



### RESEARCH ARTICLE

## EFFECT OF NITROGEN AND HUMIC ACID ON VEGETATIVE GROWTH, YIELD AND FRUIT QUALITY OF WONDERFUL POMEGRANATE TREES

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### Abstract

An experiment trial was carried out in a private orchard located on Cairo-Alexandria desert road about 50 km from Cairo (latitude 30.35 N, longitude 33.20 E at an elevation of 200 m above sea level), Egypt, during the two successive seasons of 2017 and 2018 to study the effect of different level of nitrogen fertilization (250, 350, and 450 g N/tree), humic acid application (0, 20 and 30 g HA/tree) and their interaction on vegetative growth, productivity, fruit quality and sunburned fruits as well as fruit cracking of Wonderful pomegranate trees. From the obtained results reveal that soil application of 450 g N/tree and humic acid application at 40 g/tree alone or in combination had a positive effect in improved yield, fruit quality and decreasing fruit cracking, sunburned damage of the Wonderful pomegranate cultivar as well as increased tree vegetative growth to shield the fruit from cracking and sunburn damage. Generally, 450g N/tree combined with 40g HA/tree as a soil application proved to be most efficient effect application in this respect.

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### Introduction:-

Pomegranate (*Punica granatum* L.) is valued highly for its delicious edible fruits are rich in sugars, vitamins, polysaccharides, polyphenols, and minerals (Ferrara et al., 2014). Pomegranate tree is also cultivated for its pharmaceutical and ornamental usage. It has high adaptability to versatile conditions especially stress conditions (Haggag and El Shamy, 1987). Pomegranate trees are favor for semi-arid climates (El-Falleh et al., 2009). These make it as a favorable fruit for marginal land and it is recommended for a resource limited farmers. Wonderful pomegranate cultivar is widespread and grown in the newly reclaimed area (generally sandy soil that is poor in nutrient and holding water) under Egypt conditions. Pomegranates fruits ripen in late summer to early autumn and fruits exposed throughout the summer to strong solar radiation and high temperatures where summer temperatures normally rise above 40 °C are much more vulnerable to sunburn damage and fruits cracking (Glenn et al., 2002 and Sheikh and Manjula, 2012). Fruit cracking and sunburned fruits are considered the most important factors for the reduction of pomegranate productivity (Malhotra et al., 1983). Melgarejo et al. (2004) reported that pomegranate fruit cracking is one of the serious problems because it causes loss of about 50% of the fruit market value. Moreover, Sunburn damage can be led to losses 30% of the harvested fruit. Pomegranates are terminal-bearing plants, with skinny branches bend with an increase in weight of fruit as the season proceeds so that pomegranate fruits are sensitive to sun. Some pomegranate varieties can take several ways to reduce the incidence of sunburn by have more leaf surface area, thereby providing better shading over the fruits. However, fruit that is naturally shaded within the interior canopy did not need coverage (Melgarejo et al., 2004 and Racsko and Schrader, 2012).

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Nitrogen fertilization can improve vegetative growth and thus provides shade fruits and protection from clear sunlight. Alternatively, shades or screens could be created to cover trees and fruits from direct exposure to sunlight (Melgarejo et al., 2004). However, artificial shading like screen nets are not economical in many countries for sunburn controls. Moreover, fruit that is naturally shaded within the interior canopy did not need coverage (Racsko and Schrader, 2012). Mohamed et al. (2014) showed increasing nitrogen levels from 200 to 400 g/tree improved number of new shoot/tree, length, and width of shoots, leaf area and total surface area, leaf chlorophyll content, yield and fruit quality of wonderful pomegranate trees. In addition, Bakeer (2016) found that 1500 g/tree ammonium nitrate soil application alone or in combination with 2% calcium chloride foliar spray increased tree vegetative growth to shield the fruit and reduced sunburn damage and cracking.

Humic acid (HA) are the most significant constituents of organic matter in soils. It increases the water holding capacity of soils. It also improves the soil structure and physical properties of soil. Also, it is promoting the chelation of many elements and making these available to plants (Biondi et al., 1994). In addition, humic acid reduced water evaporation and increase its use by plants. It increases the permeability of the plant membranes and intensifies enzyme systems of plants. Moreover, it stimulation plant growth and consequently yield through accelerated cell division and it enhanced uptake of nutrients and water (Chen et al., 2004 and Hussein and Hassan, 2011) and humic acid have similar effect like IAA on plants in this concern (O'Donnell, 1973). Hoany and Tichy (1976) reported that humic acid have similar effect like cytokining and gibberellin on olive and pear trees (Fawzi et al., 2007). Furthermore, applying humic acid (HA) can be used on minimizing the intensive amounts of mineral nitrogen fertilization (Mohamed and Ashraf, 2016). However, minimize the intensive amounts of nitrogen fertilization are used in pomegranate orchards is very importance to reduce their high cost and harmful effect in this concern. Application of humic acid stimulates growth, nutrient uptake and yield in olive trees (Fernández-Escobar et al., 1996). Celik et al. (1995) and Ferrara and Brunetti (2010) pointed that applied humic acid at full bloom of Italy grape cultivar increased berry weight, titratable acidity and maturity index values.

The main target of this study is to investigate the effect of different level of nitrogen fertilization, humic acid application alone or combination on vegetative growth, yield, fruit quality and sunburned fruits as well as fruit cracking of Wonderful pomegranate trees.

### Material and Methods:-

This study was carried out during two successive seasons 2017 and 2018 at orchard located on Cairo-Alexandria desert road about 50 km from Cairo (latitude 30.35 N, longitude 33.20 E at an elevation of 200 m above sea level), Egypt. Wonderful pomegranate trees (*Punica granatum* L.) aged 7 years old grown in sandy soil, and spaced 3 x 5 m apart (280 trees / fed) under drip irrigation system from well. Physical and chemical analysis of the experimental soil shown in Table 1, meanwhile the chemical analysis of used water from irrigation is recorded in (Table 2). Fifty four trees healthy, nearly uniform in shape and size and productivity and received the same horticulture practices, were subjected selected as test trees. The present study was a factorial experiment with two factors i.e. the first factor consisted of three rates of nitrogen fertilizer (250, 350, and 450 g/tree) and the second one involved three does of humic acid (0, 20 and 30 g/tree). The experiment was designed as randomized complete block design with three replicates for each treatment and each replicate was represented by two trees. Nitrogen fertilizer and humic acid were added as soil application in 15 cm depth and 1 m from the trunk.

**Table 1:-** Analysis of experimental soil in 2017 and 2018 seasons.

#### Physical analysis:

| Soil Depth (cm) | Particle size distribution |            |      |      | Texture class | Bulk Density (g/cm) | Organic matter (%) | Moisture content (%) |               |
|-----------------|----------------------------|------------|------|------|---------------|---------------------|--------------------|----------------------|---------------|
|                 | Coarse sand                | Fine sandy | Silt | Clay |               |                     |                    | Field Capacity       | Wilting Point |
| 0-30            | 0.00                       | 97.50      | 1.50 | 1.00 | sand          | 1.52                | 0.20               | 9.21                 | 4.44          |
| 30-60           | 0.00                       | 98.00      | 1.40 | 0.60 | sand          | 1.56                | 0.19               | 8.88                 | 4.49          |

#### chemical analysis:

| Soil Depth cm | CaCO <sub>3</sub> | pH Soil past | E.Ce (dSm <sup>-1</sup> ) | Soluble cations (meq/l) |                |                 |                  | soluble anions (meq/l) |                              |                               |                              |
|---------------|-------------------|--------------|---------------------------|-------------------------|----------------|-----------------|------------------|------------------------|------------------------------|-------------------------------|------------------------------|
|               |                   |              |                           | Ca <sup>++</sup>        | K <sup>+</sup> | Na <sup>+</sup> | Mg <sup>++</sup> | Cl <sup>-</sup>        | SO <sub>4</sub> <sup>=</sup> | HCO <sub>3</sub> <sup>-</sup> | CO <sub>3</sub> <sup>=</sup> |
| 0-30          | 4.1               | 7.1          | 1.8                       | 3.1                     | 1.5            | 11              | 1.8              | 9.5                    | 5                            | 1.1                           | -                            |
| 30-60         | 4.2               | 7.1          | 1.4                       | 2.8                     | 1.4            | 10.2            | 1.3              | 8.5                    | 4.5                          | 1.2                           | -                            |

