

EFFECT OF SOME OF ORGANIC AND BIO AND/OR MINERAL FERTILIZATION ON VEGETATIVE GROWTH AND CHEMICAL COMPOSITION OF *DELONIX REGIA*

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ABSTRACT: This work was executed during two successive seasons of 2018 and 2019 in the nursery and laboratory of Fac. Agric., Minia Univ., Egypt to investigate the response of vegetative and root growth and some chemical composition of *Delonix regia* seedlings to four percentages of humic acid (0, 1, 2 and 4%) and four bio- and/or mineral NPK fertilization treatments (control, 100% NPK, Minia Azotein and 75% NPK plus Minia Azotein), as well as, the interaction between them. All used three percentages of humic acid significantly increased vegetative growth (plant height, stem diameter, the aerial part dry weight), root growth (root number and roots dry weight) and chemical composition (photosynthetic pigments, NPK%, total phenolic and total flavonoids contents) over control. Humic acid at 4% more was effective treatment. All used bio-and/or mineral NPK fertilization treatments significantly increased all studied characters over control. The best treatments were 100% NPK or 75% NPK plus Minia Azotein. It could be recommended to add humic acid at 4% in combination with 100% NPK or 75% NPK plus Minia Azotein to improve growth of *Delonix regia*.

Key words: Humic acid, Bio-fertilizer, Mineral NPK fertilizer and *Delonix regia*.

INTRODUCTION

Gold mohar [*Delonix regia* (Bojer ex Hook.) Raf.] also known as royal poinciana, flame boyant and flame tree is a species of flowering plants, belonging to Family Caesalpiniaceae. This tree, native to Madagascar, but now is distributed in several countries of the tropical region and is often used to prepare extracts with antimicrobial and antifungal activities (Audipudi and Chakicherla, 2010). Gold mohar, with an impressive range of medicinal and biological properties, has been used in the folk medicine systems of several civilizations for the treatment of constipation, inflammation,

arthritis, hemiplegia, leucorrhoea and rheumatism (Shanmukha *et al.*, 2011).

Humic acid is the major component of soil organic matter. Humic acid has both direct and indirect effects on plant growth. Indirect effects involved improvement of soil properties, such as; aggregation, aeration, permeability, water holding capacity, ion transport and availability through pH buffering (Tan, 2003). Direct effects involved increasing cell membrane permeability, oxygen uptake, respiration, photosynthesis, phosphate uptake, root cell elongation, regulation of hormone level, improving plant growth and enhancing stress

tolerance (Cimrin *et al.*, 2010) and Kulikova *et al.* (2005) who pointed out that humic substances showed antistress effects under abiotic stress.

Chemical nutrients especially N, P and K are very important for plants, because NPK elements partake in structure of several components of the whole plant (protein, hormones, amino acids, enzymes, nucleic acids, fats and regulation of water conditions). However, the application of intense chemical fertilization causes serious problems on human health by pollution of the whole environmental conditions (soil, air and drainage water). Generally inorganic fertilizers are added to the soil to improve fertility and enhance vegetative growth and increase crop yield (Ingels, 1994 and Lambers *et al.*, 2000).

Biofertilizers are considered to be low cost, eco-friendly and renewable sources of plant nutrients supplementing chemical fertilizers in sustainable agricultural system. This refers to microorganisms, which increase crop growth through different mechanisms, i.e. biological nitrogen fixation, phosphate-dissolving, growth promoting or hormonal substances and increasing availability of soil nutrients (Hedge *et al.*, 1999).

It is well established that phenolic antioxidants, namely flavonoids and phenolic acids, are commonly distributed in plant leaves, flowering tissues and woody parts such as stem and bark. In plants, these antioxidant phenolics play a vital role for normal growth and protection against infection and injuries from internal and external sources (Tibiri *et al.*, 2010).

Therefore, the aim of the present work was to study the effect of humic acid, mineral NPK and/or Minia Azotein bio-fertilizer, as well as, their interactions on vegetative and root growth characters and some chemical constituents of *Delonix regia* transplants.

