPK + 30 g mycorrhiza / tree exhibited higher fruit retention percentages (92.34 and 88.70%) in the two seasons, respectively without significant differences between them in most cases. Leaves of trees fertigated by 100% mineral/tree (control) contained the highest values of N, P, K, Ca and Mg in the both seasons. The results of this study showed that it is possible to saving 50 - 75% of mineral fertilizers with obtaining higher yields with better fruit quality by adding the mycorrhiza at 30 g/tree.

Key words: NPK fertilization, Manfaloty pomegranate, fertigation, mycorrhiza, yeast extract, fruit retention yield .

INTRODUCTION

Manfaloty is considered one of the most important pomegranate cvs grown successfully in Egypt. The total acreage of pomegranate in Egypt reached 34450 fad., out of them 11752 fad., is fruitful producing about 106260 tons with an average of 9.42 tons/fad. **(Statistics of the Ministry of Agriculture, 2015**).

Pomegranate trees can be grown in tropical to hot temperate climates. However the best pomegranate fruit quality is produced in regions with cool winters and hot dry summer **(Sheets *et al.*, 2008)**. Recently, there has been an increasing demand for pomegranate (*Punica granatum* L.) to meet the need of local as well as the foreign markets of some European and Arabic countries. Nowadays a great attention is focused on minimizing the intensive amounts of mineral fertilizers, because of their harmful effect and high costs. Although pomegranate trees can survive and grow under low soil fertility and water availability conditions, many research studies have been indicating that improving soil fertility and satisfying water requirement are essential factors to obtain a high production. However, increasing pomegranate tree productivity under desert conditions must

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be based on appropriate technical and economic management to the natural resources scarcity.

Fertilization programs are very important for the production of pomegranate fruits since it improves the fruit quality and packable yield and reduces the production costs and environmental pollution. Chemical fertilizers are an indispensable in fruit crop nutrition, but excessive and indiscriminate use of chemical fertilizers has deleterious effects on soil, water and atmosphere pollution, and reflected on animal and human health, it had also adversely affected the soil fertility, water quality, yield and quality of the products **(Srivastava, 2012)**. Therefore, biofertilizers has assumed great importance for sustainable production and to improve the soil physical, chemical and biological properties, also biofertilizers is a good alternative to reduce uses of chemical fertilizers. Biofertilizers proved to eliminate the use of pesticides sometimes, and rebalance the ratio between plant nutrients in soils. Biofertilizers are easy and safe to handle with field applications improved their efficiency in increasing crop yields and decreasing the costs of some agricultural practices. It is worthy to state that biofertilizers do not replace mineral fertilizers, but significantly reduce their rate of application (**Saber, 1993**). The use of biofertilizers in enhancing plant growth and yield has gained momentum in recent years because of higher cost and hazardous effect of chemical fertilizers **(Aseri *et al*., 2008)**. Recently, the yeast extract and Mycorrhizal fungi as a natural bio-stimulant are safety and natural substances using to improve plant growth, yield and quality of many crops. They are safe for human and environment. Bio-fertilizers have been extensively used as an eco-friendly approach to minimize the use of chemical fertilizers, improve soil fertility status and for the enhancement of crop production by their biological activity in the rhizosphere **(Kannaiyan, 2002)**.

Yeast extract (*Saccharomyces cervisiae,* L) is considered as one of the promising bio-fertilizers for many crops. The higher positive action of yeast extract on growth and fruiting of fruit crops might be ascribed to its higher content of natural plant growth regulators (IAA, GA3, cytokinins), vitamins B, protein, amino acids as Arginine, Histidine, Isoleiucine, Leucine, Lysine, Methionine, Cysteine, Phenylalanine, Tyrosine, Serine, Valine, Threonine, Tryptophan, minerals such as N, P and K, nucleic acid, glutathione, lecithine, enzymes, and coenzymes. Also, it is essential for the synthesis of amino lenulinic acid (AA) and protoprophyrin the precursor of chlorophylls and in activating photosynthesis through enhancing the release of carbon dioxide **(Barnett *et al.,* 1990)**. In addition, application of active dry yeast extract is very effective in releasing CO_2 which improves net photosynthesis **(Attala *et al*., 2000; Abd El-Moniem *et al*., 2002)**.

Micro-organisms such as mycorrhiza are present in most organic fertilizers with its beneficial effect on the uptake of most nutrient elements, besides improving the microbiological activity in the rhizosphere **(Kohler *et al*., 2007)**. The arbuscular mycorrhizal (AM) symbiosis is an association between the roots of higher plants and soil fungi that promotes plant development, especially under suboptimal growth conditions **(Koltai *et al.,* 2010)**. Mycorrhiza can increase the absorption of non-mobile elements through external hyphae **(Abdul Jaleel *et al.,* 2007)**. Many studies on plants such as apple **(Branzanti *et al.,* 1992),** *Prunus avium* L. **(Arines and Ballester 1992),** *Vitis vinifera* L. **(Singh *et al.,* 2004),** Banana cv. Grade Naine **(Rodriguez-Romero *et al*., 2005)** and pomegranate **(Singh *et al.,* 2012)** have utilized AMF to increase the growth rate and nutrient uptake of plantlets.

The main target of this study is mainly to reduce the amount of chemical fertilizers and evaluate its effect with mycorrhiza and yeast extract treatments on yield and fruit quality of pomegranate Manfaloty cv. trees under the new reclaimed land conditions.

