Agricultural Research & Technology
Open Access Journal
ISSN: 2471-6774

Research Article
Volume 20 Issue 2 - February 2019
DOI: 10.19080/ARTOAJ.2019.20.556120

Agri Res & Tech: Open Access J


# Response of Cotton Plant to Fertilization Sources and Foliar Spraying with Humic Acid

**Mahmoud Wagdy Mohamed El Shazly[1], Yousef Fathy Ahmed Ata Allah[1] and Ahmed Mohamed Abd El All[2]***

[1]*Cotton Physiology Department, Cotton Research Institute, Agriculture Research Center, Egypt*

[2]*Department of Botany, Faculty of Agriculture Shebin El-Kom, Menoufia University, Egypt*

**Submission**: February 14, 2019, **Published:** February 27, 2019

***Corresponding author:** Ahmed Mohamed Abd El All, Department of Botany, Faculty of Agriculture Shebin El-Kom, Menoufia University, Egypt

**Abstract**

**Background and objective:** Two field experiments were carried out on clay loam soil at El-Gemmeiza Agricultural Research Station, El-Gharbia Governorate, Egypt for the two successive seasons of 2017 and 2018, using the Egyptian cotton cultivar Giza 86 (Gossypiumbarbadense L.).

**Methodology:** These experiments were conducted to study the effect of three sources of fertilizers (mineral NPK, organic manures i.e. cattle manure and phytocompost manure) and foliar spraying with two humic acid rates (2.5cm3/l and 5cm3/l) three times(at squaring stage, at flowering initiation and at the top of flowering) and control (without humic acid application) as well as their interaction on cotton leaf water relations, photosynthetic pigments and chemical composition, growth, earliness traits, seed cotton yield and its components and fiber quality. A split plot design with three replicates was used in both seasons.

**Results:** Source of fertilizers had a significant effect on TWC, LWD, RWC, OP and plasma membrane integrity in leaves of cotton plants in both seasons, where the cotton plants fertilized by cattle manure caused an increase in TWC as well as RWC and leaves chlorophyll a, b and carotenoids content in both seasons, leaves total carbohydrates, total sugars, N, P and K % and significantly decreased LWD, OP and plasma membrane integrity, the activity of peroxidase and phynoloxidase and proline concentration in leaves of cotton plants when compared with the control plants. Cattle manure significantly increased total bolls set/ plant, boll setting %, and 1st picking percentage in both seasons. Also, source of fertilizers exhibited significant differences in number of open bolls/plants, boll weight and seed cotton yield per feddan in both seasons, where the heaviest bolls and highest number of open bolls/plants, and seed cotton yield per feddan in both seasons, resulted from plants fertilized with chemical fertilizers and from plants fertilized with cattle manure without significant differences between these two sources, while plants fertilized with organic fertilizer in the form of phytocompost had the lowest values. Foliar feeding with humic acid either at the low or the high rate recorded a significant increase in TWC, RWC and leaves chemical compositions i.e., total carbohydrates, total sugars, nitrogen %, phosphorus % and potassium % and recorded a significant decrease in LWD, OP, plasma membrane integrity, the proline and enzymes activity (peroxidase and phynoloxidase) in leaves of cotton plants when compared with the untreated plants. Humic acid treatments gave a significant effect on plant height at harvest, number of fruiting branches/plant, boll setting % and 1st picking percentage, number of open bolls/plant, boll weight and seed cotton yield/feddan in both seasons, in favor of foliar feeding with humic acid at a rate of 5cm3/l three times (at the squaring stage, flowering initiation and at the top of flowering) but untreated plants gave the lowest values of these traits and gave the highest value of boll shedding % in both seasons. Plants fertilized by cattle manure and received humic acid at the high rate (5cm3/l) significantly increased leaves TWC, RWC, chlorophyll a, b and carotenoids content in both seasons, leaves total carbohydrates, total sugars, N, P and K% contents. Also, this interaction significantly increased plant height at harvest, in the second season and significantly decreased LWD, OP, plasma membrane integrity, the activity of peroxidase and phynoloxidase and proline concentration in leaves of cotton plants, when compared with the control plants which fertilized by mineral NPK.

**Conclusion:** It could be recommended that, the use of organic manurein the form of cattle manure interacted with humic acid application on cotton plants led to increase the productivity of cotton plants in terms of quantity and quality.

**Keywords:** Foliar feeding; Humic acid; Egyptian cotton; Fertilizers; Agriculture

**Abbrevations:** TWC: Total Water Content; LWD: Leaf Water Deficit; RWC: Relative Water Content; OP: Osmotic Pressure

## Introduction

On the way of clean agriculture, the use of organic amendments such as animal manures i.e. cattle manure or Phytocompost in farming have many advantages i.e. reduce the use of chemical fertilizers and build biologically diverse agriculture, effective means of improving soil structure and its fertility, where they are excellent source of macro and micro nutrients which are plant-available and their addition to soil could increase activity and microbial population. In addition, the use of organic manures reduces hazards from nitrate leaching into groundwater compared to those from inorganically fertilized. In addition to the high cost of chemical fertilizers, use of chemical fertilizers constantly lead to decline soil chemical and physical properties, biological activities and thus, overall, the total soil health. Thus, the undesirable impacts of chemical fertilizers, coupled with their high prices, have prompted the interest in the use of organic fertilizers as a source of nutrients. The massive application of chemical fertilizers has created serious problems due to pollution with nitrates and N volatilization such as soil degradation, water pollution, air pollution and environmental problems related to phosphate fertilizer i.e. the phenomenon of eutrophication and the accumulation of cadmium in the soil and plants due to the presence of cadmium in phosphate fertilizer, where its accumulation in the leaves increases the amount of cadmium in the human food meal, where this element is highly toxic to humans. It accumulates in the kidneys and liver and ultimately in the bones, there for there is a danger unexpectedly large for the food chain [1].

For these reasons, the world is becoming aware of the need to cultivate cotton in an ecological or organic way [2]. In this concern, cattle manure seems to act directly in increasing crop growth and yields either by accelerating respiratory process with increasing cell permeability and hormonal growth action or by the combination of all of these processes which supplies N, P and S in available form to the plants via biological decomposition and improves physical properties of soil such as aggregation, permeability and water holding capacity [3], mineral fertilizers have the merit of being readily soluble in soil solution, less bulky and easy to manipulate but their constitution in most cases does not include the much needed essential minor elements as compared to cattle manures which meet this requirement [4].

In addition to the high cost, uses of mineral fertilizers constantly lead to decline soil chemical and physical properties, biological activities and thus, overall, the total soil health. Thus, the undesirable impacts of chemical fertilizers, coupled with their high prices, have prompted the interest in the use of organic fertilizers as a source of nutrients. Cattle manure is a decayed mixture of the dung and urine of cattle or other livestock with the straw and litter used as bedding and residues from the fodder fed to them. The nitrogen in the manure is subject to volatilization and leaching losses and the material that finally will be spread on the field may have low nitrogen content. The application of well-decomposed manure is more desirable than using fresh materials [5] and [6].

Using the organic substances for minimizing the use of chemical fertilizers Humic acid might show anti-stress effects under a biotic stress conditions such as unfavorable temperature, salinity, pH, etc., the functional groups of humic substance include carboxyl, phenolic hydroxyl, alcoholic hydroxyl, ketone and quinoid [7]. Humic substances are well known as stimulators of plant growth [8]. HA increases membrane permeability and facilitates transport of essential elements within plant roots [9]. Humic application to plants under normal and salt stress conditions could induce salinity tolerance of cotton plants and in turn improved plant growth, fruiting and yield particularly under salt stress and high temperature conditions [10]. [11] found that foliar spraying of humate $5cm^3/L$ three times increase plant tall, number of sympodia and open bolls per plant, weight of boll and yield of seed cotton per fed. [12] Reported that, humic acid are referred to as humic substances and are used as fertilizer amendments as foliar spray.