MATERIALS AND METHODS

This investigation was carried out during the two successive growth seasons of 2018 and 2019 at the Nursery and Laboratory of Ornamental Plant Division, Horticulture Department, Faculty of Agriculture, Minia University. The goal of this investigation was to examine the response of *Delonix regia* to four levels of humic acid (organic extract) and four bio- and/or mineral NPK fertilization treatments, as well as, their interaction in terms of different vegetative and root growth characters and some chemical constituents.

Plant material:

Seeds of Poinciana, (*Delonix regia*) were collected from a contain mother plant in Nursery, Faculty of Agriculture, Minia University. The seeds were soaked in hot water and lifted 24 hours and planted in plastic bags (20 × 15 cm) filled with sandy soil + clay loam (1:1 v:v) in February 15th for both seasons and after about one-month seedlings were transplanted to the experimental soil (March 15th).

Experimental soil:

Physical and chemical properties of the used soil in both seasons were determined according to Jackson (1973) and shown in Table (1).

Layout of the experiment:

The experiment was arranged in a complete randomized block design in a split plot design with three replicates. This experiment included two factors (A and B). The levels of factor (A) were considered as main plot, while four levels of factor (B) were the sub plots.

Therefore, the experiment involved 16 treatments (4A × 4B). Each treatment was replicated three times. The experimental unit (plot) was 1.0×1.8 m and containing four ridges, 60 cm apart. Transplants were planted on March 15th for both seasons in hills spaced at 50 cm (2 transplants/ridge) in between.

Table 1. Physical and chemical properties of the experimental soil.

Soil chemical properties	Values	Soil chemical properties	Values	Soil physical properties	Values
pH (1:2.5 water)	7.70	Total P (g kg ⁻¹)	0.56	F.C. %	42.45
CaCO ₃ (g kg ⁻¹)	17.90	Available P (mg kg ⁻¹)	13.11	PWP %	13.78
CEC (cmolc kg ⁻¹)	37.87	Total K (g kg ⁻¹)	4.37	WHC %	48.76
EC (dS m ⁻¹ at 25 °C)	1.35	Exch. K ⁺ (mg 100 g ⁻¹ soil)	2.85	A.V. (F.C.- PWP) %	28.67
OM (g kg ⁻¹)	28.61	Exch. Ca ⁺⁺ (mg 100 g ⁻¹ soil)	31.12	A.V. (WHC-PWP) %	34.98
Total N (g kg ⁻¹)	1.29	Exch. Mg ⁺⁺ (mg 100 g ⁻¹ soil)	8.77	Bulk density (BD) g cm ⁻³	1.31
Total C/N ratio	22.17	Exch. Na ⁺ (mg 100 g ⁻¹ soil)	2.52	Particle density (PD) g cm ⁻³	2.22
SOC (g kg ⁻¹)	18.48	DTPA Ext. (mg kg ⁻¹)	Fe	8.23	Sand %
Organic N (g kg ⁻¹)	0.76		Cu	2.01	Silt %
Organic C/N ratio	24.31		Zn	2.87	Clay %
Mineral N (mg kg ⁻¹)	58.46		Mn	8.11	Soil texture
					Clay loam

Treatments:

The main plots (A) were as follows:

1. Humic acid 0% (without).
2. Humic acid 1%. (1 ml. humic acid added to 1000 ml. water).
3. Humic acid 2%. (2 ml. humic acid added to 1000 ml. water).
4. Humic acid 4%. (4 ml. humic acid added to 1000 ml. water).

The sub plots (B) were as follows:

1. Control (without).
2. 100% mineral NPK as recommended dose.
3. Minia Azotein (M.A.) at 50 ml/hills.
4. 75% NPK + Minia Azotein (M.A.).

Experimental procedures:

Humic acid was obtained from Sigma Company and added to hills beside the plant (1000 ml solution/plant) three times the first dose after two weeks from transplanting and then at one- month intervals.

Fresh and active Minia Azotein (containing N-fixing bacteria) was applied at three times at one-month interval starting 12th April for the first and second seasons. Bio-fertilizers were added to the soil around

each plant and then plants were immediately irrigated.

The recommended mineral NPK fertilization was 200 kg/fed of ammonium sulphate (20.6% N) +100 kg/fed calcium suerphosphate (15.5% P₂O₅) + 50 kg/fed potassium sulphate (48% K₂O) as recommended dose, while, 75% NPK were 150 + 75 + 37.5 kg respectively.