**Table 2:-** Chemical analysis of water used for irrigation in 2017 and 2018 seasons.

| pH   | E.C.              | O.M<br>(%) | Soluble cations (meq/l) |                  |                 |                | soluble anions (meq/l)       |                               |                 |                              |
|------|-------------------|------------|-------------------------|------------------|-----------------|----------------|------------------------------|-------------------------------|-----------------|------------------------------|
|      | dSm <sup>-1</sup> |            | Ca <sup>++</sup>        | Mg <sup>++</sup> | Na <sup>+</sup> | K <sup>+</sup> | CO <sub>3</sub> <sup>=</sup> | HCO <sub>3</sub> <sup>-</sup> | Cl <sup>-</sup> | SO <sub>4</sub> <sup>=</sup> |
| 7.00 | 0.6               | 0.8        | 1.8                     | 1.2              | 0.6             | 0.9            | 0                            | 1.8                           | 2.6             | 0.1                          |

Nitrogen applications were 250,350 and 450 g/tree, its equivalent 1219, 1707 and 2195 g/tree from ammonium sulfate (20.5%) as a source of nitrogen, respectively. Nitrogen fertilizer was added at three times, first (50% of nitrogen fertilizer was added at the end of December), second (25% nitrogen fertilizer was added at the first week of March) and third (25% nitrogen fertilizer was added at the first week of July) in both seasons. Moreover, humic acid was divided in two equal doses and added as soil application at two times in the first week of March, and second at the first week of July in both seasons.

Response of Wonderful pomegranate trees to the tested treatments was evaluated through the following determinations.

#### **Vegetative growth and leaf NPK content:**

##### **Tree height and canopy volume:**

At the end of October plant height (m) of each tree was measured from the soil surface to the main branch apex and plant canopy volume (m<sup>3</sup>) was calculated using the formula for the volume of a cylinder:

Plant canopy volume = ( $\pi$ ) (tree height) (radius<sup>2</sup>)

Each tree was measured for crown radius (m) in eight directions (every 45°) beginning with magnetic north, around the entire tree circumference. Radiuses were measured from the center of the trunk with a compass and a plummet placed in the most external point of the profile for each considered direction (Smith et al., 1997). The resulting measurements were summed and tree canopy volume was determined.

##### **Leaf area and chlorophyll content:**

The area of leaves was determined by using portable area planimeter Mod Li3100 Ali (Li-Cor) while Leaf total chlorophyll content was determined by Minolta chlorophyll meter SPAD-502.

##### **Leaf NPK content:**

Leaves samples were taken from non-fruiting shoots in both seasons, cleaned and dried at 70°C and digested according to Chapman and Pratt, (1961). Nitrogen was determined by the micro-kjeldahl method Pregl, (1945). Phosphorus percentage was determined calorimetrically using spectrophotometer 882 UV at the wave length of 660 nm according to Murphy and Riely (1962). Potassium was determined by flame-photometer according to Brown and Lilleland, (1946).

##### **Productivity:**

##### **No. of fruits/tree and yield kg/tree:**

At harvest time, the number of fruits per each treated tree was counted and reported then yield (kg) per tree was weighed and recorded.

##### **Fruit disorderd:**

##### **Fruit cracking, sunburned fruit:**

Number of cracked and sunburned fruits per tree was counted and recorded and the percentages of cracked and sunburned fruits were calculated.

##### **Fruit quality:**

##### **Fruit physical and chemical properties:**

Ten fruits were taken at harvest from each treated tree for determination of the following physical and chemical properties. Fruit weight (g), fruit length (cm), fruit diameter (cm), weight of fruit grains (g), flesh (%), weight of 100 grains (g), juice volume (cm<sup>3</sup>) per fruit, peel thickness (cm). Furthermore, total sugar (%), total soluble solids (T.S.S.) was determined by Hand refractometer, total acidity in fruit juice (expressed as citric acid per 100 ml juice), TSS/ Acid ratio and ascorbic acid (mg ascorbic acid/100 ml juice) according to A.O.A.C. (1995).

**Statistical analysis:**

The obtained data in 2017 and 2018 seasons were statistically analyzed by MSTAT-C soft-ware and means were differentiated using Rang test at the 0.05 level (Duncan, 1955).

**Results and Discussion:-****Vegetative growth and leaf NPK content:****Tree height (m):**

Table,3 shows that the highest nitrogen fertilizer rate (450g/tree) gave high positive effect on tree height as compared with the other rates in 2017 and 2018 seasons. However, humic acid applications increased tree height as compared with the untreated treatment in both seasons. Shortly, 40g HA/tree application showed superiority in this concern. Moreover, the combination between nitrogen fertilizer and humic acid application caused a significant positive increase in tree height in 2017 and 2018 seasons. Briefly, adding 450g N/tree with 40g HA/tree treatment surpassed other combinations in in this respect.

**Table 3:-** Effect of nitrogen and humic acid applications on tree height and canopy volume of Wonderful pomegranate trees (2017 and 2018 seasons).

|   | Tree height (m)                 |         |         |         |             |          |          |         |
|---|---------------------------------|---------|---------|---------|-------------|----------|----------|---------|
|   | 2017                            |         |         |         | 2018        |          |          |         |
|   | Humic acids                     |         |         |         | Humic acids |          |          |         |
| Nitrogen rates  | 0 g                             | 20 g    | 40 g    | Mean    | 0 g         | 20 g     | 40 g     | Mean    |
| 250 g N/ tree   | 201.6 g                         | 213.6 f | 220.0 e | 211.7 C | 209.3 g     | 220.0 f  | 229.0 ef | 219.4 C |
| 350 g N/ tree   | 225.0 e                         | 237.3 d | 243.6 c | 235.3 B | 233.0 de    | 237.3 de | 248.0 c  | 239.4 B |
| 450 g N/ tree   | 240.0 cd                        | 277.0 b | 293.3 a | 270.1 A | 241.3 cd    | 265.3 b  | 287.3 a  | 264.6 A |
| Mean  | 222.2 C                         | 242.6 B | 252.3 A |         | 227.8 C     | 240.8 B  | 254.7 A  |         |
|   | Canopy volume (m <sup>3</sup> ) |         |         |         |             |          |          |         |
|   | 2017                            |         |         |         | 2018        |          |          |         |
|   | Humic acids                     |         |         |         | Humic acids |          |          |         |
| Nitrogen rates  | 0 g                             | 20 g    | 40 g    | Mean    | 0 g         | 20 g     | 40 g     | Mean    |
| 250 g N/ tree   | 8.37 f                          | 9.78 e  | 10.30 e | 9.48 C  | 6.68 g      | 7.88 f   | 8.69 e   | 7.75 C  |
| 350 g N/ tree   | 10.46 e                         | 11.27 d | 12.35 c | 11.36 B | 9.26 e      | 10.49 d  | 11.55 c  | 10.43 B |
| 450 g N/ tree   | 12.62 c                         | 13.82b  | 16.50 a | 14.31 A | 10.84 cd    | 15.98 b  | 19.39 a  | 15.40 A |
| Mean  | 10.48 C                         | 11.62 B | 13.05 A |         | 8.93 C      | 11.45 B  | 13.21 A  |         |
| Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level. |                                 |         |         |         |             |          |          |         |

**Tree canopy volume (m<sup>3</sup>):**

Table, 3 reveals that Wonderful pomegranate canopy of the tree increased significantly with elevating nitrogen fertilizer rates. Generally, 450g N/tree treatment gave statically the uppermost values of canopy of the tree 14.31 and 15.40 m<sup>3</sup> as compared with 9.48 and 7.75 m<sup>3</sup> for 250g N/tree treatment in 2017 and 2018 seasons, respectively. Moreover, wonderful pomegranate canopy of the tree was improved by humic acid treatment as compared with control trees in both seasons of the present study. Shortly, 40g HA/tree in the both seasons indicated that the greatest significant values against untreated trees treatment that showed the lowest values during the two studied seasons. On the other hand, the interaction between nitrogen fertilizer and humic acid treatments induced high positive effect on canopy of the tree in the present study. Generally, 450g N/tree combined with 40g HA/tree advanced other tested treatments that exhibited intermediated values in improving canopy of the tree when compared with the untreated trees.