MATERIALS AND METHODS

This investigation was carried out through two successive seasons of 2015 and 2016 on 6-year-old Manfaloty pomegranate trees (*Punica granatum*). The trees were grown in a private orchard located at Wady El-Mollak region, Abo-Hamad Distrect , Sharkia Governerate. The trees were planted at 3 x 5 m apart, in sandy soil under drip irrigation system.

All trees were supplied with recommended ammonium nitrate (33.5% N) at 87 kg/fad./year, calcium super phosphate (15.5 % P_2O_5) at 23 kg/fad./year, potassium sulfate (50 % K_2O) at 65 kg/fad./year, magnesium sulfate at 40 kg/fad./ year and calcium nitrate at 41 kg/fad./year, in ten doses by fertigation during the season for mineral fertilizer. The experimental trees were healthy and approximately similar in growth vigor and size. The usual agriculture practices for pomegranate trees in the orchard were adapted to all trees, except those of fertilization treatments.

Arbuscular mycorrhizal (AM) was purchased from Microbiology Department, Agricultural Research Center (ARC), Egypt. The sample of AM was 30 g and added to 3 Kg washed sand and it was dried for one day. AM and sand were mixed well together and applied under the tree until they reached to hair roots (30 cm depth approximately), then the mixture was added in the wet region under the drippers. The application of mixture was at the first season (late of February) in the two seasons. As known, 1cm of AM contains 10^5 cells.

Died yeast (*Saccharomyces cerevisae*) was as a byproduct from a yeast Factory in Elobour City (Table 1). It applied in ten doses by fertigation during the season with mineral fertilizer.

Thirty-three pomegranate trees were chosen for this experiment. The selected trees were subjected to the following treatments as follows:

1. 100 % mineral fertilizer (control).
2. 75 % mineral fertilizer + 30 g arbuscular mycorrhiza (AM) / tree.
3. 50 % mineral fertilizer + 30 g AM / tree.
4. 25 % mineral + 30 g AM / tree.
5. 75 % mineral fertilizer + 30 ml yeast extract/ tree.
6. 50 % mineral fertilizer + 30 ml yeast extract/ tree.
7. 25 % mineral fertilizer + 30 ml yeast extract/ tree.
8. 75 % mineral fertilizer + 30 g AM + 30 ml yeast extract/tree.
9. 50 % mineral fertilizer + 30 g AM + 30 ml yeast extract /tree.
10. 25 % mineral fertilizer + 30 g AM + 30 ml yeast extract/tree.
11. 0 % mineral fertilizer + 30 g AM + 30 ml yeast extract / tree.

The experiment was set up in a randomized complete block design with three replicates, one tree per each. The responses of the tested trees to the applied fertilization treatments were evaluated through the following characteristics:

Fruit Set Percentage

Fruit set was record after 75% of petal fall. Date was tabulated as fruit set percentage of perfect flowers according to the following equation:

$$\text{Fruit set (\%)} = \frac{\text{Number of set fruitlets}}{\text{Number of flowers}} \times 100$$

Fruit Weight (g)

It was determined by 10 ripened fruits which were randomly collected from each replicate.

Fruit Retention Percentage

The numbers of remaining fruits at harvest date on the tagged shoots per tree were count in the end of each season. The percent of fruit retention was calculated according to the following equation:

$$\text{Fruit retention (\%)} = \frac{\text{Number of remaining fruits}}{\text{Number of set fruitlets}} \times 100$$

Yield/Tree (kg)

At harvesting, on the late of Sept. and first of Oct. in the first and second seasons, respectively fruit weight (kg) per tree was determined in each tree.

Fruit Quality

Fruit firmness (g/cm^2) was determined by using a push pull Dynamometer. Grains weight (g), number of grains per fruit, fruit juice volume (cm^3) and TSS/acid ratio were calculated. Vitamin C (mg. ascorbic acid/100 ml juice) was determined by titration in presence of 2.6 - dichlorophenol-indophenol dye (**AOAC, 2006**). Total anthocyanin content (%) was estimated according to the methods described by **Geza *et al* (1983)**

Leaf Mineral Content

About 0.2 g of the finely ground dry matter of leaves of each replicate was digested in a mixture of concentrated sulfuric and perchloric acids (2:1 *V/V*) for 15 minutes until the digestive solution became colorless, then transferred quantitavely to 50 ml volumetric flasks **(Kitson and Mellon, 1964)**. The considered mineral nutrients were determined as follows:

Total nitrogen, phosphorus, potassium, calcium, magnesium were determined according to the standard method described by **Evenhuis and Waard (1980)**.

Statistical Analysis

The obtained data was subjected to analysis of variances (ANOVA) according to **Snedecor and Cochran (1980**) using CO-STAT program. Differences between means were compared using Duncan's multiple range test at 0.05 level **(Duncan, 1958)**.

RESULTS AND DISCUSSION

Fruit Set Percentage

Results in Table, 2 reveal that the fruit set (%) of pomegranate trees cv. Manfaloty, generally, ranged from 21.86 to 30.11% in the first season and from 21.06 to 27.43% in the second one. The tested fertilization treatments significantly affected fruit set percentage in the two seasons. The trees fertilized by 0% mineral + 30 g mycorrhiza + 30 ml yeast extract recorded highest fruit set percentage (30.11% and 27.43%) in the first and second seasons, respectively compared with other treatments. The other treatments gave insignificant values between them in the two seasons.