The amounts of mineral NK fertilizers were divided into three equal batches and added at one-month interval, starting April 19th in both experimental seasons, while, all amounts of P % were added with the first dose of NK fertilizer. All other agricultural practices were carried out as usual in the region in the two experimental seasons.

Data recorded:

Vegetative growth characters:

- 1- Plant height (cm).
- 2- Stem diameter (cm).
- 3- The aerial plant dry weight (g).

Root growth characters:

- 1- Number of roots/plant.
- 2- Dry weight of roots/plant (g).

Chemical constituent characters:

1. Determination of photosynthetic pigments:

After four months from the first dose of bio. and/or mineral NPK fertilization treatments (August, 12th and 19th for bio and mineral NPK, respectively for both seasons), samples weight of 0.5 g fresh leaves from the middle part of branches, were taken and extracted by N-N dimethyl-formamide according to Moran (1982), to determine the contents of chlorophyll a, b and carotenoids.

2. N, P and K percentages:

A sample weight of 0.2 g fine powder of the dry leaves was digested using a mixture of hydrogen peroxidase (H₂O₂) and concentrated sulphuric acid (H₂SO₄) (4: 10). The clear digestion was quantitatively to 100 ml volumetric flask. In this solution the following elements were determined: N, P and K according to Wilde *et al.* (1985), Chapman and Pratt (1975) and Cottenie *et al.* (1982), respectively.

3. Determination of total phenolic contents (TPC):

Ambient-dried sample of leaves collected from the best interaction treatments (4% humic acid + 75% NPK + Minia Azotein) was ground into a fine powder (80 mesh.) in a grinding mill (Tector-Cemotec 1090 sample mill, Hognas, Sweden). Twenty grams of leaves was separately extracted with 80% methanol (methanol: water, 80:20, v/v), 80% ethanol (ethanol: water, 80:20, v/v) and distilled water (Sultana *et al.*, 2007).

Amount of TPC was assessed using Folin-Ciocalteu reagent procedure as described earlier Chaovanalikit and Wrolstad (2004).

4. Determination of total flavonoid contents (TFC):

The contents of total flavonoids were determined following the procedure described previously by Dewanto *et al.*, 2002.

5. High performance liquid chromatography (HPLC) analysis:

Identification of phenolic acids in the plant extract was performed on a Varian HPLC instrument using an ODS2 C18 reversed phase column (Chapuis-Lardy *et al.*, 2002). The HPLC assays were conducted using acidified acetonitrile (99.5%) as mobile phase in isocratic mode with a constant flow rate of 1 ml/min and detection at 280 nm. Sample injection volume was 20 µL. Phenolic compounds of each sample were identified by comparing their relative retention times with those of the standard mixture chromatogram. The concentration of an individual compound was calculated on the basis of peak area measurement and then converted to mg phenolics/100 g d.w.

Statistical analysis:

The data of the two experiments were subjected to the statistical analysis of variance MSTAT-C (1986). L.S.D. test at 0.05 was used to compare the average of treatments.

RESULTS AND DISCUSSION

Vegetative growth characters:

Data presented in Table (2) showed that supply *Delonix regia* with three levels of humic acid (1, 2 and 4%) led to significant increase in vegetative growth characters namely, plant height, stem diameter and the aerial plant parts dry weight compared to the control plants in the two growing seasons. The application of high level (4%) of humic acid recorded the tallest plants (65.4 and 72.9 cm), the thickest stems (1.59 and 1.75 cm) and the heaviest dry weight of aerial parts/plant (100.43 and 106.10 g/plant) for the first and second seasons respectively. The superiority was of the treatments of humic acid on plant growth may be attributed to the mode of action of humic acid on indirect effect involved improvement of soil properties (Tan, 2003) and direct effects involved cell membrane permeability, oxygen uptake, respiration, photosynthesis, phosphate uptake, regulate hormone level

Table 2. Effect of humic acid, bio and/or mineral NPK fertilization, as well as, their combination treatments on plant height (cm), stem diameter (cm) and the aerial plant parts dry weight/plant (g) of *Delonix regia* seedlings during the first and second seasons.