**Leaf area (cm<sup>2</sup>):**

Table, 4 indicates that nitrogen fertilizer at 450g/tree induced high positive effect on leaf area of wonderful pomegranate tress as compared with the fertilizer of 250g N/tree in both seasons. However, humic acid applications at 40g/tree increased leaf area as compared with untreated trees in 2017 and 2018 seasons. Generally, 40g HA/tree application showed superiority in this concern. Moreover, the interaction between the tested factors showed that nitrogen fertilizer combined with humic acid application enhanced leaf area. Conclusively, 450g N/tree combined 40g HA /tree in the both seasons and 20g HA/tree in the first season proved to be the superior treatment in this respect. Other combinations showed an intermediate value in this concern.

**Table 4:-** Effect of nitrogen and humic acid applications on leaf area and total chlorophyll of Wonderful pomegranate trees (2017 and 2018 seasons).

|                | Leaf area (cm <sup>2</sup> ) |           |          |         |             |         |          |         |
|----------------|------------------------------|-----------|----------|---------|-------------|---------|----------|---------|
|                | 2017                         |           |          |         | 2018        |         |          |         |
|                | Humic acids                  |           |          |         | Humic acids |         |          |         |
| Nitrogen rates | 0 g                          | 20 g      | 40 g     | Mean    | 0 g         | 20 g    | 40 g     | Mean    |
| 250 g N/ tree  | 4.20 e                       | 4.21 e    | 4.23 e   | 4.21 C  | 4.29 g      | 4.31 fg | 4.31 ef  | 4.31 C  |
| 350 g N/ tree  | 4.27 d                       | 4.30 c    | 4.31 c   | 4.29 B  | 4.34 de     | 4.35 d  | 4.39 c   | 4.35 B  |
| 450 g N/ tree  | 4.35 b                       | 4.41 a    | 4.44 a   | 4.40 A  | 4.36 d      | 4.44 b  | 4.50 a   | 4.43 A  |
| Mean           | 4.28 B                       | 4.29 B    | 4.32 A   |         | 4.32 C      | 4.36 B  | 4.41 A   |         |
|                | Total chlorophyll            |           |          |         |             |         |          |         |
|                | 2017                         |           |          |         | 2018        |         |          |         |
|                | Humic acids                  |           |          |         | Humic acids |         |          |         |
| Nitrogen rates | 0 g                          | 20 g      | 40 g     | Mean    | 0 g         | 20 g    | 40 g     | Mean    |
| 250 g N/ tree  | 49.00 cd                     | 50.93 e   | 51.70 de | 50.54 C | 50.87 f     | 51.86 e | 52.60 de | 51.78 C |
| 350 g N/ tree  | 51.00 e                      | 52.57 bcd | 53.60 bc | 52.39 B | 52.90 d     | 52.96 d | 53.27cd  | 53.04 B |
| 450 g N/ tree  | 52.50 cd                     | 53.88 b   | 55.63 a  | 54.00 A | 53.73 bc    | 54.03 b | 55.27 a  | 54.34 A |
| Mean           | 50.83 C                      | 52.46 B   | 53.64 A  |         | 52.52 B     | 52.93 B | 53.71 A  |         |

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

**Leaf total chlorophyll content:**

Table, 4 shows that the highest N fertilizer rate 450g/tree induced high positive effect on leaf total chlorophyll content as compared with the other rates in both seasons of study. However, humic acid applications increased leaf total chlorophyll content as compared with the control treatment in both seasons of study. Shortly, 40g HA/tree application showed superiority in this concern. Moreover, the combination between nitrogen fertilizer and humic acid application led to a significant increment in leaf total chlorophyll content in 2017 and 2018 seasons. Briefly, 450g N/tree combined with 40g HA/tree treatment ensured to be the most effective treatment in this respect.

The enhancement effect of nitrogen fertilizer on vegetative growth may be attributed that nitrogen fertilizer contributed in building new chlorophyll molecule primary which led to increasing leaf total chlorophyll content. Menino et al. (2003) worked on orange trees, found that strong relationship between canopy width and N, which was greater at the larger rates of fertilizer application. The obtained results of nitrogen fertilizer rates regarding their positive effect on tree growth are in harmony with the findings of Mohamed et al. (2014) on pomegranate trees. They mentioned that nitrogen fertilizer improved vegetative growth, i.e. canopy volume, leaf area and total surface area, leaf chlorophyll content. Moreover, Bakeer (2016) mentioned that nitrogen fertilizer enhanced vegetative growth of pomegranate trees.

The enhancement effect of humic acid on vegetative growth may be attributed that humic acid stimulation plant growth through accelerated cell division and it enhanced uptake of nutrients and water (Chen et al., 2004 and Hussein and Hassan, 2011) and humic acid have similar effect like IAA on plants in this concern (O'Donnell, 1973). This reflected in increased photosynthesis rate and in this way improved growth parameters. The obtained results of humic acid treatments concerning vegetative growth are in harmony with the findings of Fernández-Escobar et al. (1996) who showed that application of humic acid stimulates growth in olive trees.

**Leaf N content (%):**

Table, 5 reveals that nitrogen fertilizer at 450g /tree expressed high significant effect on nitrogen leaf content of Wonderful pomegranate trees as compared with the fertilizer of 250g N/tree in both seasons. However, 40g HA/tree application advanced leaf nitrogen content as compared with control trees in 2017 and 2018 seasons. Generally, humic acid application at 40g/tree was the best treatment in this concern. Moreover, the interaction between the two factors exhibited that nitrogen fertilizer mixed with humic acid application enhanced leaf nitrogen content. Conclusively, 450g N/tree combined 40g HA /tree in the both seasons proved to be the greatest treatment in this respect. Other combinations showed an intermediate value in this concern.

**Table 5:-** Effect of nitrogen and humic acid applications on leaves nitrogen and phosphorus content of Wonderful pomegranate trees (2017 and 2018 seasons).

|                | Leaf N content (%) |        |        |        |             |         |        |        |
|----------------|--------------------|--------|--------|--------|-------------|---------|--------|--------|
|                | 2017               |        |        |        | 2018        |         |        |        |
|                | Humic acids        |        |        |        | Humic acids |         |        |        |
| Nitrogen rates | 0 g                | 20 g   | 40 g   | Mean   | 0 g         | 20 g    | 40 g   | Mean   |
| 250 g N/ tree  | 1.66 h             | 1.71 g | 1.78 f | 1.71 C | 1.68 i      | 1.74 h  | 1.78 g | 1.73 C |
| 350 g N/ tree  | 1.83 e             | 1.84 e | 1.87 d | 1.84 B | 1.85 f      | 1.89 e  | 1.92 d | 1.88 B |
| 450 g N/ tree  | 2.12 c             | 2.21 b | 2.25 a | 2.19 A | 2.24 c      | 2.31 b  | 2.41 a | 2.32 A |
| Mean           | 1.87 C             | 1.92 B | 1.96 A |        | 1.92 C      | 1.98 B  | 2.04 A |        |
|                | Leaf P content (%) |        |        |        |             |         |        |        |
|                | 2017               |        |        |        | 2018        |         |        |        |
|                | Humic acids        |        |        |        | Humic acids |         |        |        |
| Nitrogen rates | 0 g                | 20 g   | 40 g   | Mean   | 0 g         | 20 g    | 40 g   | Mean   |
| 250 g N/ tree  | 0.12 e             | 0.13 d | 0.14 d | 0.13 C | 0.13 e      | 0.18 ab | 0.14 d | 0.14 C |
| 350 g N/ tree  | 0.14 d             | 0.15 c | 0.17 b | 0.15 B | 0.15 d      | 0.16 c  | 0.17 b | 0.16 B |
| 450 g N/ tree  | 0.17 b             | 0.18 b | 0.19 a | 0.18 A | 0.18 b      | 0.14 d  | 0.19 a | 0.18 A |
| Mean           | 0.14 C             | 0.15 B | 0.16 A |        | 0.16 B      | 0.16 B  | 0.17 A |        |

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

**Leaf P content (%):**

Table, 5 shows that the highest nitrogen fertilizer rate (450g/tree) caused high positive effect on leaf phosphorus content as compared with the other rates in both seasons. However, humic acid applications increased leaf phosphorus content in both seasons. Briefly, 40g HA/tree application showed superiority in this concern. Moreover, the combination between nitrogen fertilizer and humic acid application caused a significant positive increase in leaf phosphorus content in 2017 and 2018 seasons. Briefly, adding 450g N/tree with 40g HA/tree treatment ensured to be most effective treatment in this respect.