These results go in line with those reported by **Soliman *et al.* (2017)** on peach trees. They indicated that, Mycorrhiza increased fruit set percentage compared with control.

Bakry and Wanas (2003) on apricot, **Bakry (2007)** on orange and **Hashem *et al.* (2008)** on flame seedless **Abd El-Motty *et al.* (2010)** on mango and **Shaaban *et al.* (2015)** on apricot. They indicated that yeast extract increased fruit set percentage.

The positive effects of active dry yeast extract to increase fruit set could be considered as a natural source of cytokinins and improving net photosynthesis **(Hashem *et al.*, 2008)**. The constructive effect of spraying yeast extract could be also attributed to the enhancement of photosynthesis processes and increasing the promoter hormones as cytokinins **(Kamelia *et al.*, 2000; Abd El-Galil *et al.*, 2003)** on “King Ruby” grapevines.

Yield/ Tree

As shown in Table 2 the tested fertilization treatments exhibited significant effect on fruit yield/tree (kg) of pomegranate trees cv. Manfaloty. Generally, it was ranged from 4.75 to 38.85 kg in the first season and from 9.50 to 24.76 kg in the second season. The trees fertilized by 25% mineral + 30 g mycorrhiza/tree recorded uppermost fruit yield/tree (38.85 kg), followed by those fertilized by 75% mineral + 30 g mycorrhiza/ tree (31.16 kg) in the first season with significant differences between them. While in the second season, the uppermost values were from the trees fertilized by 100% mineral/tree (control) (24.01 kg) and those fertilized by 25 and 75% mineral + 30 g mycorrhiza/ tree (24.76 and 21.24 kg) and also those fertilized by 75 and 25% mineral + 30 ml yeast extract/tree (22.71 and 22.36 kg) without significant differences between these treatments. Whereas, the trees fertilized by 0% mineral + 30 g mycorrhiza + 30 ml yeast extract/tree (4.75 and 9.50 kg) gave the least fruit yield/tree (kg) in the two seasons, respectively. In addition, the trees fertilized by 75% mineral + 30 g mycorrhiza/ tree and trees fertilized by 75% mineral + 30 ml yeast extract/tree gave insignificant values of fruit yield/tree (kg) between them in both seasons. The differences between treatments of trees fertilized by 50% mineral + 30 g mycorrhiza + 30 ml yeast extract/tree (15.72 and 15.26 kg) and trees fertilized by 25% mineral + 30 g mycorrhiza + 30 ml yeast extract/tree (15.06 and 13.60 kg) were insignificant in the two seasons.

These results are in line with those reported by **Jansa *et al.* (2003)** on pomegranate, **Merwad *et al.* (2014)** and **Soliman *et al.* (2017)** on peach trees. They revealed that, Mycorrhiza increased yield/tree compared with control.

Hence it is clear that mycorrhiza fungi play a vital role in nutrient cycling and productivity of crops **(Lewis and Koide, 1990; Stanley *et al.*, 1993; Smith and Read, 1997).** Through appropriate management of mycorrhiza in agriculture, it is also possible to maintain soil quality and sustainability thereby protecting the environment over long term and also reducing cost of production.

Table 1. Chemical analysis of died yeast solution

Element	Concentration	Element	Concentration
Total amino acid	20%	Molybdenum (Mo)	5.3 mg/l
Free amino acid	7%	Iron (Fe)	71.0 mg/l
Nitrogen (N)	4.62%	Manganese (MN)	11.3 mg/l
Phosphorus(P_2O_5)	0.2%	Zinc(Zn)	483.9 mg/l
Potassium (K_2o)	9.8%	Copper (Cu)	5.3 mg/l
Calcium (Ca)	0.87%	Cytokines (CYT)	762.6 mg/l
Magnesium (Mg)	0.16%	Gibberellin (Gib)	495.2 mg/l
Sulfur (S)	10.04%	Boron (B)	805 mg/l
Organic matter	59.75%	Organic carbon	34.66%
pH		7.23	

Table 2. Effect of mineral fertilizers with mycorrhiza and yeast extract treatments on fruit set, yield, fruit weight and fruit retention of Manfaloty pomegranate trees (2015 and 2016 seasons)

Fertilization treatment			First season (2015)				Second season (2016)			
Mineral (%)	AM (g / tree)	Yeast extract (ml/tree)	Fruit yield/ tree (kg)	Fruit set (%)	Av. Fruit weight (g)	Fruit retention (%)	Fruit yield/ tree (kg)	Fruit set (%)	Av. Fruit weight (g)	Fruit retention (%)
100	**0**	**0**	23.09 cde	22.48 b	300.50 de	88.18 ab	24.01 a	22.04 b	304.90 d-g	90.60 a
75	**30**	**0**	31.16 b	21.86 b	351.60bcd	92.34 a	21.24 abc	22.98 b	344.30 cd	88.70 a
50	**30**	**0**	20.91 def	22.63 b	285.53 e	88.02 ab	17.20 bcd	23.55 b	325.50 cde	84.83 a
25	**30**	**0**	38.85 a	22.52 b	462.70 a	89.11 ab	24.76 a	23.46 b	462.10 a	84.73 a
75	**0**	**30**	29.01 bc	22.10 b	366.00 bc	90.53 a	22.71 ab	22.35 b	407.10 b	86.95 a
50	**0**	**30**	18.32 ef	22.78 b	305.50 cde	88.18 ab	16.41 cd	21.54 b	321.60 c-f	83.82 a
25	**0**	**30**	26.61 bcd	24.93 b	402.00 b	87.24 ab	22.36 ab	21.06 b	357.70 c	86.02 a
75	**30**	**30**	24.01 cde	21.87 b	364.90 bc	90.21 a	16.13 cd	22.13 b	289.30 efg	86.65 a
50	**30**	**30**	15.72 f	23.65 b	305.30 cde	80.18 b	15.26 d	22.60 b	278.80 fg	88.39 a
25	**30**	**30**	15.06 f	24.50 b	351.00 bcd	79.99 b	13.60 de	23.12 b	302.20 d-g	86.45 a
0	**30**	**30**	4.75 g	30.11 a	229.06 f	66.12 c	9.50 e	27.43 a	262.80 g	72.99 b