Treatments (B)	Humic acid (%) (A)										
	1 st season (2018)					2 nd season (2019)					
	0%	1%	2%	4%	Mean (B)	0%	1%	2%	4%	Mean (B)	
Plant height (cm)											
Control	52.8	72.3	80.8	102.3	77.1	60.6	83.3	94.7	105.8	86.1	
100 % Mineral NPK	69.5	79.0	100.3	127.8	94.2	82.7	94.2	102.8	142.8	105.6	
Minia Azotein (M.A.)	58.8	75.0	84.0	108.5	81.6	74.1	88.7	95.0	121.1	94.7	
75 % NPK + M.A.	68.0	77.8	99.5	119.5	91.2	81.5	89.0	98.6	140.4	102.3	
Mean (A)	35.6	43.4	52.1	65.4		42.7	50.7	55.8	72.9		
L.S.D. at 5 %	A: 4.5		B: 6.5		AB: 13.0		A: 5.0		B: 7.1		AB: 14.2
Stem diameter (cm)											
Control	1.01	2.01	2.28	2.66	1.99	1.58	2.08	2.50	2.93	2.27	
100 % Mineral NPK	1.95	2.27	2.60	2.94	2.44	2.03	2.45	2.85	3.30	2.66	
Minia Azotein (M.A.)	1.44	2.07	2.40	2.70	2.15	1.70	2.20	2.55	2.95	2.35	
75 % NPK + M.A.	1.89	2.25	2.55	2.84	2.38	2.00	2.33	2.65	3.08	2.51	
Mean (A)	0.90	1.23	1.40	1.59		1.04	1.29	1.51	1.75		
L.S.D. at 5 %	A: 0.16		B: 0.11		AB: 0.22		A: 0.20		B: 0.15		AB: 0.30
The aerial plant parts dry weight/plant (g)											
Control	66.73	89.73	115.41	157.45	107.33	70.49	94.78	121.92	166.33	113.38	
100 % Mineral NPK	87.14	110.98	153.30	187.52	134.74	92.06	117.23	161.95	198.11	142.34	
Minia Azotein (M.A.)	73.33	106.65	121.03	174.22	118.81	77.46	112.67	127.85	184.05	125.51	
75 % NPK + M.A.	86.48	108.14	149.14	183.83	131.90	91.36	114.24	157.55	194.19	139.34	
Mean (A)	44.81	59.36	76.98	100.43		47.34	62.70	81.32	106.10		
L.S.D. at 5 %	A: 13.45		B: 6.12		AB: 12.24		A: 15.10		B: 7.00		AB: 14.00

and improve plant growth (Cimrin *et al.*, 2010).

These results are agreement with those of El-Khateeb *et al.* (2011) on *Acacia saligna* and Hashish *et al.* (2015) on *Jatropha curcus*.

Regarding the effects of bio- and/or mineral NPK fertilization treatments, plant height, stem diameter and the aerial parts dry weight/plant they significantly increased due to the use of all bio- and/or mineral NPK fertilization treatments compared with that

untreated plants in both seasons as shown data presented in Table (2).

Among the four fertilization treatments, both 100% mineral NPK followed by 75% mineral NPK + Minia Azotein treatments produced significantly the tallest plants (94.2 and 91.2 cm), the thickest stems (2.44 and 2.38 cm) and the heaviest aerial parts weight/plant (134.74 and 131.90 g) in the first season and (105.6 and 102.3 cm) for plant height, (2.66 and 2.51 cm) for stem diameter and (142.43 and 139.34 g) for dry the aerial parts dry weight/plant in the second one.

The enhancement effect of bio. and/or mineral NPK fertilization treatments on vegetative growth characters may be due to the important role of NPK and growth regulators which came on a result of Minia Azotein biofertilizer that encourage the vegetative growth parameters (Lambers *et al.*, 2000; Kannaiyan, 2002 and Ali *et al.*, 2020).

In agreement with results concerning mineral NPK were those of El-Mahrouk (2000) on *Swietenia macrophylla*, Abd El-Dayem (2003) on *Taxodium distichum* and Abdou *et al.* (2003) on *Delonix regia*. Regarding the effect of bio-fertilization, Soliman *et al.* (2015) on *Delonix regia*, Sakr *et al.* (2017) on *Pinus halepensis* and Soliman (2019) on *Moringa peregrina*.