Plant height, first hand cotton seed yield, number of bolls and sympodial branches and total seed cotton yield affected by humic acid application. Humic acid application had no significant effect on ginning percentage and quality properties such as fiber length, fiber fineness and fiber strength. [13] indicated that humic acid (HA) application significantly increased leaf area per plant, plant height, number of fruiting branches per plant, dry weight and chemical constitutes either inorganic, N, P and K, while Na, Cl, Ca and Mg were decreased, or organic constitutes e.g. proline, total free amino acids, total sugars, total soluble phenols, chlorophyll a, b, total chlorophyll and total carotenoids. As a result of promoting growth induced by previous foliar applications, yield components e.g., numbers of total and open bolls/plant, seed cotton yield/plant, seed index and lint percentage were increased. [14] reported that foliar application with potassium humate (Potassium humate 85% + Potassium 8% + Fulvic Acid 3%) with $5cm^3$/liter gave the highest averages of yield and its components. Therefore, this study aimed to study the effect of using organic manures sources and humic acid as a natural material on cotton leaf water relations, photosynthetic pigments and chemical composition, growth, earliness traits, seed cotton yield and its components and fiber quality.

## Materials and Methods

### Area of study and sampling

Two field experiments were carried out at El-Gemmeiza Agricultural Research Station, El-Gharbia Governorate, Egypt for the two successive seasons of 2017 and 2018, using the Egyptian cotton cultivar Giza 86 (*Gossypiumbarbadense* L.). These experiments were conducted to study the effect of three sources of fertilizers (mineral NPK, cattle manure and phytocompost manure) and three humic acid rates (0, $2.5cm^3/l$ and $5cm^3/l$) as well as their interaction on cotton leaf chemical composition and water relations, growth, earliness traits, seed cotton yield and its components and fiber quality. A split plot design with three replicates was used in both seasons.

**The main plots were assigned to fertilizers source as followings:**

a. **$a_1$- Mineral fertilizer:** The recommended NPK rate (100%), i.e. 45kg N,22.5kg $P_2O_5$ and 24kg $K_2O$.

b. $a_2$- Phytocompost manure as a source of organic phytomanure.

c. $a_3$- Cattle manure as a source of organic animal manure.

**The sub-plots contained the humic acid (in the form of actosol) rates of:**


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a. $b_1$- Without humic acid application (control treatment).

b. $b_2$- Foliar spraying with humic acid at the rate of 2.5cm$^3$/ liter water three times.

c. $b_3$- Foliar spraying with humic acid at the rate of 5cm$^3$/ liter water three times.

Humic acid (in the form of actosol®)* as a foliar spraying on cotton leaves using hand operated sprayer compressed at a low volume of 200 liter per feddan. The lower leaf surface was sprayed until wetted as well as the upper surface.

**Table 1:** Main characteristics of humic acid in the form of actosol used in the study.

| Components | Value | Components | Value |
|---|---|---|---|
| pH | 7.6 | Total Chloride % | 0.5 |
| Humic Acid % | 20 | Total Iron ppm | 100 |
| Total Nitrogen % | 1 | Total Zinc ppm | 10 |
| Total Phosphorus % | 5 | Total Manganese ppm | 10 |
| Total Potassium % | 6 | Total Copper ppm | 10 |
| Total Magnesium % | 0.07 | Total Boron ppm | 7 |
| Total Calcium % | 0.08 | | |

*Humic acid is the active ingredient of actosol product, the natural organic fertilizer. The different constituents of actosol as reported by [15] were illustrated in Table 1. The preceding crop was Egyptian clover (Trifoliumalexandrinum L.) "berseem" from which one cut was taken and sugar beets(Beta vulgaris L.) in the first and second seasons, respectively.

## Mineral fertilizers application

**Table 2:** Soil analysis of the experimental site in the two seasons.

| Properties | Season 2017 | Season 2018 |
|---|---|---|
| Texture | Clay loam | Clay loam |
| pH | 7.9 | 8 |
| EC mmhos/ cm. | 0.33 | 0.37 |
| Organic matter % | 1.6 | 1.23 |
| Total N (mg/100g) | 56 | 43.05 |
| Available N (ppm) | 29.9 | 28.5 |
| Available P (ppm) | 12.5 | 11.9 |
| Available K (ppm) | 333 | 215 |
| Available Fe (ppm) | 11.3 | 6 |
| Available Mn (ppm) | 3.1 | 2.1 |
| Available Zn (ppm) | 1 | 0.7 |
| Available Cu (ppm) | 3.4 | 0.9 |

Phosphorus fertilizer was added as calcium super phosphate (15.5% $P_2O_5$) at a rate of 22.5kg $P_2O_5$/fed during land preparation. Inorganic nitrogen fertilizer was applied as ammonium nitrate (33.5% N) at a rate of 45kg N/ fed in two equal portions after thinning and at the next irrigation. Potassium fertilizer in the form of potassium sulphate (48% $K_2O$) was applied as soil application at a rate of 24 kg K2O at the first N dose application. Before planting, surface (0-30cm) soil samples were analyzed according to [16] and the results are depicted in Table 2.

## Organic manures application

The two organic manures were analyzed before use according to [17] and the amount used of each manure was determined according to its total nitrogen content and were incorporated with ridges after ridging and before sowing at a rate of 45kg N/fed. The results of their properties are shown in Table 3. The sub- plot size was 14 m2, (3.5m x 4m) including 5 ridges 70 cm apart and the hills 25cm apart with two plants/hill after thinning. Sowing date was 8 April in both seasons. The other cultural practices were carried out as recommended for conventional cotton seeding in the local production district.

**Table 3:** Organic manuresanalysis in the two seasons of study.

| Properties | Cattle Manure | | Phytocompost | |
|---|---|---|---|---|
| | Season 2017 | Season 2018 | Season 2017 | Season 2018 |
| $CaCO_3$ % | 1 | 1.1 | 0.2 | 0.17 |
| pH | 7.5 | 7.3 | 6.26 | 6.9 |
| EC mmhos/ cm. | 1.2 | 1.28 | 2.94 | 2.33 |
| Organic Matter % | 25 | 21.1 | 45 | 48 |
| Total N % | 0.88 | 0.76 | 2.2 | 1.94 |
| Available P% | 0.07 | 0.06 | 0.76 | 0.75 |
| Available K% | 0.59 | 0.48 | 0.7 | 0.78 |
| Available Ca% | 0.02 | 0.02 | 0.22 | 0.3 |
| Available Mg% | 0.2 | 0.19 | 0.3 | 0.22 |
| Available Na% | 0.03 | 0.03 | 0.11 | 0.02 |
| Available Fe (ppm) | 35.9 | 36.4 | 27.6 | 21.9 |
| Available Mn (ppm) | 87.3 | 77 | 110 | 125 |
| Available Zn (ppm) | 22.4 | 21.6 | 20 | 14 |
| Available Cu (ppm) | 6.7 | 6.7 | 1.7 | 1,4 |

## Studied characters

Ten leaves (fourth upper leaf) were randomly taken from plants of each plot after two weeks from the last spraying of humic acid to determine the following traits.



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**Water relations:** Total water content (TWC, %) [18] and [19], leaf water deficit (LWD, %), relative water content (RWC, %) [20], osmotic pressure [18], plasma membrane integrity [21].

**Photosynthetic pigments:** The photosynthetic pigments were extracted from fresh leaf sample (fourth upper leaf) by 85% acetone and determined according to the method described by Wettestein's formula in [22].

**Chemical analysis:** Total carbohydrates and total sugars were determinate using the phenol sulfuric acid method as described by [22]. Antioxidant enzymes activities as peroxidase and phynoloxidase were determined according to [23] and [24]. Proline concentration was measured according the ninhydrin method of [25]. N, P and K were determined as a described by [22].

**Growth:** plant height at harvest (cm) and number of fruiting branches/ plant.

**Earliness traits:** number of total flowers/plant number of total bolls/plant, boll setting percentage, boll shedding percentage and first picking percentage.