Means having the same letter (s) in each column are insignificantly different. AM = mycorrhiza

Bio-fertilizers are considered as a safe fertilization method to increase productivity and quality of many fruit species. Yeast extract as a bio-fertilizer is characterized by its own different nutrients, vitamins and cytokinin as a natural plant hormone and photosynthesis stimulator **(Nagadawithana, 1991; Mostafa, 2015).**

Fruit Weight (g)

The results presented in Table 2 show that fruit weight of Manfaloty pomegranate was significantly affected by the studied fertilization treatments during the two seasons. The uppermost values of fruit weight were from trees fertilized by 25 % mineral + 30 g mycorrhiza/ tree (462.70 and 462.10 g) in the two seasons, respectively. While, the lowermost values of fruit weight were from trees fertilized by 0% mineral+ 30 g mycorrhiza + 30 ml yeast extract/ tree (229.06 and 262.80 g) in both seasons, respectively. The other treatments gained intermediate fruit weight without significant differences between them in most cases in both seasons.

These results are consistent with those obtained by **Alok and Singh (2004)** on banana, **Abd-Ella (2006)** on pomegranate, **Gastol and Domagal-Swiatkiewiez (2015)** on apple, **El-Shamma *et al.* (2017)** on avocado and **Mohamed and Massoud (2017)** on orange, they indicated that the use of mycorrhiza increased yield/tree and fruit weight.

Nomier (2000) on grapevines**, Bakry and Wanas (2003)** on apricot, **Bakry (2007)** on orange, **Abd El-Monem *et al.* (2008)** on grapevine, **Abd El-Motty *et al.* (2010)** on mango, **Hegab *et al.* (2010)** on grapevine, **Khafagy *et al.* (2010)** on orange, **El-Sabagh *et al.* (2011)** on grapevine, **Osman *et al.* (2011)** on date palm, **El Shazly and Mustafa (2013)** on orange, **El-Sehrawy (2015)** on apple and **Shaaban *et al.* (2015)** on apricot. They indicated that application of yeast extract increased the yield and fruit weight.

Fruit Retention Percentage

The results in Table 2 show that the pomegranate trees were significantly affected by the tested fertilization treatments on fruit retention percentage in both seasons. The values ranged from 66.12 to 92.34% in the first season and from 72.99 to 90.60% in the second one. The highest fruit retention percentages came from the trees fertilized by 75% mineral + 30 g mycorrhiza /tree (92.34), followed by those fertilized by 75% mineral + 30 ml yeast extract/tree (90.53%) and trees fertilized by 75% mineral + 30 g mycorrhiza + 30 ml yeast extract/ tree (90.21%) without differences among them in the first season. All tested fertilization treatments except treatment of 0% mineral + 30 g mycorrhiza + 30 ml yeast extract/tree which recorded the highest fruit retention without significant differences among them during second season. While, the least values came from the trees fertilized by 0% mineral + 30 g mycorrhiza + 30 ml yeast extract/ tree (66.12 and 72.99%) in both seasons.

Similar results was found by **Mohamed and Massoud (2017)** who found that AM with Azotobacter induced significant increment in growth criteria and yield attributes (fruit retained after June drop (%), No. fruits/tree or Kg/ tree) as compared to uninoculated control and biofertilizer only.

Bakry (2007) on orange, **Abd El-Motty *et al.* (2010)** on mango, and **Shaaban *et al.* (2015)** on apricot they indicated that yeast extract was effective in improving fruit retention.

Fruit Firmness

Results in Table 3, reveal that, fruit firmness (g/cm^2) was significantly affected by the experimental fertilization treatments in the two seasons. Anyhow, the solidest fruit firmness was recorded for fruits produced from trees fertilized by 25% mineral + 30 g mycorrhiza/tree (759.90 and 765.50 g/cm^2) in the first and second season, respectively, without significant differences between those fertilized by 25% mineral + 30 ml yeast extract/tree (706.60 and 654.40 g/cm^2) and trees fertilized by 75% mineral + 30 g mycorrhiza + 30 ml yeast extract/tree (607.53 and 664.40 g/cm^2) in both seasons. The lowest fruit firmness was recorded for fruits produced from trees fertilized by 0% mineral+ 30 g mycorrhiza + 30 ml yeast extract/tree (295.50 and 423.30 g/cm^2) in the two seasons. The other treatments gained intermediate fruit firmness (g/cm^2) without significant differences among them in most cases in both seasons.

Similar results was found by **Soliman *et al.* (2017)**, they found that using mycorrhiza produced solidest peach fruit compared with control.