The interaction between humic acid and bio. and/or mineral NPK fertilization treatments was significant for plant height, stem diameter and the aerial parts dry weight/plant in both seasons as shown in

Table (2). The best interaction treatments were obtained by the used humic acid (4%) in combination with full dose of mineral NPK (100%) or reduced dose of NPK (75%) + Minia Azotein without significant differences in between.

Root growth characters:

Data presented in Table (3) showed that all three used treatments of humic acid led to significant increase in number of roots/plant and dry weight of roots/plant in both seasons as compared to control. The highest number of roots (4.61 and 4.72) and heaviest dry weight (15.74 and 17.47 g) respectively in the first and second seasons were obtained by adding humic acid at 4%. Humic acid may play an important role in root cell elongation and regulating the plant root metabolism (Norman *et al.*, 2006 and Cimrin *et al.*, 2010). Similar results were obtained by Hashish *et al.* (2015) on *Jatropha curcus* and Taha (2017) on *Juglans regia*.

Table 3. Effect of humic acid, bio and/or mineral NPK fertilization, as well as, their combination treatments on number of roots/plant and dry weight of roots (g/plant) of *Delonix regia* seedlings during the first and second seasons.

Treatments (B)	Humic acid (%) (A)									
	1 st season (2018)					2 nd season (2019)				
	0%	1%	2%	4%	Mean (B)	0%	1%	2%	4%	Mean (B)
Number of roots/plant										
Control	4.20	6.45	6.89	7.50	6.26	4.30	6.60	7.05	7.67	6.41
100 % Mineral NPK	6.12	6.84	7.25	8.55	7.19	6.26	7.00	7.42	8.75	7.36
Minia Azotein (M.A.)	5.70	6.60	7.05	7.95	6.83	5.83	6.75	7.21	8.14	6.98
75 % NPK + M.A.	6.11	6.81	7.20	8.26	7.10	6.25	6.97	7.37	8.46	7.26
Mean (A)	3.16	3.81	4.06	4.61		3.23	3.90	4.15	4.72	
L.S.D. at 5 %	A: 0.18		B: 0.15		AB: 0.30	A: 0.22		B: 0.16		AB: 0.32
Dry weight of roots/plant (g)										
Control	4.39	10.18	21.40	25.07	15.26	4.87	11.30	23.76	27.83	16.94
100 % Mineral NPK	7.68	21.09	23.92	30.34	20.76	8.53	23.41	26.56	33.68	23.05
Minia Azotein (M.A.)	5.06	13.96	21.58	26.28	16.72	5.62	15.49	23.95	29.17	18.56
75 % NPK + M.A.	6.87	19.96	22.26	28.50	19.40	7.62	22.16	24.71	31.63	21.53
Mean (A)	3.43	9.31	12.74	15.74		3.81	10.34	14.14	17.47	
L.S.D. at 5 %	A: 2.41		B: 1.45		AB: 2.90	A: 3.11		B: 1.55		AB: 3.10

Root number and dry weight of roots/plant of *Delonix regia* were significantly increased as a result of supplying bio. and/or mineral NPK fertilization treatments. Among these treatments, mineral NPK (full dose) followed by 75% NPK + Minia Azotein recorded the greatest number of roots (7.19 and 7.10 in the first season) and (7.36 and 7.26 respectively in the second season) and the heaviest roots dry weight as gave 20.76 and 19.40 g in the first season and 23.05 and 21.53 g respectively in the second season.

The superiority of the treatment of mineral NPK (full dose) or 75% NPK (reduced dose) + Minia Azotein on roots parameters may be attributed to the role of NPK on the plant physiological processes that increased both root number and roots dry weight (Ingels, 1994). Minia Azotein increased soil available nitrogen and its products from auxins consequently, increased cell root number (Spérnat, 1990).