**Leaf K content (%):**

Table, 6 demonstrates that leaf potassium content increased significantly with increasing nitrogen fertilizer rates. Generally, 450g N/tree treatment showed superiority in this concern in both seasons. 40 g humic acid per tree applications increased leaf potassium content as compared with the control treatment in both seasons. 450g N/tree combined 40g HA /tree in the both seasons proved to be the greatest treatment in this respect.

**Table 6:-** Effect of nitrogen and humic acid applications on leaf potassium content of Wonderful pomegranate trees (2017 and 2018 seasons).

|                | Leaf K content (%) |         |         |         |             |        |        |        |
|----------------|--------------------|---------|---------|---------|-------------|--------|--------|--------|
|                | 2017               |         |         |         | 2018        |        |        |        |
|                | Humic acids        |         |         |         | Humic acids |        |        |        |
| Nitrogen rates | 0 g                | 20 g    | 40 g    | Mean    | 0 g         | 20 g   | 40 g   | Mean   |
| 250 g N/ tree  | 0.91 c             | 0.93 bc | 0.94 bc | 0.930 B | 0.93 f      | 0.94 f | 0.95 f | 0.94 C |
| 350 g N/ tree  | 0.95 bc            | 0.96 bc | 0.96 bc | 0.957 B | 0.95 f      | 0.99 e | 1.02 d | 0.98 B |
| 450 g N/ tree  | 0.97 bc            | 0.99 b  | 1.09 a  | 1.018 A | 1.06 c      | 1.09 b | 1.15 a | 1.10 A |
| Mean           | 0.94 C             | 0.96 B  | 1.00A   |         | 0.98 C      | 1.00 B | 1.04 A |        |

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

The enhanced effect of nitrogen fertilizer rates on leaf NPK content may be attributed that nitrogen is a necessary element for chlorophyll, protoplasm, protein and nucleic acid synthesis (Nijjar, 1985) so that its application can result in an increase in the cell number and cell size with an increase in the growth. All of these led to more uptakes of nutrients and reflected on leaf minerals content. The obtained results regarding the effect of nitrogen fertilizer rates on leaf NPK content go with line with the findings of Ramy et al. (2015) on pomegranate; EL-Gioushy (2016) on pomegranate.

The enhanced effect of humic acid on leaf mineral content may be attributed that humic acid is promoting the chelation of many elements and making these available to plants (Biondi et. al., 1994). Moreover, humic acid have similar effect like IAA on plants (O'Donnell, 1973) and it enhanced uptake of nutrients and water (Chen et al., 2004 and Hussein and Hassan, 2011). Thus, it reflected on improved nutritional status of tree. The obtained results of humic acid treatments regarding leaf mineral content are in agreement with the findings of Fernández-Escobar et al. (1996) who mentioned that humic acid treatments stimulates nutrient uptake and improved leaf nutritional status of olive trees

#### No. of fruits/tree and yield kg/tree:

##### No. of fruits/tree:

Table, 7 shows that nitrogen fertilizer succeeded in improving number of fruits /tree. Meanwhile, the biggest number of fruits/tree was achieved by nitrogen fertilizer rate at 450g/tree followed by 350g/tree. Finally, the lowest number of fruits/tree was recorded with the lessening nitrogen fertilizer rate at 250g/tree in both seasons. Moreover, humic acid improved fruit number/tree as compared with untreated trees in both seasons. Generally, 20g /tree and 40g /tree of humic acid soil application recorded the most influenced treatments in this respect. However, the interaction between nitrogen fertilizer and humic acid treatments proved that 450g N/tree treatment combined with 20g HA /tree and 40g HA/tree treatments gave the highest significant effect on fruit number/tree. On the contrary, nitrogen fertilizer rate at 250g /tree combined with untreated HA/trees gave the lessening value in this respect. Other combinations illustrated an intermediate values.

**Table 7:-** Effect of nitrogen and humic acid applications on number of fruits per tree and yield of Wonderful pomegranate trees (2017 and 2018 seasons).

|   | No. of fruits/tree |         |         |         |             |          |          |         |
|---|--------------------|---------|---------|---------|-------------|----------|----------|---------|
|   | 2017               |         |         |         | 2018        |          |          |         |
|   | Humic acids        |         |         |         | Humic acids |          |          |         |
| Nitrogen rates  | 0 g                | 20 g    | 40 g    | Mean    | 0 g         | 20 g     | 40 g     | Mean    |
| 250 g N/ tree   | 52.0 e             | 53.0 de | 53.3 de | 52.7 C  | 58.0 d      | 59.6 cd  | 60.0 c   | 59.2 C  |
| 350 g N/ tree   | 54.0 cd            | 55.6 bc | 56.0 b  | 55.2 B  | 61.0 c      | 61.3 bc  | 63.0 b   | 61.7 B  |
| 450 g N/ tree   | 56.3 b             | 57.3 ab | 59.0 a  | 57.5 A  | 63.0 b      | 65.0 a   | 66.3 a   | 64.7 A  |
| Mean  | 54.1 B             | 55.3 A  | 56.1 A  |         | 60.6 B      | 62.0 A   | 63.1 A   |         |
|   | Yield (kg)/tree    |         |         |         |             |          |          |         |
|   | 2017               |         |         |         | 2018        |          |          |         |
|   | Humic acids        |         |         |         | Humic acids |          |          |         |
| Nitrogen rates  | 0 g                | 20 g    | 40 g    | Mean    | 0 g         | 20 g     | 40 g     | Mean    |
| 250 g N/ tree   | 16.20 g            | 16.40 f | 16.50 e | 16.36 B | 17.16 f     | 17.80 ef | 18.23 e  | 17.73 C |
| 350 g N/ tree   | 17.00 d            | 18.00 c | 19.00 b | 18.00 B | 18.76 de    | 19.53 cd | 20.26 bc | 19.66 B |
| 450 g N/ tree   | 17.00 d            | 18.00 c | 19.50 a | 18.16 A | 20.70 b     | 21.20 b  | 22.23 a  | 21.23 A |
| Mean  | 16.73 C            | 17.46 B | 18.33 A |         | 18.73 C     | 19.51 B  | 20.38 A  |         |
| Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level. |                    |         |         |         |             |          |          |         |

##### Yield kg/tree:

Table, 7 demonstrates that pomegranate yield/tree increased significantly with increasing nitrogen fertilizer rates. Generally, 450g N/tree treatment gave the best values of yield in 2017 and 2018 seasons, respectively. Moreover, Wonderful pomegranate tree productivity was influenced by humic acid treatment as compared with control trees in both seasons of present study. Shortly, 40g HA/tree gave the high value as compared with untreated treatment during the two seasons. However, the interaction between nitrogen fertilizer and humic acid treatments induced high positive effect on the yield in the present study. Shortly, 450g N/tree combined with humic acid at 40g/tree surpassed other treatments in improving tree yield.

The enhanced effect of nitrogen fertilizer rates on tree yield may be attributed that nitrogen fertilization is considered an important and limiting factor for fruiting of fruit trees (Nijjar, 1985). Also, the increment of chlorophyll production and photosynthesis processes lead to increase in number of fruits per tree and yield. Nitrogen is major constituent of many compounds of great physiological importance in metabolism, such as amino acids, proteins, nucleic acids, enzymes, plant pigments, vitamins, hormones as well as building cell walls, middle lamella

and enhancing division and coenzymes (Mengel et al., 2001), which induced a positive effect on reducing fruit drop and increase number of fruits per tree and yield kg/tree. The obtained results regarding the effect of nitrogen fertilizer rates on tree yield go with line with the findings of Mohamed et al. (2014) reported that nitrogen fertilizer improved number of fruit/tree and yield of wonderful pomegranate trees. Moreover, Bakeer (2016) mentioned that nitrogen fertilization enhancing yield of pomegranate.

The enhanced effect of humic acids on tree yield may be attributed that humic acid stimulation plant growth and consequently yield through accelerated cell division and it enhanced uptake of nutrients and water (Chen et al., 2004 and Hussein and Hassan, 2011) and humic acid have similar effect like IAA on plants (O'Donnell, 1973), which required for preventing the abscission layer formation which led to reduce fruit drop and increase fruit retention subsequently, increased number of fruits per tree and improved yield per tree. The obtained results of humic acids are in agreement with the findings of Fernández-Escobar et al. (1996) They reported that humic acid applications increased yield of olive trees.