Table 3. Effect of mineral fertilizers with mycorrhiza and yeast extract treatments on fruit firmness, grains weight and number/fruit and Juice volume/fruit of Manfaloty pomegranate trees (2015 and 2016 seasons)

Fertilization treatment			First season (2015)				Second season (2016)			
Mineral (%)	AM (g/ tree)	Yeast extract (ml/ tree)	Fruit firmness (g/cm^2)	Number of grains/ fruit	Grains weight (g)	Juice volume/ fruit (cm^3)	Fruit firmness (g/cm^2)	Number of grains/ fruit	Grains weight (g)	Juice volume/ fruit (cm^3)
100	**0**	**0**	520.70 c	428.50 de	146.80 d	201.60 abc	463.30 cd	386.87 bc	142.60 ef	215.00 abc
75	**30**	**0**	564.40 bc	506.10 bc	153.20 d	240.00 a	564.40 bc	447.30 ab	154.80 de	256.66 a
50	**30**	**0**	513.30 c	498.20 bc	152.90 cde	213.30 a	576.60 bc	492.30 a	155.50 de	206.66 abc
25	**30**	**0**	759.90 a	630.70 a	227.70 a	223.30 a	765.50 a	484.20 a	213.50 a	243.33 ab
75	**0**	**30**	595.30 abc	494.40 bc	148.30 d	171.60 bcd	571.00 bc	448.00 ab	206.60 ab	191.60 bcd
50	**0**	**30**	545.50 bc	449.60 cd	160.30 d	163.30 cd	542.20 bcd	341.80 cd	176.60 cd	193.33 bcd
25	**0**	**30**	706.60 ab	523.60 b	202.40 b	205.00 ab	654.40 ab	353.00 cd	197.10 ab	215.00 abc
75	**30**	**30**	607.53 abc	401.90 def	188.50 b	113.30 e	664.40 ab	312.33 d	191.30 bc	196.66 bcd
50	**30**	**30**	579.90 bc	373.00 ef	152.60 d	136.60 de	592.20 bc	368.20 cd	162.30 de	155.00 d
25	**30**	**30**	566.40 bc	466.40bcd	174.40 c	145.00 de	495.50 cd	336.20 cd	163.30 de	205.00 abcd
0	**30**	**30**	295.50 d	346.50 f	119.60 e	148.30 de	423.30 d	305.60 d	129.30 f	158.33 cd

Means having the same letter (s) in each column are insignificantly different. AM = mycorrhiza

Bakry and Wanas (2003), mentioned that spraying yeast extract had positively effect on fruit firmness of apricot.

Number of Grains/Fruit

As shown in Table 3 the number of grains per fruit was significantly affected by fertilization treatments in the two experimental seasons. The maximum number of grains per fruit (630.70 and 492.30 grain) was gained by the trees fertilized by 25 and 50% mineral + 30 g mycorrhiza /tree in the first and second seasons, respectively without significant differences between them, as well, those fertilized by 25% mineral + 30 g mycorrhiza /tree (484.20 grain) and those fertilized by 75% mineral + 30 ml yeast extract or mycorrhiza/tree (448.00 and 447.30 grain) in the second season only. Whereas, the least number of grains per fruit was recorded for trees fertilized by 0% mineral + 30 g mycorrhiza + 30 ml yeast extract/tree (346.50 and 305.60 grain) in the two seasons. The trees fertilized by 75% mineral + 30 g mycorrhiza + 30 ml yeast extract/ tree and the trees fertilized by 50 or 25% mineral + 30 g mycorrhiza + 30 ml yeast extract/tree gave in between values without significant differences among them in both seasons. The other treatments gained intermediate values without significant differences among them in most cases in both seasons.

Similar results were found by **Abd El-Monem *et al.* (2008), Hashem *et al.* (2008) and Fawzi *et al.* (2014)** on grapevine. They found that berry numbers were significantly increased by yeast extract strains.

Grains Weight

Results in Table 3 show that grains weight (g) was significantly affected by the studied fertilization treatments in the two seasons of study. The highest grains weight of fruit was gained by the trees fertilized by 25% mineral + 30 g mycorrhiza /tree (227.70 and 213.50 g) in the first and second seasons, respectively. The trees fertilized by 75 or 25% mineral + 30 ml yeast extract/tree (206.60 and 197.10 g), respectively, without significant differences between them in the second season, respectively. While, the lowest weight of grains per fruit was recorded for trees fertilized by 0% mineral + 30g mycorrhiza + 30 ml yeast extract/ tree (119.60 and 129.30 g) in the two seasons. The other treatments gained intermediate values without significant differences among them in most cases in both seasons.

Abd El-Monem *et al.* (2008), Hashem *et al.* (2008) and **Fawzi *et al.* (2014)** on grapevine found that berry weight was significantly increased by yeast extract.

Fruit Juice Volume

It is quite evident from Table 3 that fruit juice volume (cm^3) was significantly affected by the experimented fertilization treatments in the two seasons. Trees fertilized by 75% mineral + 30 g mycorrhiza/tree gained the maximum fruit juice volume (240.00 and 256.66 cm^3) in the 1st and 2nd seasons, respectively without significant differences between them and those treated by 50% (213.30 and 206.66 cm^3), 25% (223.30 and 243.33 cm^3) mineral + 30 g mycorrhiza / tree, and those fertilized by 100% mineral/tree (control) (201.00 and 215.00 cm^3) and those fertilized by 25% mineral + 30 ml yeast extract/tree (205.00 and 215.00 cm^3) in both seasons. The other treatments gained intermediate fruit juice volume (cm^3) without significant differences among them in most cases in both seasons.