**Seed cotton yield and its components:** number of open bolls per plant, boll weight (g), limit percentage and seed index (weight of 100 cotton seeds in grams).The seed cotton yield per feddan was estimated as the weight of seed cotton in kilograms picked twice from each-sub plot and transformed to kentars per feddan (one kentar = 157.5kg)

**Fiber quality:** Samples of lint were collected from each treatment at each replicate to determine the following characters at the laboratories of Cotton Research Institute, ARC, under standard conditions of test as reported by [26]: fiber length (2.5% span length in mm) and uniformity index (%) were determined by fibrograph instrument, fiber fineness (micronaire reading), it was determined by Micronaire instrument and fiber strength (Pressley index), it was determined by Pressley instrument.

**Statistical analysis:** The statistical analysis of the obtained data in the two seasons was done and performed according to [27] using M State-C microcomputer program for split plot design, and the treatments means were compared using LSD at 0.05.

## Results

### Water relations

**Table 4:** Effect of fertilization sources and foliar feeding with humicacid as well as their interaction on water relations of cotton plants in 2017 and 2018 seasons.

| Traits\Treatments | | TWC (%) | LWD (%) | RWC (%) | O.P. (bar) | Plasa. Memb. Perm. (%) |
|---|---|---|---|---|---|---|
| Season 2017 | | | | | | |
| A-source of Fertilizers | | | | | | |
| A1Mineral Fertilizer | | 81.37 | 10.15 | 72.07 | 5.6 | 22.25 |
| A2 Compost | | 81.22 | 10.02 | 71.72 | 5.8 | 21.95 |
| A3 Cattle Manure | | 83.91 | 9.67 | 73.61 | 4.78 | 21.44 |
| LSD at 5% | | 0.34 | 0.3 | 0.68 | 0.36 | 0.41 |
| B-Humic Acid Concentration | | | | | | |
| B1 Control | | 80.84 | 10.46 | 72 | 5.7 | 22.11 |
| B2 2.5cm$^3$/l | | 82.23 | 9.36 | 72.4 | 5.54 | 21.95 |
| B3 5cm$^3$/l | | 83.43 | 10.02 | 73 | 4.94 | 21.58 |
| LSD at 5% | | 1.38 | 0.28 | 0.7 | 0.39 | 0.15 |
| AXB Interaction | | | | | | |
| A1 | B1 | 78.81 | 10.53 | 70.52 | 5.46 | 21.99 |
| | B2 | 81.91 | 9.12 | 72.56 | 6.12 | 22.55 |
| | B3 | 83.4 | 10.81 | 73.13 | 5.21 | 22.22 |
| A2 | B1 | 80.83 | 10.07 | 72.37 | 6.33 | 22.23 |
| | B2 | 80.92 | 9.42 | 71.16 | 5.52 | 22.12 |
| | B3 | 81.91 | 10.58 | 71.64 | 5.55 | 21.49 |
| A3 | B1 | 82.89 | 10.78 | 73.11 | 5.31 | 22.11 |
| | B2 | 83.87 | 9.55 | 73.49 | 4.97 | 21.2 |
| | B3 | 84.98 | 8.68 | 74.23 | 4.06 | 21.02 |
| LSD at 5% | | 2.39 | 0.48 | 1.21 | 0.67 | 0.26 |
| Season 2018 | | | | | | |
| A-Source of Fertilizers | | | | | | |



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| | | | | | |
|---|---|---|---|---|---|
| A1 Mineral Fertilizer | | 84.31 | 10.96 | 74.41 | 6.4 | 29.3 |
| A2 Compost | | 83.86 | 11.06 | 74.72 | 6.16 | 29.55 |
| aA3 Cattle Manure | | 86.43 | 9.31 | 76.7 | 4.61 | 27.43 |
| LSD at 5% | | 0.72 | 0.82 | 1.06 | 1.03 | 0.88 |
| **B-Humic Acid Concentration** | | | | | | |
| B1 Control | | 83.4 | 10.7 | 74.2 | 6.56 | 29.56 |
| B2 2.5cm3/l | | 85.11 | 10.56 | 75.21 | 5.67 | 28.88 |
| B3 5cm3/l | | 86.08 | 10.06 | 76.42 | 4.94 | 27.86 |
| LSD at 5% | | 0.77 | 0.31 | 1.08 | 0.95 | 0.55 |
| **AXB Interaction** | | | | | | |
| A1 | B1 | 83.84 | 10.62 | 73.86 | 6.84 | 30.81 |
| | B2 | 84.05 | 12.65 | 74.24 | 6.72 | 29.1 |
| | B3 | 85.03 | 9.6 | 75.13 | 5.65 | 28 |
| A2 | B1 | 80.67 | 11.54 | 73.07 | 7.41 | 29.82 |
| | B2 | 84.92 | 10.14 | 74.83 | 5.72 | 29.78 |
| | B3 | 85.99 | 11.49 | 76.26 | 5.34 | 29.06 |
| A3 | B1 | 85.69 | 9.94 | 75.66 | 5.44 | 28.04 |
| | B2 | 86.36 | 8.9 | 76.56 | 4.56 | 27.75 |
| | B3 | 87.23 | 9.09 | 77.87 | 3.82 | 26.51 |
| LSD at 5% | | 1.33 | 0.54 | 1.87 | 1.65 | 0.95 |

The data in Table 4 showed that, the cotton plants fertilized by cattle manure caused an increase in TWC as well as RWC and decrease in LWD, OP and plasma membrane integrity in leaves of cotton plants, when compared with the control plants (Mineral fertilizer). The second season is the same of the first one. In the same table, the high level of humic acid ($5cm^2/l$) recorded a significant increase in TWC and RWC and recorded a decrease in LWD, OP and plasma membrane integrity in leaves of cotton plants, when compared with the control plants.

The same increase in TWC and RWC was recorded at the all interactions between compost and Cattle manure with humic acid. And the same interactions caused a significant decrease in LWD, OP and plasma membrane integrity in leaves of cotton plants. The higher increase in TWC and RWC and the lowest values of LWD, OP and plasma membrane integrity in leaves of cotton plants throw the interactions was recorded at Cattle manure interacted with humic acid at the high level. The results of the second season are the same of the first one.

## Photosynthetic pigments

**Table 5:** Effect of fertilization sources and foliar feeding with humic acid as well as their interaction on photosynthetic pigments of cotton plants leaves in 2017 and 2018 seasons.

| Treatments\ Traits | Chl. A.(mg/gdwt) | Chl. B. (mg/gdwt) | Carotenoides (mg/gdwt) | Chl. A. (mg/gdwt) | Chl. B. (mg/gdwt) | Carotenoides (mg/gdwt) |
|---|---|---|---|---|---|---|
| | **Season 2017** | | | **Season 2018** | | |
| **A-Source of Fertilizers** | | | | | | |
| A1Mineral Fertilizer | 3.494 | 1.414 | 1.525 | 3.593 | 1.463 | 1.587 |
| A2 Compost | 3.496 | 1.42 | 1.579 | 3.595 | 1.475 | 1.62 |
| A3 Cattle manure | 3.703 | 1.602 | 1.811 | 3.81 | 1.647 | 1.858 |
| LSD at 5% | 0.008 | 0.017 | 0.056 | 0.006 | 0.009 | 0.039 |
| **B-Humic Acid Concentration** | | | | | | |
| B1 Control | 3.453 | 1.345 | 1.457 | 3.558 | 1.413 | 1.516 |
| B2 $2.5cm^3/l$ | 3.567 | 1.511 | 1.683 | 3.664 | 1.554 | 1.723 |
| B3 $5cm^3/l$ | 3.673 | 1.58 | 1.775 | 3.776 | 1.618 | 1.826 |
| LSD at 5% | 0.095 | 0.053 | 0.085 | 0.068 | 0.054 | 0.085 |
| **AXB Interaction** | | | | | | |



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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| A1 | B1 | 3.461 | 1.299 | 1.265 | 3.354 | 1.373 | 1.438 |
| | B2 | 3.462 | 1.439 | 1.559 | 3.625 | 1.476 | 1.596 |
| | B3 | 3.558 | 1.503 | 1.752 | 3.799 | 1.541 | 1.727 |
| A2 | B1 | 3.272 | 1.173 | 1.364 | 3.554 | 1.246 | 1.312 |
| | B2 | 3.531 | 1.485 | 1.682 | 3.564 | 1.541 | 1.728 |
| | B3 | 3.685 | 1.601 | 1.690 | 3.668 | 1.639 | 1.828 |
| A3 | B1 | 3.625 | 1.563 | 1.742 | 3.766 | 1.62 | 1.798 |
| | B2 | 3.708 | 1.608 | 1.807 | 3.802 | 1.646 | 1.844 |
| | B3 | 3.776 | 1.636 | 1.883 | 3.861 | 1.674 | 1.931 |
| LSD at 5% | | 0.164 | 0.092 | 0.147 | 0.118 | 0.093 | 0.147 |

The illustrated data in Table 5 cleared that, the cotton plants fertilized by compost as well as cattle manure increased the values of leaves chlorophyll a, b and carotenoids contents in both seasons. Whereas, the greatest values of leaves plant pigments contents were recorded in leaves of cotton plants fertilized by cattle manure. On the same side, the all levels of humic acid significantly increased leaves concentration of chlorophyll a, b and carotenoids as compared with the control in both of seasons. The highest increase of chlorophyll a, b and carotenoids content in cotton leaves were obtained as a result of foliar spraying of humic acid level at 5.0cm$^3$/l.

