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INTERACTIVE INFLUENCE OF COMPOST, BORON AND IRON ON EGGPLANT YIELD AND QUALITY

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Abstract

This study was carried out in an alluvial soil to evaluate the impact of organic fertilizer (animal compost) with foliar spraying of both boron and iron elements on enhancing the fruit yield and quality of eggplants (*Solanum melongena* L.*)* during the two successive summer seasons of 2018 and 2019. The used experimental design was a split-split plot design. The compost treatments were C_1: (20 m^3 animal compost fed^{-1}), C_2: (30 m^3 animal compost fed^{-1}) and C_3: (40 m^3 animal compost fed^{-1}). The foliar application of boron levels were B_0: (0.00 mgL^{-1}), B_1: (100 mgL^{-1}) and B_2: (200 mgL^{-1}). The foliar application of iron levels were Fe_0: (0.00 mgL^{-1}), Fe_1: (200 mgL^{-1}) and Fe_2: (400 mgL^{-1}). In addition to control treatment (without any addition [C_0 B_0 Fe_0]). The values of all quality parameters of eggplant fruits at harvest stage and cumulative yield were significantly influenced under all investigated treatments. For all quality and yield parameters except nutrient content of eggplant fruit, the highest values were obtained at [C_3 (40 m^3 animal compost fed^{-1}) × B_2 (200 mg B L^{-1})×Fe_2 (400 mg Fe L^{-1})] treatment, while the lowest values were obtained at control treatment [C_0 (without animal compost) × B_0 (0.00 mg B L^{-1}) ×Fe_0 (0.00 mg Fe L^{-1})]. Also, the values of N, P, K, B and Fe contents in eggplant fruits at harvest stage were assessed under the combination impact of animal compost and foliar application of both boron and iron.

Keywords: Animal compost, boron, iron and eggplant.

Introduction

Eggplant (*Solanum melongena* L). also known as Garden egg, Brinjal, and ‘Anara’ belongs to family of Solanaceae, and genus Solanum. Eggplant is the most important vegetable crop in the world after tomato, cucumber and potato Agbo and Nwosu, (2009). Eggplant fruits are good source of Fe, Ca, Pv and vitamins especially ‘B’ group. Eggplant is also valued for its medicinal attributes and due to presence of poly-unsaturated fatty acids (lenolenic and linoleic) present in seeds and flesh of eggplant fruit in higher amount (65.1%), eggplant has got de-cholestrolizing property primarily (Kantharajah and Golegaonkar, 2004; Siddiky *et al.,* 2007 and Zenia and Halina, 2008).

The organic fertilizers have the possibility supplying macro and microelements, providing energy of micoflora, increasing the availability of microelements and enhancing soil fertility (Mansour, 2012). The usage of compost in agricultural purposes positively affects the soil physical and chemical properties such as structure, porosity, compression strength, water holding capacity, nutrient content and O.M. content of the soil , thus enhances plant growth, crop yield and crop quality(Offiong *et al*., 2010 and Sanni and Okeowo, 2016).

Microelements as the essential nutrients are important in plant nutrition.They are required for development and growth of plant in small quantities .Micronutrients such as Fe and B are elements with specific and essential physiological functions in plants (Khedr *et al.,* 2004 and El-Nemr *et al.,* 2012). Iron (Fe) is essential for chlorophyll synthesis. Also, Fe is a constituent of some of the enzymes that operate in respiratory mechanism as peroxidase, catalase and the cytochrome oxidase. Fe plays essential role in growth by stimulating cell division. Fe is a cofactor for many enzyms (approximately 140 enzymes) that catalyze unique biochemical reactions. Thus, Fe fills many necessary roles in plant growth and development, including thylakoid synthesis, chlorophyll synthesis and chloroplast development. Fe is needed at many steps in the biosynthetic pathways (Brittenham, 1994 and El-Nemr *et al.,* 2012). Boron plays an essential role in sugar transport, cell-wall synthesis, membrane functioning, cell division, differentiation, root elongation and regulation of plant hormone levels (Dursun *et al*., 2010).

Because of the eggplant importance as a food in Egypt, the objective of this investigation is to enhance the fruit yield and quality of the eggplant plants and evaluation of different animal compost levels (20, 30 and 40 m^3fed^{-1}), different boron rates (0.00, 100 and 200 mgL^{-1} B using calcium borate) and different iron rates (0.00, 200 and 400 mgL^{-1} Fe using [Fe-EDTA 12%Fe]) and find out the positive effect of these treatments on grown plant and their quality.