Similar results were found by **Mohamed and Massoud (2017)** on orange, who found that AM with Azotobacter promoted the fruit physical *i.e.,* juice volume as compared to uninoculated control and biofertilizer only.

Bakry (2007) and **El Shazly and Mustafa (2013)** on orange showed that all biostimulants (yeast extract) increased fruit juice (%).

TSS/Acid Ratio

Table 4 clarified that TSS/acid ratio in the fruit juice was significantly affected by the studied fertilization treatments in both seasons. The uppermost values of TSS/acid ratio were obtained from fruit juice of trees fertilized by 25% mineral + 30 g mycorrhiza /tree (34.27 and 32.49) in the first and second season, respectively. The lowermost values of TSS/acid ratio were obtained from fruit juice of trees fertilized by 50% mineral + 30 ml yeast extract/tree (12.39) and those fertilized by 25% mineral + 30 g mycorrhiza + 30 ml yeast extract/tree (12.52) in the first season without differences between them and with trees fertilized by 50% mineral + 30 g mycorrhiza / tree, while, in the second one were from fruit juice of trees fertilized by 50% mineral + 30 g mycorrhiza /tree (12.64) and trees fertilized by 50% mineral + 30 ml yeast extract/ tree (10.45). The other treatments gained intermediate values of fruit juice TSS/acid ratio without significant differences among them in both seasons.

These results are in line with those reported by **Mohamed and Massoud (2017)** on orange, they indicated that, using mycorrhiza with Azotobacter promoted the fruit chemical properties *i.e.,* TSS/acid ratios as compared to uninoculated control and biofertilizer only.

Nomier (2000), **Hegab *et al.* (2010), El-Sabagh *et al*. (2011)** and **Sabry *et al*. (2013)** on grapevine, **Abdel-Mohsen and Kamel (2015)** on apricot and **El-Sehrawy (2015)** on apple, they mentioned that active dry yeast extract increased TSS/acid ratio.

Vitamin C content

As shown in Table 4 ascorbic acid (vitamin C) content in pomegranate fruit juice was significant affected by the tested fertilization treatments in the two seasons. However, fruits produced on trees fertilized by 75% mineral + 30 g mycorrhiza + 30 ml yeast extract/tree (0.010 mg/100 ml) contained the highest vitamin C content in the first season without significant differences with those fertilized by 100% mineral, 25 or 50% mineral + 30 g mycorrhiza / tree, 75% mineral + 30 ml yeast extract/ tree and 25% mineral + 30 ml yeast extract and 30 g mycorrhiza. In the second season the highest values came for trees fertilized by 50 or 25% mineral + 30 g mycorrhiza /tree without significant differences with all treatments except those fertilized by 0% mineral + 30 g mycorrhiza + 30 ml yeast extract/tree which recorded the lowermost vitamin C content.

Similar results were stated by **Abd-Ella (2006)** who found that using microbial biofertilization (AM) on pomegranate trees did not affect vitamin C contents. The first treatment (trees

Table 4. Effect of mineral fertilizers with mycorrhiza and yeast extract treatments on some fruit chemical constituents of Manfaloty pomegranate trees (2015 and 2016 seasons)

Fertilization treatment			First season (2015)			Second season (2016)		
Mineral (%)	**AM (g/ tree)**	**Yeast extract (ml/tree)**	**Vitamin C (mg/100 ml)**	**TSS/ acid ratio**	**Total anthocyanin content (%)**	**Vitamin C (mg/100 ml)**	**TSS/ acid ratio**	**Total anthocyanin content (%)**
100	**0**	**0**	0.009 ab	14.90 bcd	22.60 i	0.009 ab	15.51 bc	23.75 j
75	**30**	**0**	0.004 c	30.56 abc	31.36 b	0.007 ab	30.39 ab	32.44 b
50	**30**	**0**	0.007 abc	14.34 cd	29.57 d	0.010 a	12.64 c	30.79 d
25	**30**	**0**	0.007 abc	34.27 a	32.42 a	0.011 a	32.49 a	33.17 a
75	**0**	**30**	0.006 abc	16.59bcd	29.56 d	0.007 ab	24.79 abc	30.27 e
50	**0**	**30**	0.005 bc	12.39 d	27.50 f	0.009 ab	10.45c	28.94 g
25	**0**	**30**	0.005 bc	20.33 a-d	30.74 c	0.007 ab	17.78 abc	31.95 c
75	**30**	**30**	0.010 a	31.92 ab	26.56 g	0.009 ab	24.32abc	27.57 h
50	**30**	**30**	0.005 bc	30.59abc	25.28 h	0.007 ab	18.18 abc	26.10 i
25	**30**	**30**	0.007 abc	12.52 d	28.62 e	0.006 ab	16.87 abc	29.74 f
0	**30**	**30**	0.004 c	30.23 abc	26.64 g	0.005 b	25.50 abc	27.50 h

Means having the same letter (s) in each column are insignificantly different. AM = mycorrhiza

were microbial inoculation and received 100% of the recommended doses of chemical fertilizers) had a slight increase in vitamin C content in both seasons.

Khafagy *et al*. (2010) concluded that spraying of Navel orange trees with 4.0% yeast extract combined with 1.0% zinc sulphate recorded the highest values of ascorbic acid.