In agreement with these results concerning NPK fertilizers were those of Abdou (2001) on *Jacaranda ovalifolia* and Abdou and Badran (2018) on *Delonix regia*. Moreover, Meenakshisundaram *et al.* (2011) and Soliman *et al.* (2015) on *Delonix regia* found that dual bio-fertilizers led to significant increase in root number and dry weight, similarly Ali *et al.* (2020).

The interaction between main and sub plots (AXB) was significant for both roots number and roots dry weight in both seasons (Table, 3). The highest values were obtained due to humic acid (4%) in combination with 100% NPK followed by humic acid (4%) plus 75% NPK + Minia Azotein.

Chemical constituents' characters:

Photosynthetic pigments and N, P and K (%):

Data presented in Tables (4 and 5) revealed that using humic acid at three

percentages (1, 2 and 4%) significantly increased both the three photosynthetic pigments (chlorophyll a, b and carotenoids) in the fresh leaves and the three percentages of N, P and K in the dry leaves of *Delonix regia* over the control in both seasons. Supplying plants with humic acid at 4% resulted in the highest contents of chlorophyll a, b and carotenoids and highest percentages of N, P and K in both seasons. Humic acid treatments increased photosynthesis, respiration and pigment content (Yildirim, 2007). Also, humic acid positively influenced the uptake of N, P and K nutrients (Junior *et al.*, 2019). Similar results were obtained by El-Khateeb *et al.* (2011) on *Acacia saligna*, Hashish *et al.* (2015) and Ahmed *et al.* (2018) on *Jatropha curcus*.

Data indicated also, that all used three fertilization treatments significantly increased chlorophyll a, b and carotenoids, as well as, N, P and K % over the control (Tables 4 and 5). The highest values of pigments and NPK % were obtained from two treatments of NPK (100%) followed by NPK (75%) + Minia Azotein without significant differences between such two superior treatments. The stimulatory effect of bio. and/or mineral NPK fertilization treatments on pigments and NPK % may be due to the role of N, P and K fertilizers and cytokinin's, as well as, enzymes which came from addition of these different fertilizers, thus producing more photosynthetic pigments and delayed leaf senescence as emphasized by Al-Menaie *et al.* (2010) on *Cassia fistula* and *Cassia nodosa* and Abdou and Badran (2018) on *Delonix regia* regarding the effect of mineral NPK. Moreover, Soliman *et al.* (2015) on *Delonix regia* and Ganaw (2017) and Soliman (2019) on moringa concerning the effect of bio-fertilizers.

Table 4. Effect of humic acid, bio and/or mineral NPK fertilization, as well as, their combination treatments on photosynthetic pigments (mg/g fresh weight) of *Delonix regia* seedlings during the first and second seasons.

Treatments (B)	Humic acid (%) (A)									
	1 st season (2018)					2 nd season (2019)				
	0%	1%	2%	4%	Mean (B)	0%	1%	2%	4%	Mean (B)
Chlorophyll a content (mg/g f.w.)										
Control	2.340	2.411	2.451	2.507	2.427	2.390	2.461	2.504	2.560	2.478
100 % Mineral NPK	2.405	2.445	2.492	2.563	2.476	2.458	2.495	2.544	2.618	2.529
Minia Azotein (M.A.)	2.371	2.433	2.476	2.529	2.452	2.421	2.482	2.529	2.581	2.503
75 % NPK + M.A.	2.402	2.436	2.488	2.547	2.468	2.451	2.488	2.541	2.600	2.520
Mean (A)	1.360	1.389	1.415	1.449		1.388	1.418	1.445	1.480	
L.S.D. at 5 %	A: 0.022		B: 0.015		AB: 0.030	A: 0.025		B: 0.016		AB: 0.032
Chlorophyll b content (mg/g f.w.)										
Control	0.756	0.779	0.792	0.810	0.784	0.772	0.795	0.809	0.827	0.801
100 % Mineral NPK	0.777	0.790	0.805	0.828	0.800	0.794	0.806	0.822	0.846	0.817
Minia Azotein (M.A.)	0.766	0.786	0.800	0.817	0.792	0.782	0.802	0.817	0.834	0.809
75 % NPK + M.A.	0.776	0.787	0.804	0.823	0.797	0.792	0.804	0.821	0.840	0.814
Mean (A)	0.439	0.449	0.457	0.468		0.449	0.458	0.467	0.478	
L.S.D. at 5 %	A: 0.007		B: 0.003		AB: 0.006	A: 0.008		B: 0.005		AB: 0.010
Carotenoids content (mg/g f.w.)										
Control	0.916	0.943	0.959	0.981	0.950	0.935	0.963	0.980	1.002	0.970
100 % Mineral NPK	0.941	0.957	0.975	1.003	0.969	0.962	0.976	0.996	1.025	0.989
Minia Azotein (M.A.)	0.928	0.952	0.969	0.989	0.960	0.947	0.971	0.989	1.010	0.979
75 % NPK + M.A.	0.940	0.953	0.974	0.997	0.966	0.959	0.974	0.994	1.017	0.986
Mean (A)	0.532	0.544	0.554	0.567		0.543	0.555	0.566	0.579	
L.S.D. at 5 %	A: 0.009		B: 0.004		AB: 0.008	A: 0.010		B: 0.006		AB: 0.012