In the same table, the interaction between the compost and Cattle manure with humic foliar applications recorded an increase in chlorophyll a, b and carotenoids at all levels.

## Chemical composition

**Table 6:** Effect of fertilization sources and foliar feeding with humic acid as well as their interaction on chemical composition of cotton plants leaves in 2018 season.

| Traits\Treatments | | Total Carbohydrates (mg/g d. wt) | Total Sugars (mg/g d. wt) | Per-oxidase (O.D./g fwt. after 2min.) | Phenol-oxidase (O.D./g fwt after 45min.) | Proline conc. (µg lucine/ gm d.wt) | N % | P % | K % |
|---|---|---|---|---|---|---|---|---|---|
| A-Source of Fertilizers | | | | | | | | | |
| A1Mineral Fertilizer | | 136.16 | 68.35 | 134.09 | 58.92 | 335.98 | 1.985 | 0.264 | 2.62 |
| A2 Compost | | 148.51 | 75.11 | 128.52 | 56.55 | 320.62 | 2.176 | 0.267 | 2.825 |
| A3 Cattle Manure | | 209.63 | 104.4 | 113.94 | 52.22 | 297.83 | 2.873 | 0.352 | 3.328 |
| LSD at 5% | | 10.38 | 2.4 | 6.35 | 0.25 | 4.34 | 0.104 | 0.007 | 0.206 |
| B-Humic Acid Concentration | | | | | | | | | |
| B1 Control | | 127.56 | 61.62 | 136.78 | 58.83 | 337.69 | 2.097 | 0.24 | 2.551 |
| B2 2.5cm$^3$/l | | 165.05 | 85.87 | 124.83 | 55.99 | 317.85 | 2.275 | 0.308 | 2.965 |
| B3 5cm$^3$/l | | 201.69 | 100.37 | 114.94 | 52.87 | 298.88 | 2.662 | 0.334 | 3.256 |
| LSD at 5% | | 18.05 | 7.87 | 1.15 | 1.77 | 7.61 | 0.163 | 0.025 | 0.124 |
| AXB Interaction | | | | | | | | | |
| A1 | B1 | 98.59 | 49.66 | 142.58 | 61.09 | 353.71 | 1.872 | 0.217 | 2.276 |
| | B2 | 132.08 | 66.59 | 141.63 | 60.73 | 347.7 | 1.917 | 0.277 | 2.464 |
| | B3 | 177.81 | 88.79 | 117.85 | 54.95 | 306.52 | 2.165 | 0.298 | 3.119 |
| A2 | B1 | 93.2 | 44.84 | 151.75 | 62.29 | 354.03 | 1.86 | 0.196 | 2.215 |
| | B2 | 153.09 | 86.72 | 118.58 | 55.17 | 308.92 | 2.109 | 0.289 | 3.069 |
| | B3 | 199.23 | 93.78 | 115.24 | 52.18 | 298.91 | 2.559 | 0.315 | 3.192 |
| A3 | B1 | 190.88 | 90.35 | 116 | 53.1 | 305.34 | 2.559 | 0.308 | 3.162 |
| | B2 | 209.97 | 104.31 | 114.09 | 52.07 | 296.93 | 2.798 | 0.359 | 3.363 |
| | B3 | 228.03 | 118.55 | 111.73 | 51.49 | 291.21 | 3.263 | 0.388 | 3.458 |
| LSD at 5% | | 31.26 | 13.63 | 1.99 | 3.07 | 13.17 | 0.282 | 0.043 | 0.215 |



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Data in Table 6, showed that, the leaves chemical contents of cotton plants which fertilized by compost as well as cattle manure increased the leaves total carbohydrates, total sugars, N%, P% and K%. Meanwhile, the activity of peroxidase and phynoloxidase and proline concentration were decreased as a result of compostand cattle manure treatments when compared with the control plants. Whereas, at cattle manure fertilizer produced the higher concentration of leaves chemical contents as total carbohydrates, total sugars, N%, P% and K% by about53.96, 52.74, 44.74, 33.33 and 27.02% respectively.

The highest valuesof total carbohydrates, total sugars, N, P and K % content in cotton leaves throw the interactions were recorded at cattle manure fertilizer interacted with humic level 5 $cm^3$/l followed by cattle manure fertilizer interacted with humic level 2.5 $cm^3$/l respectively, when compared with the control plants. The results in the second season are the seamed of the first one.

When regard to the chemicals content and were recorded in Table 6, the results cited that, the humic acid levels had a significant increase in leaves chemical compositions i.e., total carbohydrates, total sugars, nitrogen %, phosphorus % and potassium %. Meanwhile, the proline and enzymes activity (peroxidase and phynoloxidase) were recorded a low concentration as a result of hmic acid treatments when compared with the untreated plants. The highest increase of total carbohydrates, total sugars, N, P and K% content in cotton leaves were obtained as a result of foliar spraying of humic acid at 5$cm^3$/l as compared with the control plants.

## Growth traits

**Table 7:** Effect of fertilization sources and foliar feeding with humic acid as well as their interaction on growth traits in 2017 and 2018 seasons.

| Traits\Treatments | | Final Plant Height (cm) | | No. of Fruiting Branches/Plant | |
|---|---|---|---|---|---|
| | | Season 2017 | Season 2018 | Season 2017 | Season 2018 |
| **A-Source of Fertilizers** | | | | | |
| A1Mineral Fertilizer | | 158.34 | 145.49 | 15.81 | 15.91 |
| A2 Compost | | 156.63 | 144.97 | 15.66 | 15.7 |
| A3 Cattle Manure | | 158.13 | 150.29 | 15.76 | 15.95 |
| LSD at 5% | | NS | 1.19 | NS | NS |
| **B-Humic Acid Concentration** | | | | | |
| B1 Control | | 158.64 | 144.21 | 15.81 | 15.67 |
| B2 2.5$cm^3$/l | | 157.12 | 147.04 | 15.68 | 15.81 |
| B3 5$cm^3$/l | | 157.36 | 149.49 | 15.73 | 16.08 |
| LSD at 5% | | NS | 1.13 | NS | 0.06 |
| **AXB Interaction** | | | | | |
| A1 | B1 | 161.08 | 140.2 | 16.07 | 15.63 |
| | B2 | 158.28 | 146.93 | 15.81 | 15.93 |
| | B3 | 155.67 | 149.33 | 15.57 | 16.17 |
| A2 | B1 | 154.93 | 143.97 | 15.47 | 15.5 |
| | B2 | 156.97 | 144 | 15.7 | 15.47 |
| | B3 | 158 | 146.93 | 15.8 | 16.13 |
| A3 | B1 | 159.9 | 148.47 | 15.9 | 15.89 |
| | B2 | 156.1 | 150.2 | 15.53 | 16.03 |
| | B3 | 158.4 | 152.2 | 15.83 | 15.93 |
| LSD at 5% | | 3.72 | 1.96 | NS | 0.18 |

Results in the second season (Table 7) revealed that compared to the control (the recommended mineral fertilizer), the application of cattle manure as organic fertilizer resulted in significantly taller plants in the second season followed by application of of mineral fertilizers (control). While, shorter plants were obtained from plants which received phytocompostas organic manure. However, the differences in number of fruiting branches/plant did not reach the level of significance in both seasons.