El-Shazly and Mustafa (2013) on orange, they cleared that vitamin C contents markedly increased with biostimulants (potassium humate, yeast extract and amino acid) treatments compared to control.

Total Anthocyanin Content

Results in Table 4 clear that the studied fertilization treatments significantly affected juice total anthocyanin content (%) in the two seasons. The highest juice total anthocyanin content was gained from fruits produced on trees fertilized by 25% mineral + 30g mycorrhiza/tree (32.42 and 33.17%) in both seasons. While, lowermost juice total anthocyanin content (%) was recorded from fruits produced on trees fertilized by 100% mineral (control) (22.60 and 23.75%) in the two seasons. The other tested fertilization treatments, recorded inbetween values in both seasons.

These results are in agreement with those stated by **Abd-Ella (2006)** who reported that**,** microbial inoculation of pomegranate trees with (AM) and received 75% of the recommended doses of chemical fertilizers recorded the highest juice anthocyanin content.

Hegab *et al*. (2010), Sabry *et al*. (2013) and Masoud and Abou-Zaid (2017) on grapevine, mentioned that using yeast extract enhancing anthocyanins content in berry skin and increased berry color.

Bakry and Wanas (2003) found that apricot fruit quality measurements positively responded to the application of yeast extract and kinetin treatments. In addition, all applied yeast extract and kinetin treatments increased leaf photosynthetic pigments content during the stages of fruit development.

Leaf Mineral Content

Results presented in Table 5 reveal that the tested fertilization treatments significantly affected leaf N, P and K percentages in both seasons. The highest values of N% (2.47 and 2.68%), P% (0.287 and 0.296%) and K% (3.35 and 3.24%) resulted from the trees fertilized by 100% mineral/tree (control) in the first and second seasons, respectively. On the other hand, the lowermost values of N% (1.55 and 1.51%), P% (0.237 and 0.229%) and K% (2.54 and 2.20%) came from the trees fertilized by 0% mineral + 30 g mycorrhiza + 30 ml yeast extract/ tree in the first and second seasons respectively. The other treatments gave intermediate values without significant differences among them in some cases.

Results in Table 6 clear that the tested fertilization treatments significantly affected Ca and Mg percentages in the leaves of pomegranate trees cv. Manfaloty throughout the two seasons. The highest values of Ca % (2.71 and 2.74 %) and Mg % (0.975 and 0.979 %) resulted from the trees fertilized by 100 % mineral/tree (control) in the first and second seasons, respectively. Whereas, the trees fertilized by 0% mineral + 30 g mycorrhiza + 30 ml yeast extract/tree recorded the least values of Ca% (1.80 and 1.70%) and Mg% (0.777 and 0.662%) in both seasons. The other treatments gave intermediate values without significant differences among them in some cases.

These results are in consistent with those obtained by **Alok and Singh (2004)** and **Rodríguez-Romero *et al.* (2005)** on banana, **Abd Ella (2006)** on Arabi pomegranate, **Qiang-Sheng and Ying-Ning (2009)** on trifoliate orange, **Dutt *et al.* (2013)** on apricot, **Merwad *et al.* (2014)** on Valencia orange, **Ortas and Ustuner (2014)** on sour orange**, Hosseini and Gharaghani (2015)** on apple, **Trouvelot *et al.* (2015)** on grapevine, **Chen *et al.* (2017)** on trifoliate orange, **Mohamed and Massoud (2017)** on orange, **Salama *et al.* (2017)** on Washington navel orange, **Soliman *et al.* (2017)** on peach, they indicated that, mineral fertilization improved leaf-macro and micronutrients contents.

Table 5. Effect of mineral fertilizers with mycorrhiza and yeast extract treatments on leaf mineral content (N, P, K, Ca and Mg) of Manfaloty pomegranate trees (2015 and 2016 seasons)

Fertilization treatment			First season (2015)			Second season (2016)		
Mineral (%)	AM (g/tree)	Yeast extract (ml/tree)	N (%)	P (%)	K (%)	N (%)	P (%)	K (%)
100	**0**	**0**	2.47 a	0.287 a	3.35 a	2.68 a	0.296 a	3.24 a
75	**30**	**0**	2.04 b	0.274 b	3.09 b	2.23 b	0.279 b	3.18 a
50	**30**	**0**	1.89 bc	0.267 c	2.87 c	2.04 c	0.271 c	2.74 b
25	**30**	**0**	1.81 cde	0.261 d	2.85 c	1.92 d	0.263 d	2.73 b
75	**0**	**30**	1.73 cdef	0.273 bc	2.78 cd	1.80 e	0.257 de	2.60 cd
50	**0**	**30**	1.84 cd	0.255 de	2.72 d	1.68 f	0.256 de	2.69 bc
25	**0**	**30**	1.79 cde	0.252 e	2.59 ef	1.66 fg	0.250e	2.62 cd
75	**30**	**30**	1.76 cde	0.240 f	2.90 c	1.77 ef	0.236 fg	2.55 d
50	**30**	**30**	1.65 def	0.238 f	2.69 de	1.49 h	0.240 f	2.39 e
25	**30**	**30**	1.61 ef	0.242 f	2.55 f	1.56 gh	0.235 fg	2.42 e
0	**30**	**30**	1.55 f	0.237 f	2.54 f	1.51 h	0.229 g	2.20 f

Means having the same letter (s) in each column are insignificantly different. AM = mycorrhiza.