Materials and Methods

To achieve the goal of this investigation, field trial was carried out in the experimental farm of Temi El-Amdid, Agricultural Research Station, El-Dakahlia Governorate, Egypt during the two successive summer seasons of 2018 and 2019 to evaluate the influence of organic fertilization (animal compost) with foliar spraying of boron and iron elements on improving the fruit yield and quality of the eggplants (*Solanum melongena* L.) grown in an alluvial soil. The combined influences of boron, iron and compost on growth and yield of eggplants were investigated by combining three animal compost rates and three spraying rates of both boron and iron.The treatments of animal compost were three levels i.e. (C_1): animal compost was applied at rate of 20.0 m^3fed^{-1} two weeks before planting, (C_2): animal compost was applied at rate of 30.0 m^3fed^{-1}two weeks before planting and (C_3): animal compost was applied at rate of 40.0 m^3fed^{-1}two weeks before planting. The foliar boron treatments were (B_0): without boron addition (0.00 mgL^{-1}), (B_1): B was foliar applied as calcium borate at rate of 100 mg L^{-1} and (B_2): B was foliar applied as calcium borate at rate of 200 mg L^{-1}. The foliar iron treatments were (Fe_0): without iron addition (0.00 mgL^{-1} Fe), (Fe_1): Fe was foliar applied at rate of 200 mgL^{-1} Fe using [Fe-EDTA 12%Fe] and (Fe_2): Fe was foliar applied at rate of 400 mgL^{-1} Fe using

[Fe-EDTA 12%Fe]. The treatments of the field trial were 3 "animal compost levels" ×3 "boron rates" × 3 "iron rates" in addition to control treatment C_0 B_0 Fe_0 (without any addition of compost C_0 and without foliar spraying of both boron B_0 and iron Fe_0) each treatment was done in 3 replicates. The used experimental design was split-split plot design.

According to Dewis and Fertias (1970), the soil used was analyzed before sowing as a routine work. Table 1 shows some chemical and physical properties of experimental soil. Chemical analysis of the experimental animal compost are presented in Table (2).

Table 1 : Some physical and chemical characteristics of the experimental soil before cultivating eggplant seedlings.

Particle size distribution (%)				**Textural class class**		**EC, dSm^{-1*}**	**pH ****	**CaCO$_3$**	**O.M**		**F.C**	**SP**
C. sand	**F. sand**	**Silt**	**Clay**	**Sandy clay loamy**				**(%)**				
3.55	25.12	37.92	33.41			0.90	8.02	4.66	1.81		31.75	63.5
Soluble cations (meq L^{-1})				**Soluble anions (meq L^{-1})**				**Available element, mg kg $^{-1}$**				
Ca^{++}	**Mg^{++}**	**Na^{+}**	**K^{+}**	**CO$_3^{--}$**	**HCO$_3^{-}$**	**Cl^{-}**	**SO$_4^{--}$**	**N**	**P**	**K**	**B**	**Fe**
3.00	1.40	3.10	1.50	-	0.75	4.05	4.20	57.9	5.00	181.6	0.81	2.95

* Soil Electrical Conductivity (EC) and soluble ions were determined in saturated soil paste extract.
** Soil pH was determined in soil suspension (1: 2.5).

Table 2 : Chemical analysis of the animal compost used in experiment.

Weight of m^3 kg^{-1}	**pH 1:10**	**EC (1:10) (dSm^{-1})**		**O.M**	**Organic carbon**	**Total N**	**C/N ratio**	**Total P**	**Total K**
				%				**%**	
645	6.63	4.09		32.82	19.08	1.22	15.7	0.42	0.66
Available micronutrients and heavy metals. (mg kg^{-1})									
Iron	**Manganese**	**Boron**	**Copper**		**Zinc**	**Lead**		**Nickel**	**Cadmium**
61.32	26.40	5.0	5.65		18.43	6.38		0.89	2.05

Seeds of eggplants (*Solanum melongena* L., Sawad Ellel variety) were sown in the nursery on 21th April in both seasons of the study, after 45 days from sowing the seedlings were transplanted in the north side of the row. At soil preparation, the compost manure was applied according to treatments two weeks before planting. The spraying of Fe-EDTA and calcium borate with the above-mentioned rates was repeated 2-times. The first spraying was after 30 and 45 days from transplanting for iron and boron, respectively, while the second spraying was after 45 and 60 days from transplanting for iron and boron, respectively. Harvesting started on September 2 (after 90 days from transplanting) and continued until September 30 with one week intervals period in both seasons. Number of pickings was 5 in both seasons.

Quality parameters: Recorded chemical traits of eggplant fruits were N, P, K, Fe and B concentrations of fruits, Anthocyanin fruit content (mg/100g FW),Total phenolic compounds fruit content (mg/g Dw) and Total soluble solids content (TSS %) of the fresh eggplant fruits. Recorded physical characters of eggplant fruits were average fruit weight (g), average fruit diameter (cm) and average fruit length (cm). Fruit yield parameters of eggplant were early recorded and total yield (ton/fed).