Results in Table 7 show that, humic acid treatments exhibited significant differences in plant height at harvest and number of fruiting branches/plant in the second season only. Compared to the control (untreated plants), the plants received humic acid at the high rate (5$cm^3$/l water) three times in the second season. significantly increased plant height at harvest and number of fruiting branches/plant at harvest followed by the plants received humic acid at the low rate (2.5$cm^3$/l water) three times. The differences



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in plant height at harvest and number of fruiting branches/plant due to humic acid application may be attributed mainly to the differences in average inter node length and/or number of main stem internodes.

The interaction between source of fertilizers and humic acid treatments (A x b) for plant height at harvest was significant in both seasons (Table 7), in favor of mineral fertilized plants without humic acid application in the first season and in favor of cattle manure fertilized plants which received humic acid as foliar spraying at the high rate (5cm$^3$/l water) three times. While, plants fertilized with phytocompost manure or with mineral fertilizer without humic acid application produced the shortest plants in the first and second seasons, respectively. Regarding number of fruiting branches/plant, the interaction gave significant effect on this trait in the second season only, in favor of cattle manure fertilized plants which received humic acid as foliar spraying at the high rate (5cm$^3$/l water) three times.

## Earliness traits

Concerning the effect of the fertilization sources on number of total flowers/plant, number of total bolls set/plant, boll setting %, boll shedding % and 1$^{st}$ picking percentage, the results in Table 8 show that the differences among the three sources reach the level of significance for number of total flowers / plant in the second season only, in favor of mineral source, for number of total bolls set/plant, boll setting %, and 1$^{st}$ picking percentage in both seasons, in favor of cattle manure. While, the lowest number of total bolls set/plant, boll setting %, and 1$^{st}$ picking percentage and the highest boll shedding % were obtained from phytocompost manure in both seasons.

Humic treatments gave significant effect on boll setting % and 1$^{st}$ picking percentage in both seasons (Table 8), in favor of foliar feeding with humic acid at the high rate following by the low rate and at last untreated plants without significant differences between the two former treatments. Also, the two rates of humic acid had pronounced effect on number of total flowers/plant and number of total bolls set/plant in both seasons, but untreated plants gave the lowest values of these two traits and gave the highest value of boll shedding % in both seasons. The interaction gave insignificant effect on these traits during the two seasons of study (Table 8).

## Seed cotton yield/feddan and its components

**Table 8:** Effect of fertilization sources and foliar feeding with humic acid as well as their interaction on earliness traits in 2017 and 2018 seasons.

| Traits\Treatments | | No. of Total Flowers/ Plant | No. of Total Bolls/ Plant | Boll Setting % | Boll Shedding % | Earliness % |
|---|---|---|---|---|---|---|
| Season 2017 | | | | | | |
| A-Source of Fertilizers | | | | | | |
| A1Mineral Fertilizer | | 29.9 | 20.75 | 69.37 | 30.63 | 73.78 |
| A2 Compost | | 29.88 | 20.12 | 67.25 | 32.75 | 71.16 |
| A3 Cattle Manure | | 29.51 | 21.06 | 71.3 | 28.7 | 75.13 |
| LSD at 5% | | NS | 0.59 | 1.55 | 1.55 | 2.26 |
| B-Humic Acid Concentration | | | | | | |
| B1 Control | | 28.3 | 18.92 | 66.85 | 33.15 | 66.08 |
| B2 2.5cm$^3$/l | | 30.66 | 21.58 | 70.39 | 29.61 | 76.72 |
| B3 5cm$^3$/l | | 30.34 | 21.44 | 70.69 | 29.31 | 77.28 |
| LSD at 5% | | 0.61 | 0.69 | 1.69 | 1.69 | 2.36 |
| AXB Interaction | | | | | | |
| A1 | B1 | 28.3 | 19.2 | 67.84 | 32.16 | 67.2 |
| | B2 | 31 | 21.41 | 69.04 | 30.96 | 77.56 |
| | B3 | 30.39 | 21.65 | 71.24 | 28.76 | 76.58 |
| A2 | B1 | 28.36 | 18.21 | 64.19 | 35.81 | 63.14 |
| | B2 | 30.75 | 21.01 | 68.31 | 31.69 | 75.46 |
| | B3 | 30.54 | 21.14 | 69.24 | 30.76 | 74.9 |
| A3 | B1 | 28.23 | 19.35 | 68.52 | 31.48 | 67.9 |
| | B2 | 30.23 | 22.31 | 73.8 | 26.2 | 77.14 |
| | B3 | 30.08 | 21.53 | 71.59 | 28.41 | 80.36 |
| LSD at 5% | | NS | NS | NS | NS | NS |
| Season 2018 | | | | | | |



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| | | | | | | |
|---|---|---|---|---|---|---|
| **A-Source of Fertilizers** | | | | | | |
| A1 Mineral Fertilizer | | 31.28 | 20.16 | 64.44 | 35.56 | 71.17 |
| A2 Compost | | 31.16 | 19.46 | 62.41 | 37.59 | 69.74 |
| A3 Cattle Manure | | 29.94 | 19.86 | 66.27 | 33.73 | 72.26 |
| LSD at 5% | | 0.89 | 0.44 | 1.47 | 1.47 | 1.6 |
| **B-Humic Acid Concentration** | | | | | | |
| B1 Control | | 28.79 | 17.84 | 62.04 | 37.96 | 63.93 |
| B2 2.5cm³/l | | 31.42 | 20.52 | 65.4 | 34.6 | 73.55 |
| B3 5cm³/l | | 32.17 | 21.12 | 65.69 | 34.31 | 75.69 |
| LSD at 5% | | 0.91 | 0.35 | 1.6 | 1.6 | 1.26 |
| **AXB Interaction** | | | | | | |
| A1 | B1 | 29.37 | 18.49 | 62.98 | 37.02 | 63.17 |
| | B2 | 32.29 | 20.7 | 64.12 | 35.88 | 74.14 |
| | B3 | 32.19 | 21.3 | 66.21 | 33.79 | 76.21 |
| A2 | B1 | 29.3 | 17.41 | 59.51 | 40.49 | 62.36 |
| | B2 | 31.83 | 20.18 | 63.43 | 36.57 | 72.33 |
| | B3 | 32.35 | 20.8 | 64.31 | 35.69 | 74.52 |
| A3 | B1 | 27.71 | 17.63 | 63.62 | 36.38 | 66.27 |
| | B2 | 30.14 | 20.69 | 68.64 | 31.36 | 74.17 |
| | B3 | 31.97 | 21.26 | 66.54 | 33.46 | 76.34 |
| LSD at 5% | | NS | NS | NS | NS | NS |

Concerning the effect of fertilizers source on number of open bolls/plant, results in Table 9 show that, source of fertilizers exhibited significant differences in number of open bolls/plant in both seasons (Table 9), where the highest number resulted from plants fertilized with cattle manure in the first season and from plants fertilized with chemical fertilizers in the second season without significant differences between this treatment and the former treatment in both seasons., while plants fertilized with organic fertilizer in the form of phytocompost had the lowest number in both seasons. Fertilizers source exhibited significant differences in seed cotton yield per feddan in both seasons (Table 9). The highest seed cotton yield per feddan (9.53 and 9.54, 11.76 and 11.63 kentar) were obtained from plants which fertilized with mineral fertilizers and cattle manure in the first and second seasons, respectively without significant differences between these two sources then it considerably decreased as a result of using phytocompost manure.