Table 6. Effect of mineral fertilizers with mycorrhiza and yeast extract treatments on leaf mineral content of Manfaloty pomegranate trees (2015 and 2016 seasons)

Fertilization treatments			First season (2015)		Second season (2016)	
Mineral (%)	AM (g/tree)	Yeast extract (ml/tree)	Ca (%)	Mg (%)	Ca (%)	Mg (%)
100	**0**	**0**	2.71 a	0.975 a	2.74 a	0.979 a
75	**30**	**0**	2.58 b	0.937 b	2.69 a	0.948 b
50	**30**	**0**	2.40 d	0.917 c	2.45 b	0.931 c
25	**30**	**0**	2.30 e	0.903 d	2.41 b	0.933 c
75	**0**	**30**	2.50 c	0.887 e	2.40 b	0.882 e
50	**0**	**30**	2.16 f	0.888 e	2.15 c	0.871 e
25	**0**	**30**	2.06 g	0.869 f	1.91 e	0.880 e
75	**30**	**30**	1.89 h	0.883 e	1.90 e	0.839 f
50	**30**	**30**	2.01 g	0.829 g	2.08 d	0.905 d
25	**30**	**30**	1.85 hi	0.809 h	1.76 f	0.803 g
0	**30**	**30**	1.80 i	0.777 i	1.70 g	0.662 h

Means having the same letter (s) in each column are insignificantly different. AM = mycorrhiza.

Soliman *et al.* (2017) on peach, they indicated that using mycorrhiza decreased leaf-Na, as compared to that of the control. Also, Mycorrhiza was superior to leaf-P and Mg contents.

The mycorrhiza fungi can be benefit to plants by enhancing the availability and uptake of soil water and nutrients **(Smith and Read, 1997; Abdul Malik, 2000)**.

Masoud and Abou-Zaid (2017) on grapevines, **El-Sayed (2013)** on olive, **El-Shazly and Mustafa (2013)** on orange, **Mohsen *et al.* (2014), Abd El-Rahman and Mansour (2015)** on banana**, El-Sehrawy (2015)** on apple, **Kamel (2015)** on pomegranate, **Haggag *et al.* (2015)** on olive, **Shaaban *et al.* (2015)** on apricot, **Abdel-Rahman and Tolba (2016)** on grapevine, **Masoud** and **Abou-Zaid (2017)** on grapevine. They cleared that application of yeast extract enhanced and increased leaf mineral contents.

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اتجـــاه لتقليـــل كميـــة الأسمدة المعدنية لأشجار الرمان المنفلوطي باستخدام الميكورهيزا والخميــرة

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أجريت تجربة حقلية على أشجار رمان منفلوطي عمر ٦ سنوات مزروعة في تربة رملية على مسافة ٣ × ٥ م تحت نظام الري بالتنقيط بمنطقة أبو حماد- محافظة الشرقية خلال موسمي ٢٠١٥ و٢٠١٦، خضعت ٣٣ شجرة لإحدى عشرة معاملة تسميد معدني مع أو بدون الميكورهيزا أو الخميرة، سمدت أشجار الكنترول بنسبة ١٠٠% سماد معدني دون إضافة الميكورهيزا أو الخميرة، وكانت التوليفات الأخرى هي ٧٥، ٥٠ و ٢٥% سماد معدني مع أو بدون ٣٠ جم من الميكوريزا أو الخميرة، حيث تم إضافة السماد المعدنى والخميرة مع ماء الرى على ١٠ جرعات خلال الموسم بينما أضيفت الميكورهيزا للتربة مرة واحدة فى بداية الموسم (آخر فبراير). أظهرت النتائج المتحصل عليها أن الأشجار التي سمدت بنسبة ٢٥% معدني + ٣٠ جم ميكورهيزا/شجرة أعطت أعلى محصول (٣٨,٨٥ و٢٤,٧٦ كجم/شجرة)، متوسط وزن الثمرة (٤٦٢,٧٠ و٤٦٢,١٠ جم)، صلابة الثمار (٧٥٩,٩٠ و٧٦٥,٥٠ جم/سم٢)، عدد الحبات/ثمرة (٦٣٠,٧٠ و٤٨٤,٢٠ حبة) ووزن الحبات (٢٢٧,٧٠ و٢١٣,٥٠ جم) في كلا الموسمين، على التوالي، احتوت الثمار الناتجة على أشجار هذه المعاملة على أعلي نسبة لكل من المواد الصلبة الذائبة الكلية/الحموضة والأنثوسيانين الكلي، أظهرت الأشجار التي سمدت بنسبة ٧٥% معدني + ٣٠ جم ميكورهيزا/ شجرة أعلى نسبة بقاء للثمار (٩٢,٣٤ و٨٨,٧٠%) في الموسمين، على التوالي وبدون فروق معنوية بينها وبين المعاملات الأخرى في معظم الحالات، كما احتوت أوراق الأشجار المسمدة بنسبة ١٠٠% معدني/شجرة (الكنترول) على أعلى القيم لكل من النيتروجين، الفوسفور، البوتاسيوم، الكالسيوم والماغنسيوم في كلا الموسمين، وأظهرت نتائج هذه الدراسة أنه من الممكن توفير ٥٠ - ٧٥% من الأسمدة المعدنية مع الحصول على أعلى محصول وأفضل جودة ثمار بإضافة الميكورهيزا بمعدل ٣٠ جم لكل شجرة.

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