The interaction between humic acid and bio. and/or mineral NPK fertilization treatments was significant for the six studied parameters, except P% in both seasons as shown in Tables (4 and 5). The highest values were obtained by adding 4% humic acid in combination with mineral NPK (full dose) or with NPK (75%) + Minia Azotein.

Total phenolic compounds (TPCs) and total flavonoids (TFs) contents:

The total phenolic contents (TPCs) and total flavonoid contents (TFs) were determined in the best interaction treatment (100% NPK) or with NPK (75%) + Minia

Azotein in the leaves extract and are shown in Table (6). The TPC and TFC of the leaves extract ranging from 0.93–3.76 g GAE/100 g dw and 0.25–1.33 g CE/100 g dw, respectively. Among the different solvent extracts tested in this study, 80% methanol extract of leaves showed the highest TPCs and TFs. as 80% methanol is known to be an efficient and widely used solvent to extract phenolics and flavonoids from plant materials, due to the fact that methanol-water mixtures are highly polar and thus show greater efficacy in the extraction of polar phytochemicals such as phenolics and flavonoids (Siddiq *et al.*, 2005).

Table 5. Effect of humic acid, bio and/or mineral NPK fertilization, as well as, their combination treatments on the percentages of N, P and K of *Delonix regia* seedlings during the first and second seasons.

Treatments (B)	Humic acid (%) (A)									
	1 st season (2018)					2 nd season (2019)				
	0%	1%	2%	4%	Mean (B)	0%	1%	2%	4%	Mean (B)
	N %									
Control	2.183	2.551	2.956	3.368	2.765	2.194	2.564	2.971	3.385	2.778
100 % Mineral NPK	2.433	2.833	3.246	3.662	3.044	2.445	2.847	3.259	3.680	3.058
Minia Azotein (M.A.)	2.247	2.645	3.051	3.464	2.852	2.258	2.658	3.066	3.481	2.866
75 % NPK + M.A.	2.410	2.821	3.240	3.655	3.032	2.422	2.835	3.256	3.673	3.047
Mean (A)	1.325	1.550	1.785	2.021		1.331	1.558	1.793	2.031	
L.S.D. at 5 %	A: 0.215		B: 0.086		AB: 0.172	A: 0.221		B: 0.091		AB: 0.182
	P %									
Control	0.235	0.305	0.377	0.428	0.336	0.243	0.316	0.390	0.443	0.348
100 % Mineral NPK	0.285	0.356	0.425	0.484	0.388	0.295	0.369	0.440	0.501	0.401
Minia Azotein (M.A.)	0.252	0.322	0.394	0.441	0.352	0.260	0.333	0.408	0.456	0.364
75 % NPK + M.A.	0.268	0.339	0.411	0.467	0.371	0.278	0.351	0.425	0.483	0.384
Mean (A)	0.149	0.189	0.230	0.260		0.154	0.196	0.238	0.269	
L.S.D. at 5 %	A: 0.023		B: 0.017		AB: N.S.	A: 0.028		B: 0.019		AB: N.S.
	K %									
Control	1.540	1.800	2.086	2.376	1.950	1.548	1.809	2.096	2.388	1.960
100 % Mineral NPK	1.717	1.999	2.290	2.584	2.147	1.725	2.009	2.299	2.596	2.157
Minia Azotein (M.A.)	1.585	1.866	2.153	2.444	2.012	1.593	1.875	2.163	2.456	2.022
75 % NPK + M.A.	1.700	1.990	2.286	2.579	2.139	1.709	2.000	2.297	2.591	2.149
Mean (A)	0.935	1.094	1.259	1.426		0.939	1.099	1.265	1.433	
L.S.D. at 5 %	A: 0.155		B: 0.064		AB: 0.128	A: 0.159		B: 0.070		AB: 0.140