### Fruit cracking and sunburned fruit percentage:

#### Fruit cracking (%):

Table, 8 indicates that fruit cracking percentage was diminished significantly by elevating nitrogen fertilizer treatments from 250g N/tree to 450g N/tree. Generally, in both seasons nitrogen fertilizer at 450g N/tree scored the lower values of cracked fruit percentage. Furthermore, humic acid treatments succeeded in reducing percentage of cracked fruits which reached the minimum value with 40g humic acid /tree when compared with untreated trees in 2017 and 2018 seasons respectively. However, the interaction between the two studied factors noted that nitrogen fertilizer and humic acid treatments induced high reduction of percentage of cracked fruits in both seasons. Generally, 450g N/tree treatment combined with 40g humic acid/tree indicated high reduction of percentage of cracked fruit and surpassed other combined treatments in lessening percentage of cracked fruits in the present study.

**Table 8:-** Effect of nitrogen and humic acid applications on fruit cracking percentage and sunburned fruit percentage of Wonderful pomegranate trees (2017 and 2018 seasons).

| Nitrogen rates | Fruit cracking %  |          |         |         |             |          |         |         |
|----------------|-------------------|----------|---------|---------|-------------|----------|---------|---------|
|                | 2017              |          |         |         | 2018        |          |         |         |
|                | Humic acids       |          |         |         | Humic acids |          |         |         |
|                | 0 g               | 20 g     | 40 g    | Mean    | 0 g         | 20 g     | 40 g    | Mean    |
| 250 g N/ tree  | 26.16 a           | 24.66 ab | 23.75 b | 24.85 A | 23.88 a     | 22.38 ab | 21.47 b | 22.57 A |
| 350 g N/ tree  | 23.82 b           | 20.81 c  | 19.52 c | 21.38 B | 21.54 b     | 18.53 c  | 17.24 c | 19.10 B |
| 450 g N/ tree  | 17.48 d           | 14.86 e  | 11.10 f | 14.48 C | 15.20 d     | 12.58 e  | 8.82 f  | 12.20 C |
| Mean           | 22.48 A           | 20.11 B  | 18.12 C |         | 20.20 A     | 17.83 B  | 15.84 C |         |
| Nitrogen rates | Sunburned fruit % |          |         |         |             |          |         |         |
|                | 2017              |          |         |         | 2018        |          |         |         |
|                | Humic acids       |          |         |         | Humic acids |          |         |         |
|                | 0 g               | 20 g     | 40 g    | Mean    | 0 g         | 20 g     | 40 g    | Mean    |
| 250 g N/ tree  | 21.16 a           | 19.66 ab | 18.75 b | 19.85 A | 19.23 a     | 17.73 ab | 16.86 b | 17.95 A |
| 350 g N/ tree  | 18.82 b           | 15.81 c  | 14.52 c | 16.38 B | 16.82 b     | 13.88 c  | 12.59 c | 14.43 B |
| 450 g N/ tree  | 12.48 d           | 9.86 e   | 6.10 f  | 9.48 C  | 10.55 d     | 7.93 e   | 5.17 f  | 7.83 C  |
| Mean           | 17.48 A           | 15.11 B  | 13.12 C |         | 15.53 A     | 13.81 B  | 11.55 C |         |

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

#### Sunburned fruit (%):

Table, 8 indicates that sunburned fruit percentage was diminished significantly by elevating nitrogen fertilizer treatments from 250g N/tree to 450g N/tree. Generally, in both seasons nitrogen fertilizer at 450g N/tree scored the lower values of sunburned fruit percentage. Furthermore, humic acid treatments succeeded in reducing percentage of sunburned fruits which reached the minimum value with 40g humic acid /tree and 20g humic acid /tree when compared with untreated trees in 2017 and 2018 seasons respectively. However, the interaction between the two studied factors noted that nitrogen fertilizer and humic acid treatments induced high reduction of percentage of sunburned fruits in both seasons. Generally, 450g N/tree treatment combined with 40g humic acid/tree and 350g



N/tree treatment combined with 20g humic acid/tree indicated high reduction of percentage of sunburned fruit and surpassed other combined treatments in lessening percentage of sunburned fruits in the present study.

The enhancement effect of nitrogen fertilizer rates and regarding their positive effect on reduce fruit cracking and sunburn damage through increasing vegetative growth to protect fruits from strong solar radiation and hot temperatures are in harmony with the findings of Melgarejo et al. (2004) who noted that improved in nitrogen fertilization could increase growth, increase growth extension and thereby provide better shading over the fruits. Mitra (1997) stated that some nutrients, such as nitrogen have an important role in reducing fruit cracking. If those nutrients were applied in balance rates, these will lead to enhanced fruit growth and cause maintaining of water balance between exocarp and inside fruit tissues, and keep fruit cell walls flexibility and strength. Moreover, nitrogen is major constituent of many compounds of great physiological importance in metabolism, such as amino acids, proteins, nucleic acids, enzymes, plant pigments, vitamins, hormones as well as building cell walls, middle lamella and enhancing division and coenzymes (Mengel et al., 2001), which lead to positive effect on reduced fruit cracking and sunburned fruit. Moreover, the efficiency of nitrogen fertilization can improve the vegetative growth and tree canopy which led to pomegranate fruits protection from direct sunlight and reduced sunburned fruit and fruit cracking of pomegranate trees. The obtained results regarding the effect of nitrogen fertilizer rates are in harmony with the findings Mohamed et al. (2014) and Bakeer (2016) on pomegranate trees.

The improved effect of humic acids on reduced fruit cracking and sunburned fruit percentage may be attributed that humic acid stimulation plant growth and accelerated cell division and it enhanced uptake of nutrients and water (Chen et al., 2004; Hussein and Hassan, 2011), also, the enhanced in tree vegetative growth shield the fruit and reduced sunburn damage and fruit cracking. Humic acid have similar effect like IAA on plants (O'Donnell, 1973). That reflected on reduced of fruit cracking and sunburned fruit percentage. The obtained results of humic acids on reduced fruit cracking and sunburned fruit percentage are in agreement with the findings of Ghanbarpour (2019) on pomegranate trees.

### Fruit physical and chemical properties:

#### Fruit weight (g):

Data of both seasons in table, 9 illustrates that Wonderful pomegranate fruit weight increased by increment of nitrogen fertilizer amount in both seasons. The upper most fruit weight was recorded with the highest nitrogen fertilizer rate at 450g N/tree in both seasons, whereas, the lowest fruit weight was recorded with the lowest nitrogen fertilizer rate at 250g N/tree. Moreover, humic acid treatments produced higher values of fruit weight as compared with control trees in both seasons. In general, 40g HA/tree application was the most effective treatment in this respect. Furthermore, the interaction between nitrogen fertilizer and humic acid treatment gave high value of fruit weight. Generally, 450g N/tree treatment combined with 40g HA/tree treatment surpassed the other combinations.

**Table 9:-** Effect of nitrogen and humic acid applications on fruit weight and fruit length of Wonderful pomegranate trees (2017 and 2018 seasons).

|                | Fruit weight (g)  |         |         |         |             |          |          |         |
|----------------|-------------------|---------|---------|---------|-------------|----------|----------|---------|
|                | 2017              |         |         |         | 2018        |          |          |         |
|                | Humic acids       |         |         |         | Humic acids |          |          |         |
| Nitrogen rates | 0 g               | 20 g    | 40 g    | Mean    | 0 g         | 20 g     | 40 g     | Mean    |
| 250 g N/ tree  | 285.6 g           | 290.0 g | 296.3 f | 290.6 C | 289.6 h     | 343.6 b  | 310.0 f  | 298.2 C |
| 350 g N/ tree  | 301.3 e           | 310.3 d | 314.3 d | 308.6 B | 314.0 ef    | 318.3 de | 322.0 cd | 318.1 B |
| 450 g N/ tree  | 318.6 c           | 335.3 b | 346.0 a | 333.3 A | 325.0 c     | 295.0 g  | 354.0 a  | 340.8 A |
| Mean           | 301.8 C           | 311.8 B | 318.8 A |         | 309.5 C     | 319.0 B  | 328.6 A  |         |
|                | Fruit length (cm) |         |         |         |             |          |          |         |
|                | 2017              |         |         |         | 2018        |          |          |         |
|                | Humic acids       |         |         |         | Humic acids |          |          |         |
| Nitrogen rates | 0 g               | 20 g    | 40 g    | Mean    | 0 g         | 20 g     | 40 g     | Mean    |
| 250 g N/ tree  | 7.88 f            | 8.23 d  | 8.28 d  | 8.13 C  | 8.28 f      | 8.29 f   | 8.34 e   | 8.304 C |
| 350 g N/ tree  | 7.95 e            | 8.37 c  | 8.38 c  | 8.23 B  | 8.35 de     | 8.37 cde | 8.38 bcd | 8.370 B |
| 450 g N/ tree  | 8.25 d            | 8.86 b  | 8.97 a  | 8.69 A  | 8.39 c      | 8.77 b   | 8.90 a   | 8.69 A  |
| Mean           | 8.02 C            | 8.49 B  | 8.54 A  |         | 8.34 C      | 8.48 B   | 8.54 A   |         |

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5%

level.