**Table 9:** Effect of fertilization sources and foliar feeding with humic acid as well as their interaction on seed cotton yield and yield components in 2017 and 2018 seasons.

| Traits\Treatments | No. of Open Bolls/ Plant | Boll Weight (g) | Lint % | Seed Index (g) | Seed Cotton Yield (kentar/fed) |
|---|---|---|---|---|---|
| **Season 2017** | | | | | |
| **A-Source of Fertilizers** | | | | | |
| A1Mineral Fertilizer | 20.75 | 3.19 | 41.51 | 11.oo | 9.53 |
| A2 Compost | 20.12 | 3.09 | 41.47 | 10.98 | 9.11 |
| A3 Cattle Manure | 21.06 | 3.11 | 41.4 | 10.8 | 9.54 |
| LSD at 5% | 0.59 | 0.04 | NS | NS | 0.12 |
| **B-Humic Acid Concentration** | | | | | |
| B1 Control | 18.92 | 3.02 | 41.07 | 10.77 | 8.61 |
| B2 2.5cm3/l | 21.58 | 3.18 | 41.55 | 11.19 | 9.78 |
| B3 5cm3/l | 21.44 | 3.19 | 41.75 | 10.81 | 9.78 |
| LSD at 5% | 0.69 | 0.07 | NS | NS | 0.33 |
| **AXB Interaction** | | | | | |



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| | | | | | | |
|---|---|---|---|---|---|---|
| A1 | B1 | 19.2 | 3.08 | 41 | 10.8 | 8.77 |
| | B2 | 21.41 | 3.23 | 41.7 | 11.22 | 9.74 |
| | B3 | 21.65 | 3.25 | 41.83 | 10.97 | 10.07 |
| A2 | B1 | 18.21 | 3.01 | 41 | 10.85 | 8.39 |
| | B2 | 21.01 | 3.18 | 41.6 | 11.27 | 9.61 |
| | B3 | 21.14 | 3.08 | 41.8 | 10.81 | 9.33 |
| A3 | B1 | 19.35 | 2.98 | 41.2 | 10.67 | 8.69 |
| | B2 | 22.31 | 3.12 | 41.36 | 11.09 | 9.99 |
| | B3 | 21.53 | 3.22 | 41.63 | 10.64 | 9.94 |
| LSD at 5% | | NS | NS | NS | NS | NS |
| **Season 2018** | | | | | | |
| **A-Source of Fertilizers** | | | | | | |
| A1 Mineral Fertilizer | | 20.16 | 3.12 | 40.87 | 10.22 | 11.76 |
| A2 Compost | | 19.46 | 3.08 | 41.38 | 10.1 | 11.08 |
| A3 Cattle Manure | | 19.86 | 3.14 | 41.46 | 9.98 | 11.63 |
| LSD at 5% | | 0.44 | 0.02 | NS | NS | 0.25 |
| **B-Humic Acid Concentration** | | | | | | |
| B1 Control | | 17.84 | 3.06 | 41.07 | 10.15 | 9.84 |
| B2 2.5cm³/l | | 20.52 | 3.14 | 41.25 | 9.93 | 12.07 |
| B3 5cm³/l | | 21.12 | 3.14 | 41.39 | 10.22 | 12.56 |
| LSD at 5% | | 0.35 | 0.02 | NS | NS | 0.21 |
| **AXB Interaction** | | | | | | |
| A1 | B1 | 18.49 | 3.04 | 39.07 | 10.62 | 10.23 |
| | B2 | 20.7 | 3.13 | 41.64 | 9.81 | 12.18 |
| | B3 | 21.3 | 3.18 | 41.9 | 10.24 | 12.86 |
| A2 | B1 | 17.41 | 3.05 | 41.98 | 9.96 | 9.5 |
| | B2 | 20.18 | 3.11 | 41.8 | 10.04 | 11.73 |
| | B3 | 20.8 | 3.08 | 40.36 | 10.3 | 12.01 |
| A3 | B1 | 17.63 | 3.07 | 42.15 | 9.88 | 9.79 |
| | B2 | 20.69 | 3.15 | 40.32 | 9.95 | 12.3 |
| | B3 | 21.26 | 3.17 | 41.92 | 10.12 | 12.81 |
| LSD at 5% | | NS | 0.06 | NS | NS | NS |

Significant differences were found among the three humic acid treatments as for number of open bolls/plant and boll weight in both seasons (Table 9), in favor of foliar feeding with humic acid at a rate of 5cm³/l three times followed in ranking by foliar feeding with humic acid at a rate of 2.5cm³/l three times and untreated plants (control). The positive effect due to humic acid is due primarily to the significant increase in number of fruiting branches/plant in the second season and boll setting percentage in both seasons. The significant increase in boll weight due to humic acid application over the control is mainly referring to the little increase in both seed index and lint percentage.

Regarding the effect of humic acid treatments with regard to seed cotton yield/fed, results in Table 9 show that seed cotton yield/fed was significantly affected by humic acid treatments (without, 2.5cm³/land 5.0 5cm³/l) in both seasons, where foliar feeding with humic acid in the form of actosolat a rate of 5.0g/l three times [at the squaring stage, flowering initiation and at the top of flowering] significantly out- yielded humic acid at the low rate (2.5cm³/l) and the control (untreated plants). The increase in seed cotton yield/fed obtained by humic acid application at the high rate (5.0cm³/l) was about 13.59% and 27.64% over the control (untreated plants) in the first and second seasons, respectively and by 4.06% over humic acid at the low rate (2.5cm³/l) in the second season.

The interaction between source of fertilizers and humic acid treatments (A x b) had a significant effect on boll weight in the second season only (Table 9), in favor of mineral fertilized plants and cattle manure fertilized plants which received humic acid as foliar


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spraying at the high rate (5cm$^3$/l water) three times and gave insignificant effect on number of open bolls/plant and seed cotton yield/fed in both seasons.

## Fiber traits

Source of fertilization significantly affected fiber length and uniformity index in the second season only (Table 10), where the longest fibers and highest uniformity index were obtained from phytocompost manure followed by cattle manure. However, the shortest fibers and the lowest uniformity index were recorded by mineral fertilization (the control treatment). Micronaire reading and fiber strength were insignificantly affected by source of fertilization.

**Table 10:** Effect of fertilization sources and foliar feeding with humic acid as well as their interaction on fiber traits in 2017 and 2018 seasons.

| Traits\Treatments | | 2.5% Span Length(mm) | Uniformity Index (%) | Micronaire Reading | Pressley Index |
|---|---|---|---|---|---|
| **Season 2017** | | | | | |
| **A-Source of Fertilizers** | | | | | |
| A1Mineral Fertilizer | | 34.47 | 86.7 | 4.4 | 10 |
| A2 Compost | | 34.63 | 86.17 | 4.63 | 10.07 |
| A3 Cattle Manure | | 33.97 | 86.5 | 4.63 | 9.93 |
| LSD at 5% | | NS | NS | NS | NS |
| **B-Humic Acid Concentration** | | | | | |
| B1 Control | | 34.27 | 86.97 | 4.63 | 9.57 |
| B2 2.5cm$^3$/l | | 34.13 | 86.13 | 4.57 | 10.4 |
| B3 5cm$^3$/l | | 34.67 | 86.27 | 4.47 | 10.03 |
| LSD at 5% | | NS | NS | NS | NS |
| **AXB Interaction** | | | | | |
| A1 | B1 | 34.2 | 87.4 | 4.4 | 9.8 |
| | B2 | 34.4 | 86.6 | 4.5 | 10.4 |
| | B3 | 34.8 | 86.1 | 4.3 | 9.8 |
| A2 | B1 | 34.8 | 87.2 | 4.8 | 9.4 |
| | B2 | 35.4 | 85.3 | 4.5 | 10.5 |
| | B3 | 33.7 | 86 | 4.6 | 10.3 |
| A3 | B1 | 33.8 | 86.3 | 4.7 | 9.5 |
| | B2 | 32.6 | 86.5 | 4.7 | 10.3 |
| | B3 | 35.5 | 86.7 | 4.5 | 10 |
| LSD at 5% | | NS | NS | NS | NS |
| **Season 2018** | | | | | |
| **A-Source of Fertilizers** | | | | | |
| A1 Mineral Fertilizer | | 33.25 | 85.75 | 4.63 | 10.25 |
| A2 Compost | | 33.62 | 86.73 | 4.55 | 10.33 |
| A3 Cattle Manure | | 33.38 | 85.83 | 4.48 | 10.25 |
| LSD at 5% | | 0.19 | 0.23 | NS | NS |
| **B-Humic Acid Concentration** | | | | | |
| B1 Control | | 33.67 | 86.35 | 4.56 | 10.22 |
| B2 2.5cm$^3$/l | | 33.1 | 85.42 | 4.59 | 10.23 |
| B3 5cm$^3$/l | | 33.48 | 86.55 | 4.53 | 10.38 |
| LSD at 5% | | 0.2 | 0.35 | NS | NS |
| **AXB Interaction** | | | | | |
| A1 | B1 | 33.6 | 85.55 | 4.6 | 10.05 |
| | B2 | 32.95 | 85.45 | 4.6 | 10.1 |
| | B3 | 33.2 | 86.25 | 4.7 | 10.6 |