Table 6. Determination of TPCs and TFs in the solvent extracts.

Parameters	Solvent extracts		
	Methanol (80%)	Ethanol (80%)	Distilled water
TPCs (g/100 g dw)	3.76±0.13	2.45±0.09	0.93±0.04
TFs (g/100 g dw)	1.33±0.05	0.88±0.03	0.25±0.01

Among the tested solvents, 80% methanol was found to be the most efficient solvent to extract TPCs from the leaves. So, this solvent extract was further analyzed by HPLC to quantify the individual phenolic

acids in the leaves of the plant Table (7). Of the eight phenolic compounds tested by HPLC only twenty were detected in the extract. Gallic acid, salicylic acid and chlorogenic acid were the most abundant

Table 7. HPLC quantification of 80% methanol soluble phenolic acids (mg/100 g d.w.) identified in leaves of Gold Mohar.

Compounds	Methanol (80%)
Sinapic acid	1.31
<i>P</i> -Coumaric acid	1.35
Ferulic acid	1.19
Caffeic acid	1.45
Salicylic acid	5.81
Chlorogenic acid	1.47
Gallic acid	5.35
3-Hydroxybenzoic acid	0.91

phenolic acids in the extract. All of the detected phenolic compounds are known to have antioxidant properties (Rawat *et al.*, 2011, Zheng and Wang, 2001 and Merkl *et al.*, 2010). Gallic acid, which is efficiently absorbed in human body, shows positive effects against cancer cell under *in vitro* condition (Tomas-Barberan and Clifford, 2000). *P*-coumaric acid is believed to reduce the risk of stomach cancer by reducing the formation of carcinogenic nitrosamines (Ferguson *et al.*, 2005).

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تأثير بعض الاسمدة العضوية والحيوية و/أو المعدنية على النمو الخضري والمكونات الكيماوية لنبات البوانسيانا

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هذا البحث تم اجراءه خلال موسمي ٢٠١٨ و ٢٠١٩ بمشنتل ومعمل الزينة، كلية الزراعة، جامعة المنيا لبحث استجابة النمو الخضري والجذري وبعض الصفات الكيماوية لنبات البوانسيانا لأربع مستويات من حمض الهيومك (٠، ١، ٢، ٤٪) وأربعة معاملات حيوية و/أو معدنية ن فو بو (كنترول، ١٠٠٪ ن فو بو، منيا ازوتين، ٧٥٪ ن فو بو + منيا ازوتين) والتفاعل بينهما. كل النسب المستخدمة من معاملات حمض الهيومك أدت الى زيادة معنوية في الصفات الخضرية (ارتفاع النبات، قطر الساق، الوزن الجاف للأجزاء الهوائية) والصفات الجذرية (عدد ووزن جاف للجذور) والمكونات الكيماوية (صبغات البناء الضوئي، النسبة المئوية للعناصر ن فو بو، الفينولات الكلية، المكونات الفلافونيدية) مقارنة بالكنترول. وكانت معاملة ٤٪ حمض الهيومك هي أكثر كفاءة عن كل معاملات التسميد الحيوي و/أو المعدني ن فو بو أدت الى زيادة معنوية في كل الصفات المدروسة مقارنة بالكنترول. وكانت أحسن المعاملات هي ١٠٠٪ ن فو بو يليها ٧٥٪ ن فو بو + منيا ازوتين بدون فرق معنوي بينهما. يمكن التوصية بإضافة حمض الهيومك ٤٪ مع ١٠٠٪ ن فو بو أو مع ٧٥٪ ن فو بو + منيا أزوتين لتحسين نمو البوانسيانا.