#### Fruit length (cm):

Table, 9 reveals that nitrogen fertilizer enhanced fruit length parameter. Moreover, the highest fruit length was presented by nitrogen fertilization rate at 450g N/tree and the lowest value of fruit length was observed with 250g N/tree treatment in both seasons. Moreover, humic acid treatment take the same line of trend data as illustrated by 40g humic acid /tree treatment which exhibited the highest increment of wonderful pomegranate fruit length aspect. Also, the interaction between nitrogen fertilizer and humic acid treatments indicated that 450g N/tree associated with 40g humic acid/tree treatment gave the upper most significant fruit length. Other associated treatments gave an intermediated value.

#### Fruit diameter (cm):

Table, 10 illustrates that nitrogen fertilizer enhanced fruit diameter parameter. Moreover, the highest fruit diameter was presented by nitrogen fertilization rate at 450g N/tree and the lowest value of fruit diameter was observed with 250g N/tree treatment in both 2017 and 2018 seasons. Moreover, humic acid treatment showed the same direction of trend data as noted by 40g humic acid /tree treatment which recorded the highest increase of wonderful pomegranate fruit diameter aspect. Also, the interaction between nitrogen fertilizer and humic acid treatments indicated that 450g N/tree associated with 40g humic acid/tree treatment gave the upper most significant fruit diameter .On the contrary, 250g N/tree combined with untreated tree exhibited the lessening value in this discussed parameter. The Other combined treatments gave an intermediated record.

**Table 10:-** Effect of nitrogen and humic acid applications on fruit diameter and weight of fruit grains of Wonderful pomegranate trees (2017 and 2018 seasons).

|   | Fruit diameter (cm)        |          |          |          |             |          |          |          |
|---|----------------------------|----------|----------|----------|-------------|----------|----------|----------|
|   | 2017                       |          |          |          | 2018        |          |          |          |
|   | Humic acids                |          |          |          | Humic acids |          |          |          |
| Nitrogen rates  | 0 g                        | 20 g     | 40 g     | Mean     | 0 g         | 20 g     | 40 g     | Mean     |
| 250 g N/ tree   | 8.79 f                     | 8.87 e   | 8.91 de  | 8.85 C   | 8.94 f      | 9.05 e   | 9.07 de  | 9.02 C   |
| 350 g N/ tree   | 8.91 d                     | 8.93 cd  | 8.96 c   | 8.93 B   | 9.03 e      | 9.14 c   | 9.17 bc  | 9.11 B   |
| 450 g N/ tree   | 8.96 c                     | 9.06 b   | 9.15 a   | 9.05 A   | 9.12 cd     | 9.22 ab  | 9.28 a   | 9.20 A   |
| Mean  | 8.88 C                     | 8.95 B   | 9.00 A   |          | 9.03 B      | 9.14 A   | 9.17 A   |          |
|   | Weight of fruit grains (g) |          |          |          |             |          |          |          |
|   | 2017                       |          |          |          | 2018        |          |          |          |
|   | Humic acids                |          |          |          | Humic acids |          |          |          |
| Nitrogen rates  | 0 g                        | 20 g     | 40 g     | Mean     | 0 g         | 20 g     | 40 g     | Mean     |
| 250 g N/ tree   | 116.00 i                   | 121.00 h | 125.00 g | 120.67 C | 120.33 i    | 125.67 h | 132.67 g | 126.22 C |
| 350 g N/ tree   | 134.00 f                   | 140.67 e | 145.00 d | 139.89 B | 138.00 f    | 145.67 e | 151.00 d | 144.89 B |
| 450 g N/ tree   | 148.00 c                   | 161.33 b | 170.67 a | 160.00 A | 154.00 c    | 166.00 b | 173.67 a | 164.56 A |
| Mean  | 132.67 C                   | 141.00 B | 146.89 A |          | 137.44 C    | 145.78 B | 152.44 A |          |
| Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level. |                            |          |          |          |             |          |          |          |

#### Weight of fruit grains (g):

Table, 10 demonstrates that nitrogen fertilizer succeeded in improving pomegranate fruit grain weight. Meanwhile, the biggest fruit grain weight record was achieved by nitrogen fertilizer rate at 450g N/tree in both studied season. Finally, the lowest fruit grain weight was recorded with the lessening nitrogen fertilizer rate at 250g N/tree in both seasons. Moreover, humic acid improved grain weight as compared with other treatments rates in 2017 and 2018 seasons. Generally, 40g/tree of humic acid soil application recorded the best treatment in this respect. However, the interaction between nitrogen fertilizer and humic acid treatments proved that 450g N/tree treatment combined with 40g /tree of humic acid treatment gave the highest significant effect on grain weight. Other combinations illustrated an intermediate values.

#### Flesh (%):

Table, 11 demonstrates that pomegranate flesh weight increased significantly with increasing nitrogen fertilizer rates. Generally, 450g N/tree treatment gave statically the uppermost values of flesh weight 47.95 and 48.24 as

compared with 41.50 and 42.31 for 250g N/tree treatment in 2017 and 2018 seasons, respectively. Moreover, wonderful pomegranate flesh weight was influenced by humic acid treatment as compared with untreated trees in both seasons of the present study. Shortly, 40g HA/tree 45.87 and 46.24 % against 43.83 and 44.28 % for untreated trees treatment during the two consecutive seasons. However, the interaction between nitrogen fertilizer and humic acid treatments induced high positive effect on the flesh weight in the present study. Shortly, 450g N/tree combined with humic acid at 40g /tree surpassed other treatments in improving Flesh weight.

**Table 11:-** Effect of nitrogen and humic acid applications on flesh percentage and weight of 100 grains of Wonderful pomegranate trees (2017 and 2018 seasons).

|   | Flesh (%)                |           |           |         |             |          |          |         |
|---|--------------------------|-----------|-----------|---------|-------------|----------|----------|---------|
|   | 2017                     |           |           |         | 2018        |          |          |         |
|   | Humic acids              |           |           |         | Humic acids |          |          |         |
| Nitrogen rates  | 0 g                      | 20 g      | 40 g      | Mean    | 0 g         | 20 g     | 40 g     | Mean    |
| 250 g N/ tree   | 40.60 g                  | 41.72 f   | 42.18 f   | 41.50 C | 41.54 f     | 42.60 f  | 42.79 f  | 42.31 C |
| 350 g N/ tree   | 44.46 e                  | 45.32 de  | 46.12 cd  | 45.30 B | 43.94 e     | 45.75 d  | 46.89 cd | 45.53 B |
| 450 g N/ tree   | 46.43 c                  | 48.10 b   | 49.32 a   | 47.95 A | 47.38 bc    | 48.30 ab | 49.05 a  | 48.24 A |
| Mean  | 43.83 C                  | 45.05 B   | 45.87 A   |         | 44.28 B     | 45.55 A  | 46.24 A  |         |
|   | Weight of 100 grains (g) |           |           |         |             |          |          |         |
|   | 2017                     |           |           |         | 2018        |          |          |         |
|   | Humic acids              |           |           |         | Humic acids |          |          |         |
| Nitrogen rates  | 0 g                      | 20 g      | 40 g      | Mean    | 0 g         | 20 g     | 40 g     | Mean    |
| 250 g N/ tree   | 33.00 f                  | 35.00 de  | 35.66 cde | 34.55 C | 32.00 f     | 37.00 c  | 37.66 c  | 35.55 C |
| 350 g N/ tree   | 34.66 e                  | 36.00 cde | 37.00 bc  | 35.88 B | 34.00 e     | 38.00 bc | 39.00 b  | 37.00 B |
| 450 g N/ tree   | 36.33 cd                 | 38.33 ab  | 39.66 a   | 38.11 A | 35.66 d     | 40.33 a  | 41.66 a  | 39.22 A |
| Mean  | 34.66 C                  | 36.44 B   | 37.44 A   |         | 33.88 C     | 38.44 B  | 39.44 A  |         |
| Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level. |                          |           |           |         |             |          |          |         |

#### Weight of 100 grains (g):

Table, 11 reveals that nitrogen fertilizer improved weight of 100 grain. Meanwhile, the uppermost weight of 100 grain was gained by nitrogen fertilizer rate at 450g N/tree in both seasons. Moreover, humic acid enhanced weight of 100 grain as compared with other treatments rates in 2017 and 2018 seasons. Generally, 40g /tree of humic acid soil application recorded the best treatment in this respect. However, the interaction between nitrogen fertilizer and humic acid treatments proved that 450g N/tree treatment combined with 40g /tree of humic acid treatment gave the highest effect on weight of 100 grain record. Other combinations illustrated intermediate records.