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| | | | | | |
|---|---|---|---|---|---|
| A2 | B1 | 33.65 | 86.6 | 4.43 | 10.45 |
| | B2 | 33.6 | 86.45 | 4.6 | 10.15 |
| | B3 | 33.6 | 87.15 | 4.63 | 10.4 |
| A3 | B1 | 33.75 | 86.9 | 4.63 | 10.15 |
| | B2 | 32.75 | 84.35 | 4.53 | 10.45 |
| | B3 | 33.65 | 86.25 | 4.27 | 10.15 |
| LSD at 5% | | 0.3 | 0.6 | NS | NS |

Untreated plants and foliar feeding with humic acid at the high rate (5cm$^3$/l water) three times significantly increased fiber length and uniformity index in the second, but the lowest values resulted from humic acid at the low rate (2.5cm$^3$/l water). The interaction gave significant effect on fiber length and uniformity index in the second season only, in favor of organic manures when combined with the humic acid or without humic acid application.

## Discussion

The balance of water relations in plant cells of cotton plants and treated with organic manure, humic acid and their interaction is refer to the good water absorption and plant cells contains of good concentrations of N, P and K. [28] reported that the hormone-like activity of HA, which is indicated as concentration-specific improved absorption of mineral nutrients because of increases in cell permeability and [29] found that foliar feeding with humic acid (5cm$^3$/L) caused a significant increase in total water and relative water contents in leaves of cotton plant in both seasons. However, foliar feeding with humic acid (5cm$^3$/L) caused a significant reduction in osmotic pressure and the plasma membrane permeability of cotton plants in both seasons. The increase in chlorophyll a, b and carotene which refer to the application of cattle manure and phytocompost could be attributed to increasing N in leaves.

Nitrogen is an essential nutrient in creating plant dry matter as well as many energy rich compounds which regulate photosynthesis. There is an optimal relationship between nitrogen contents in the plant and $CO_2$ assimilation. In this concern, [30] the highest chlorophylls content obtained from the application of organic manure (sheep manure compost) at rate 30kg N+30kg N mineral and sprayed with kinetin treatment. [31] on cotton plants, humic acid as a foliar application increase organic constitutes e.g., chlorophyll a, b, total chlorophyll and total carotenoids. [32] results indicated that the highest seed yield, straw yield and oil yield were obtained at humic acid (50kg/fed) with foliar treatment of proline at rate of (100mg/L).

This may be due to the significant increase in photosynthetic pigment (chlorophyll a, chlorophyll b, carotenoids and total pigments) of flax shoots. In this regard, [33] stated that humic acid could sustain photosynthetic tissues and [13] indicated that humic acid increased chlorophyll a, b, total chlorophyll and total carotenoids, [29] found that foliar feeding with humic acid (5cm$^3$/l) gave the highest values of leaves concentrations of photosynthetic pigments i.e. chlorophyll a, chlorophyll b and total chlorophyll in both seasons and carotenoids in the second season and the lowest values were obtained from untreated plants (without natural materials application). [34] found that MI + GS (manure incorporated before planting and gliricídia applied on the surface days after planting) increased N, P, and K accumulation in cotton. [31] on cotton plants, cited that, humic acid as a foliar applications increase chemical constitutes related to salt tolerance either inorganic, (N, P and K), or organic constitutes e.g., proline, total sugars. [32] results indicated that the highest seed yield, straw yield and oil yield were obtained at humic acid (50kg/fed) with foliar treatment of proline at rate of (100mg/L). This may be due to the highest total soluble sugar content of flax shoots. In this concern, [13] indicated that humic acid increased chemical constitutes of inorganic nutrients (N, P and K), total sugars and total soluble phenols, [35] pointed out that HA-treated plants showed improved nutritional status as compared to untreated plants. [29] Found that foliar feeding with 5cm$^3$/L humic acid significantly increased percentages of N, P and K in leaves in both seasons. Foliar feeding with humic acid (5cm$^3$/L) gave the highest values of leaves concentrations of total carbohydrates and total sugars in both seasons and the lowest values were obtained from untreated plants (without natural materials application). Applying 5cm$^3$/g humic acid gave the lowest values of proline content, peroxidase and phenoloxidase activity in leaves in both seasons and at last untreated plants, which indicates favorable conditions and reduces environmental stress effect. The positive effect on leaf chemical composition due to the foliar feeding with humic acidis mainly referred to:

Application of humic acid in the form of actosol through foliar spraying increased the uptake of N, P and K (Table 6).

Humic acid (in the form of actosol) enriched the leaves with appreciable amount of N, P, K, Cl, Ca, Mg, Fe, Zn, Mn, Cu and B (Table 1).

Humic acid have the ability to retain micro nutrients in a complex or chelate forms through their active groups, and consequently improve the plant nutrition status [36].

The results in the same table showed that, the chemical constituents were decreased at the all interactions except the interaction between cattle manure fertilizer with humic levels 2.5 and 5cm$^3$/l. The higher increase in total carbohydrates, total sugars, N%, P% and K% was recorded at cattle manure fertilizer interacted with humic level 5cm$^3$/l respectively, when compared with the control plants.


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The superiority of humic acid over the other treatments could be attributed to the stimulatory effects of humic acid on increasing chlorophyll and chemical concentration in leaves, it might be also attributed to the low pH value, as well as increasing the activity of soil micro-organisms to liberate more nutrients from the unavailable reserves [32]. [37] stated that, the increase in berry size because of HA-S application at full bloom is probably ascribed to the uptake of mineral nutrients by the grapevines, but the possible hormone like activity of the HA-S (i.e., auxin, gibberellin and cytokinin-like activity) should also be taken into consideration. HA found to promote soil water holding capacity and reduce watering requirements for plants [38].

Some studies reported that HA could be used as a growth regulator to regulate hormone level, improve plant growth and enhance stress tolerance [39]. Moreover, [40] reported that humic substances prevented immobilization of Fe and P and facilitated their translocation from roots to shoots. In addition, [41] suggested that humic substances exert two types of effects in relation to plants;

a. Indirect effects through acting as suppliers and regulators of plant nutrients similar to synthetic ion exchangers.

b. Direct effects through uptake of humic substances by plant roots.

This result is mainly due to that organic fertilizer sources in the form of cattle manure or phytocompost manure had a high macro and micro nutrients as shown in Table 3. Also, these two organic sources significantly increased leaves total carbohydrates, total sugars, N%, P% and K% (Table 6). In this regard, [42] reported that compared to the control (60kgN/fed), farm yard manure (FYM) gave the highest values of final plant height and number of fruiting branches/plant and [43] found that final plant height and number of fruiting branches/plant significantly increased in favor of applying 12$m^3$ FYM/fed + 30kg N/fed as compared with the control (60kg N/fed).

### The positive effect of foliar feeding with humic acid on growth could be explain as follow

a. Enhancing plants water and nutrition absorption capacity due to humic acid application [44].

b. Humic acid contains higher macro and micro nutrients (Table 1) in addition to increase uptake of N (Table 6) which is essential for building up protoplasm and protein as well as induce cell division, which resulted in an increase in cell number and cell size with an overall increase in plant growth.

c. Humic acid increases photosynthesis pigments (Table 5) and could sustain photosynthetic tissues and thus total dry weight would increase [33].

d. Humic acid stimulates nucleic acid metabolism, the hormonal activity, enzyme activation, changes in membrane permeability, protein synthesis, the activation of biomass production and plant growth by the assimilation of major and minor elements, In addition to, the influence of HA on respiration and photosynthesis. These factors that have been used to describe the effect of HA on plant growth parameters [45].

e. Humic acid increases plant growth, production, and quality improvement through chelating different nutrients to overcome the lack of nutrients and due to having hormonal compounds [46].

f. Humic substances are assumed to have specific importance for the transport and availability of micro and macro-elements in the plants [47].

In this concern, [48] found that plant height and number of fruiting branches/plant were significantly increased by application of humic acid solution compared with control treatment in both seasons, [13] indicated that humic acid (HA) application significantly increased plant height and number of fruiting branches per plant, [35] pointed out that plants treated with humic acid showed improved photosynthetic efficiency, WUE and nutritional status compared to untreated plants and [29] found that the plants received humic acid significantly increased plant height and number of fruiting branches/plant at harvest in both seasons.

### The positive response due to cattle manure is mainly due to that

The high leaves NPK percentages (Table 6) due to cattle manure application are directly linked to boll retention, either by themselves or as activators of nutrient concentrations in addition to the nutrients content in the cattle manure compound which surely reflected on increasing bolls set and improving plant metabolism which increases boll setting and encouraging plant to accumulate more of its total dry weight in fruiting parts and this is coincided with higher boll retention/plant and reduced abscission by mobilizing nutrients to fruiting organs.

### The positive response due to humic acid is mainly due to that

The high leaves NPK percentages due to humic acid application are directly linked to boll retention, either by themselves or as activators of nutrient concentrations in addition to the nutrients content in the humic acid compound which surely reflected on increasing bolls set and improving plant metabolism which increases boll setting and encouraging plant to accumulate more of its total dry weight in fruiting parts and this is coincided with higher boll retention/plant and reduced abscission by mobilizing nutrients to fruiting organs. [29] found that boll setting percentage and 1st picking percentage were found to improve considerably by applying humic acid (5$cm^3$/L) while untreated plants produced the lowest boll setting percentage and 1st picking percentage and the highest boll shedding % in both seasons. The significant increase of open bolls/plant which resulted from the former and latter treatments is due mainly to significant increase boll setting percentage as compared with the plants fertilized with organic fertilizer in the form of phytocompost. Also, source of fertilizers exhibited significant differences in boll weight in both seasons (Table


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9), where the heaviest bolls resulted from plants fertilized with chemical fertilizers in the first season and from plants fertilized with cattle manure in the second season, while plants fertilized with organic fertilizer in the form of phytocompost had the lowest value.

### The significant increase in seed cotton yield per feddan of mineral fertilizers and cattle manure as compared with phytocompost manure is mainly due to the following reasons

a. The promoting effect of cattle manure source on leaves total carbohydrates and total sugars contents (Table 6) due to its promoted effect on leaves photosynthetic pigments content, chlorophyll a, b and carotenoids (Table 5), which reflects on the increase of photosynthetas.

b. The significant increase of N, P and K percentages in leaves refer to cattle manure (Table 6).

c. Cattle manure contains large amount of nutrients (Table 3) and influences plant growth and production via improving chemical, physical and biological fertility.

d. Mineral fertilizers and cattle manure sources produced highest number of open bolls and heaviest bolls (Table 9).

e. Under increasing or reducing water above or less the optimal requirement, levels of photosynthesis was limited by low $CO_2$ availability due to reduced stomatal and mesophyll conductance and thereby with decreased $CO_2$ fixation.

f. Cattle manure source provided cotton plants with the higher absorption of nutrients (Table 6) and water (Table 4) leading to production of higher growth and productivity.

In this concern, Mineral fertilizers have the merit of being readily soluble in soil solution, less bulky and easy to manipulate but their constitution in most cases does not include the much-needed essential minor elements as compared to cattle manures which meet this requirement [4], the importance of cattle manure is being recognized because of the increased cost of mineral fertilizers from time to time. Cattle manure is a potential source of organic fertilizer. Cattle manure seems to act directly in increasing crop growth and yields either by accelerating respiratory process with increasing cell permeability and hormonal growth action or by the combination of all of these processes which supplies N, P and S in available form to the plants via biological decomposition and improves physical properties of soil such as aggregation, permeability and water holding capacity [3]. Retaining more bolls and reducing boll shedding % (Table 8).

### The positive effect of humic acid application at the high rate (5.0cm3/l) on seed cotton yield/ fed and its components is mainly due to

a. The positive effect of HA on photosynthetic pigments (Table 5) which reflects in significant increase in production of assimilates by the leaves (source) due to an increase in $CO_2$ assimilation and photosynthetic rate which increased mineral uptake by the plant [49].

b. The stimulatory effect of HA due to increase permeability of plant membranes (Table 4) and enhance uptake of nutrients (Table 6) by building complex forms or chelating agents of HA matter with metallic cations, thereby increasing their availability to plants [50].

c. The positive effect of Humic Acid on cell membrane functions by promoting nutrient uptake, respiration, biosynthesis of nucleic acid, ion absorption, enzyme and hormone-like substances [51].

d. [52] postulated that HA increases the permeability of the cell membrane which results in increased uptake of moisture and nutrient elements.

e. Humic acid in the form of actosol improves the supply of essential nutrients such as potassium, manganese, copper, zinc, iron, calcium, nitrogen and phosphorus etc. that enhance the resistance to adverse conditions.

f. The high leaves nitrogen content due to humic acid application (Table 6) makes these plants utilized of the absorbed light energy in electron transport and tolerant to photo-oxidative damage under high intensity light and consequently increases photosynthesis capacity.

g. Enhanced the chlorophyll content reflecting from their role in enhancing leaf nutritional status (Table 6) especially, N as an important part of chlorophyll molecule.

h. Humic acid decreased cell membrane permeability, thus promoting greater efficiency in the absorption of nutrients with direct relation on cotton growth and productivity and improve the plant response to water stress.

i. Humic acid may have various biochemical effects either at cell wall level or in the cytoplasm including in plants enhanced protein synthesis and plant hormone-like activity, which resulted in increasing boll weight.

j. Humic acid may interact with the phospholipids structures of cell membranes and react as carries of nutrients through them.

k. This result could be explained on the basis that experimental soil being low in organic matter and available nitrogen (Table 2) and the supplied of humic acid increased leaves NPK content (Table 6) and the ingredients contained in actosol provided plants with their requirements of macronutriens (Ca, Mg, K, N and P) and micronutrients (Fe, Mn, Zn and Cu).

l. Retaining more bolls and reducing boll shedding % (Table 8).

Thus, it is clear that applying foliar spraying with humic acid (in the form of actosol) three times at a rate (5.0cm$^3$/l) could be considered as the proper rate for Giza 86 cotton cultivar under the environmental conditions of El-Gemmeiza region, where the yield per feddan was very close from this treatment.



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## Conclusion

It could be concluded that it is better to substitute mineral NPK fertilizers added to the soil by applying cattle manure as source of organic fertilization in combined with foliar feeding with humic acid (in the form of actosol) as source of natural materials at a rate ($5.0 cm^3/l$) three times (at squaring stage, at flowering initiation and at the top of flowering) to achieve the maximum quantity and quality of cotton production with minimum environmental pollution.

## Acknowledgment

We extend our sincere thanks to all the employees of Botany Department, Agriculture Faculty, Menoufia University, Egypt and Cotton Physiology Department, Cotton Research Institute, Agriculture Research Center, Giza, Egypt. Including our professors and colleagues for their support and help me in ending this work.

## Conflict of Interest Statement

The author whose name are listed immediately below certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria, educational grants, participation in speakers' bureaus, membership, employment, consultancies, stock ownership, or other equity interest, and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

Authors names: Mahmoud Wagdy Mohamed El Shazly, Yousef F. A. Ata Allah and Ahmed Mohamed Abd El All.

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DOI: 10.19080/ARTOAJ.2019.20.556120




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