#### Juice volume / fruit (cm<sup>3</sup>):

Tabulated data recorded that the uppermost nitrogen fertilizer rate (450g /tree) induced high positive effect on fruit juice volume of Wonderful pomegranate as compared with the other rates in both seasons. While, humic acid applications improved fruit juice volume as compared with the untreated trees treatment in both seasons of study. Shortly, 40g /tree of humic acid application showed superiority in this concern (Table, 12). With respect of the combination between nitrogen fertilizer and humic acid application it was observed a significant increment in fruit juice volume due to this combination in 2017 and 2018 seasons. Briefly, 450g N/tree associated with 40g/tree of humic acid treatment ensured to be the most effective treatment in this respect.

#### Peel thickness (cm):

Table, 12 shows that nitrogen fertilizer improved peel thickness record. Moreover, the highest fruit peel thickness was observed by nitrogen fertilization rate at 450g N /tree and the lowest value of peel thickness was noted with 250g N/tree treatment in both 2017 and 2018 seasons. Moreover, humic acid treatment showed the same direction of trend data as observed by 40g humic acid /tree treatment which indicated the uppermost increment of wonderful pomegranate fruit peel thickness. Also, the interaction between nitrogen fertilizer and humic acid treatments indicated that 450g N/tree combined with 40g humic acid/tree treatment showed the highest fruit peel thickness. On the contrary, 250g N/tree combined with control tree exhibited the lowest value in this mentioned parameter. The Other mixed treatments gave an intermediated value.

**Table 12:-** Effect of nitrogen and humic acid applications on juice volume and peel thickness of Wonderful pomegranate trees (2017 and 2018 seasons).

|                | Juice volume/fruit (cm <sup>3</sup> ) |          |          |          |             |          |          |          |
|----------------|---------------------------------------|----------|----------|----------|-------------|----------|----------|----------|
|                | 2017                                  |          |          |          | 2018        |          |          |          |
|                | Humic acids                           |          |          |          | Humic acids |          |          |          |
| Nitrogen rates | 0 g                                   | 20 g     | 40 g     | Mean     | 0 g         | 20 g     | 40 g     | Mean     |
| 250 g N/ tree  | 150.33 h                              | 171.00 g | 188.33 f | 169.89 C | 158.33 g    | 167.33 f | 186.67 e | 170.78 C |
| 350 g N/ tree  | 192.33 e                              | 205.67 d | 217.67 c | 205.22 B | 187.33 e    | 200.67 d | 212.67 c | 200.22 B |
| 450 g N/ tree  | 220.00 c                              | 237.33 b | 267.00 a | 241.44 A | 216.00 c    | 233.00 b | 262.00 a | 237.00 A |
| Mean           | 187.56 C                              | 204.67 B | 224.33 A |          | 187.22 C    | 200.33 B | 220.44 A |          |
|                | Peel thickness (cm)                   |          |          |          |             |          |          |          |
|                | 2017                                  |          |          |          | 2018        |          |          |          |
|                | Humic acids                           |          |          |          | Humic acids |          |          |          |
| Nitrogen rates | 0 g                                   | 20 g     | 40 g     | Mean     | 0 g         | 20 g     | 40 g     | Mean     |
| 250 g N/ tree  | 0.30 g                                | 0.35 ef  | 0.35 ef  | 0.33 C   | 0.31 g      | 0.34 f   | 0.35 ef  | 0.33 C   |
| 350 g N/ tree  | 0.34 f                                | 0.35 de  | 0.36 cd  | 0.35 B   | 0.35 def    | 0.35 ced | 0.36 cd  | 0.35 B   |
| 450 g N/ tree  | 0.37 c                                | 0.39 b   | 0.40 a   | 0.39 A   | 0.36 c      | 0.40 b   | 0.42 a   | 0.39 A   |
| Mean           | 0.33 C                                | 0.36 B   | 0.37 A   |          | 0.34 C      | 0.36 B   | 0.37 A   |          |

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

**Fruit total sugar content:**

Table, 13 shows that Wonderful pomegranate total sugar fruit content increased significantly with increasing nitrogen fertilizer rates. Generally, 450g N/tree treatment gave statically the uppermost values of total sugar as compared with 250g N/tree treatment in 2017 and 2018 seasons. Moreover, Wonderful pomegranate total sugar was increased by humic acid treatment as compared with untreated trees in both seasons. Shortly, 40g humic acid /tree in the both season and 20g humic acid/tree in the first season indicated the best significant values against untreated trees treatment that exhibited the lowest values during the two consecutive seasons. On the other hand, the interaction between nitrogen fertilizer and humic acid treatments induced high positive effect on total sugar content in the present study. Shortly, 450g N/tree combined with humic acid at 40g/tree surpassed other tested treatments that exhibited intermediated values in improving total sugar content when compared with the untreated trees.

**Table 13:-** Effect of nitrogen and humic acid applications on total sugar and T.S.S.of Wonderful pomegranate trees (2017 and 2018 seasons).

|                | Total sugar (%) |          |           |         |             |          |          |         |
|----------------|-----------------|----------|-----------|---------|-------------|----------|----------|---------|
|                | 2017            |          |           |         | 2018        |          |          |         |
|                | Humic acids     |          |           |         | Humic acids |          |          |         |
| Nitrogen rates | 0 g             | 20 g     | 40 g      | Mean    | 0 g         | 20 g     | 40 g     | Mean    |
| 250 g N/ tree  | 11.70 e         | 11.85 de | 11.90 d   | 11.81 C | 11.35 g     | 11.44 f  | 11.59 e  | 11.46 C |
| 350 g N/ tree  | 12.00 cd        | 12.12 bc | 12.17 abc | 12.09 B | 12.20 d     | 12.28 c  | 12.34 b  | 12.27 B |
| 450 g N/ tree  | 12.20 abc       | 12.26 ab | 12.34 a   | 12.27 A | 12.22 d     | 12.36 b  | 12.47 a  | 12.35 A |
| Mean           | 11.96 B         | 12.08 A  | 12.13 A   |         | 11.92 C     | 12.03 B  | 12.13 A  |         |
|                | T.S.S. (%)      |          |           |         |             |          |          |         |
|                | 2017            |          |           |         | 2018        |          |          |         |
|                | Humic acids     |          |           |         | Humic acids |          |          |         |
| Nitrogen rates | 0 g             | 20 g     | 40 g      | Mean    | 0 g         | 20 g     | 40 g     | Mean    |
| 250 g N/ tree  | 14.54 e         | 14.58 e  | 14.67 de  | 14.59 C | 14.51 f     | 14.59 ef | 14.71 de | 14.60 C |
| 350 g N/ tree  | 14.75 de        | 14.79 de | 14.88 cd  | 14.80 B | 14.72 de    | 14.80 d  | 14.95 c  | 14.82 B |
| 450 g N/ tree  | 15.10 c         | 15.66 b  | 16.60 a   | 15.78 A | 15.43 b     | 15.55 b  | 15.69 a  | 15.56 A |
| Mean           | 14.79 C         | 15.01 B  | 15.38 A   |         | 14.89 C     | 14.98 B  | 15.12 A  |         |

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

**Fruit T.S.S. (%):**

Table, 13 reveals that Wonderful pomegranate fruit T.S.S. content increased significantly with elevating nitrogen fertilizer rates. Generally, 450g N/tree treatment gave statically the uppermost values of T.S.S. as compared with 250g N/tree treatment in 2017 and 2018 seasons, respectively. Moreover, wonderful pomegranate T.S.S. was improved by humic acid treatment as compared with control trees in both seasons study. Shortly, 40g humic acid /tree in the both seasons recorded the best significant values against untreated trees treatment that exhibited the lowest values during the two studied seasons. On the other hand, the interaction between nitrogen fertilizer and humic acid treatments induced high positive effect on T.S.S. in the present study. 450g N/tree combined with humic acid at 40g /tree surpassed other tested treatments that exhibited intermediated values in improving T.S.S. when compared with the untreated trees

**Fruit total acidity (%):**

Table, 14 indicates that fruit acidity was diminished significantly by elevating nitrogen fertilizer treatments from 250gN/tree to 450g N/tree. Generally, in both seasons nitrogen fertilizer at 450g N/tree scored the lower values of fruit acidity content. Furthermore, humic acid treatments succeed in lessening fruits acidity content which reached the minimum value with 40g humic acid /tree when compared with control trees in 2017 and 2018 seasons. However, the interaction between the two studied factors noted that nitrogen fertilizer and humic acid treatments influenced high reduction of fruit acidity content in both seasons. Generally, 450g N/tree treatment combined with 40g humic acid/tree recorded high reduction of fruit acidity content and surpassed other mixed treatments in lessening fruits acidity in this study.

**Table 14:-** Effect of nitrogen and humic acid applications on acidity percentage and T.S.S./ acid ratio of Wonderful pomegranate trees (2017 and 2018 seasons).

|   | Acidity (%)       |         |         |         |             |         |         |         |
|---|-------------------|---------|---------|---------|-------------|---------|---------|---------|
|   | 2017              |         |         |         | 2018        |         |         |         |
| Nitrogen rates  | Humic acids       |         |         |         | Humic acids |         |         |         |
|   | 0 g               | 20 g    | 40 g    | Mean    | 0 g         | 20 g    | 40 g    | Mean    |
| 250 g N/ tree   | 1.71 a            | 1.63 b  | 1.61 bc | 1.65 A  | 1.73 a      | 1.63 c  | 1.57 cd | 1.64 A  |
| 350 g N/ tree   | 1.69 a            | 1.58 c  | 1.50 d  | 1.59 B  | 1.71 ab     | 1.53 d  | 1.46 e  | 1.57 B  |
| 450 g N/ tree   | 1.68 a            | 1.41 e  | 1.37 f  | 1.49 C  | 1.64 bc     | 1.43 e  | 1.37 f  | 1.48 C  |
| Mean  | 1.69 A            | 1.54 B  | 1.49 C  |         | 1.69 A      | 1.53 B  | 1.47 C  |         |
|   | T.S.S./acid ratio |         |         |         |             |         |         |         |
|   | 2017              |         |         |         | 2018        |         |         |         |
| Nitrogen rates  | Humic acids       |         |         |         | Humic acids |         |         |         |
|   | 0 g               | 20 g    | 40 g    | Mean    | 0 g         | 20 g    | 40 g    | Mean    |
| 250 g N/ tree   | 8.50 f            | 8.94 e  | 9.11 de | 8.85 C  | 8.38 g      | 8.93ef  | 9.32 de | 8.88 C  |
| 350 g N/ tree   | 8.69 f            | 9.31 d  | 9.90 c  | 9.30 B  | 8.59 fg     | 9.63 d  | 10.24 c | 9.48 B  |
| 450 g N/ tree   | 8.95 e            | 11.05 b | 12.05 a | 10.68 A | 9.38 de     | 10.87 b | 11.43 a | 10.56 A |
| Mean  | 8.71 C            | 9.77 B  | 10.35 A |         | 8.78 C      | 9.81 B  | 10.33 A |         |
| Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level. |                   |         |         |         |             |         |         |         |

**Fruit T.S.S./acidity ratio:**

Tabulated data of 2017 and 2018 seasons illustrates that the uppermost N fertilizer rate (450g/tree) induced high significant effect on TSS/acidity ratio of wonderful pomegranate as compared with the other studied rates in both studied seasons .While, humic acid applications improved TSS/acidity ratio as compared with the untreated trees treatment in both seasons. Shortly, 40g/tree of humic acid application showed superiority in this concern (Table, 14). With respect of the combination between nitrogen fertilizer and humic acid application it was observed a significant increment in TSS/acidity ratio due to this combination in 2017 and 2018 seasons. Briefly, 450g N/tree associated with 40g /tree of humic acid treatment ensured to be the most effective treatment in this respect.

**Fruit ascorbic acid content (mg/100 ml juice):**

Table, 15 reveals that nitrogen fertilizer at 450g /tree expressed high effect on ascorbic content of Wonderful pomegranate fruit as compared with the fertilizer of 250g N/tree in both seasons. However, humic acid applications at 40g/tree advanced ascorbic acid content as compared with control trees in 2017 and 2018 seasons. Generally,

humic acid application at 40g /tree was the best treatment in this concern. Moreover, the interaction between the studied factors exhibited that nitrogen fertilizer mixed with humic acid application enhanced fruit ascorbic acid content. Conclusively, 450g N/tree combined 40g HA /tree in the both season proved to be the greatest treatment in this respect. Other combinations showed an intermediate value in this concern.

**Table 15:-** Effect of nitrogen and humic acid applications on fruit ascorbic acid content of Wonderful pomegranate trees (2017 and 2018 seasons).

| Nitrogen rates  | Ascorbic acid (mg/100 ml juice) |         |         |         |             |         |         |         |
|---|---------------------------------|---------|---------|---------|-------------|---------|---------|---------|
|   | 2017                            |         |         |         | 2018        |         |         |         |
|   | Humic acids                     |         |         |         | Humic acids |         |         |         |
|   | 0 g                             | 20 g    | 40 g    | Mean    | 0 g         | 20 g    | 40 g    | Mean    |
| 250 g N/ tree   | 14.39 i                         | 14.50 h | 14.62 g | 14.50 C | 14.47 h     | 14.60 g | 14.77 f | 14.61 C |
| 350 g N/ tree   | 14.71 f                         | 14.85 e | 14.91 d | 14.82 B | 14.81 f     | 14.94 e | 15.07 d | 14.94 B |
| 450 g N/ tree   | 15.03 c                         | 15.23 b | 15.36 a | 15.21 A | 15.14 c     | 15.27 b | 15.36 a | 15.26 A |
| Mean  | 14.71 C                         | 14.86 B | 14.96 A |         | 14.81 C     | 14.94 B | 15.07 A |         |
| Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level. |                                 |         |         |         |             |         |         |         |

The enhancement effect of nitrogen fertilizer rates on fruit quality properties may be attributed that nitrogen is major constituent of many compounds of great physiological importance in metabolism (Mengel et al., 2001). Moreover, nitrogen fertilizer improved chlorophyll production and photosynthesis processes lead to more carbohydrate production which reflected on fruit quality. The obtained results of nitrogen fertilizer rates are in harmony with the findings of Mohamed et al. (2014) mentioned that nitrogen fertilization enhanced fruit quality of wonderful pomegranate trees.

The improved effect of humic acids on fruit quality may be due to it stimulation plant growth and consequently fruit quality through accelerated cell division and it enhanced uptake of nutrients and water (Chen et al., 2004 and Hussein and Hassan, 2011) and humic acid have similar effect like IAA on plants in this concern (O'Donnell, 1973) subsequently, improved fruit quality. Also, the increase in leaf total chlorophyll content was reflected in increasing rate of photosynthesis rate and accumulation of carbohydrates reserves which lead to positive effect on fruit quality. The obtained results of humic acids are in agreement with the findings of Celik et al. (1995) and Ferrara and Brunetti (2010) mentioned that applied humic acid at full bloom of Italy grape cultivar increased berry weight and maturity index values.

### Conclusion:-

In conclusion, results obtained in the current study showed that soil application of nitrogen fertilizer at 450 g/tree and humic acid application at 40g /tree alone or in combination enhanced vegetative growth, yield and fruit quality as well as reduced fruit cracking and sunburn damage of Wonderful pomegranate trees.

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