Chemical Analysis of fruits: To determine N, P, K, Ca, Fe and B concentrations in eggplant fruits, 0.4 g crude dried kept powder from each sample was wet digested with a mixture of concentrated perchloric ($HClO_4$) and sulphoric (H_2SO_4) acids, then heated until become clear solution, then it was transferred into 100 ml measuring flask and kept for chemical determinations (Gotteni *et al*., 1982). Total –N, total-P and total-K were determined as described by Jones *et al*. (1991), Peters *et al*. (2003) and Peters *et al*. (2003), respectively. Boron concentration was determined by colorimetric method as mentioned by Bingham (1982), while iron concentration was determined by atomic absorption spectrophotomer as described by Chapman and Pratt (1978). Total soluble solids (TSS %) was estimated according to A.O.A.C (1980). The carotene (mg100g^{-1}) content of eggplant shoots was measured spectrophotometrically as described by Ranganna (1997). Total anthocyanin content of eggplant fruit extracts was measured colorimetrically according to the method described by Du and Francis (1973). Also,above eggplant fruits was used to measure the total phenolic compounds using the modified Folin-Ciocaltue colorimetric method according to (Eberhardt *et al.,* 2000).

Statistical analysis: was calculated using CoStat (Version 6.303, CoHort, USA, 1998–2004), data were statistically analyzed according to Gomez and Gomez (1984).

Results and Discussion

Fruit Quality Traits

(i) Average fruit weight (g), fruit diameter and length (cm)

Data illustrated in Tables (3 and 4) show the effect of different levels of animal compost, boron and iron applications and their interactions on the average values of eggplant fruit characters such as fruit weight (g), fruit diameter and length (cm) during the two successive summer seasons of 2018 and 2019.

From data of Table (3), the highest values of all aforementioned traits are obtained from C_3 treatment (40 m^3 animal compost fed^{-1}) compared to other treatments. The C_2 treatment (30 m^3 animal compost fed^{-1}) came in the second order, thenC_1 (20 m^3 animal compost fed^{-1}). This trend was found for the two studied seasons. Also, data in the same Table (3) show the individual effect of boron applications on average fruit weight (g), fruit diameter and length (cm)in the both studied seasons and indicate that foliar application of 200mg B L^{-1} (B_2 treatment) recorded the highest values of all aforementioned traits of eggplant fruit compared to other treatments in this respect. Also, the B_1 treatment (100mg

BL^{-1}) increased the values of all aforementioned traits more than control treatment (B_0: 0.0 mg B L^{-1}), where the lowest values were found at the control treatment (without application of boron). The trend of iron effect on all aforementioned traits looks just like the trend of boron effect. This trend was found for the both studied seasons.

The interaction effect among the treatments under study on average fruit weight (g), fruit diameter and length (cm) in both studied seasons of eggplant are presented in Table (4). It could be observed that; the values of fruit weight (g), fruit diameter and length (cm) of eggplant were significantly affected due to addition of all investigated treatments, where the highest values in both studied seasons were noticed at [C_3 (40 m^3 animal compost fed^{-1}) × B_2 (200 mg B L^{-1})×Fe_2 (400 mg Fe L^{-1})] treatment, while the lowest values were obtained at control treatment [C_0 (without animal compost) × B_0 (0.00 mg B L^{-1}) ×Fe_0 (0.00 mg Fe L^{-1})]. Data in the same Table, also reveal that; spraying boron at rate of 200 mg B L^{-1} (B_2) with spraying iron at rate of 400 mg Fe L^{-1} gave higher fruit weight (g), fruit diameter and length (cm) of eggplant at any level of compost compared to the same compost level without both boron and iron application. For example, under C_1 treatment (20 m^3 animal compost fed^{-1}),the highest values of fruit weight (g), fruit diameter and length (cm) of eggplant were at [B_2 (200 mg B L^{-1})×Fe_2 (400 mg Fe L^{-1})] treatment, while the lowest values were at [B_0 (0.0 mg B L^{-1})× Fe_0 (0.00 mg Fe L^{-1})] treatment. This trend was realized under both other levels of compost (C_2 and C_3treatments), but the obtained values were increased as the levels of compost was increased. The present results agree with those obtained by Sharma and Brar (2008); Agbo *et al.* (2012); Bozorgi (2012); Abd El-Gawad and Osman (2014); and Hussein and Muhammed (2017).

(ii) Nutritional content in eggplant fruits.

Data illustrated in Tables (5 and 6) reflect the effect of compost, boron, iron and their interactions on nitrogen, phosphorus and potassium percentages as well as boron and iron concentrations (mg kg^{-1}) in fruits of eggplant at harvest stage during the two seasons of 2018 and 2019.

Data in Table (5) indicate that applying animal compost to the soil before sowing at rate of 20, 30 and 40 m^3 fed^{-1}pronouncedly affected the values of N, P and K % as well as B and Fe (mg kg^{-1}) in eggplant fruits at harvest stage during both seasons. The values of N, P and K % as well as B and Fe (mg kg^{-1}) in eggplant fruits significantly increased with the increase of added compost level , where the highest values of N, P and K % as well as B and Fe (mg kg^{-1}) were realized due to the addition of 40 m^3 compost fed^{-1} (C_3) as soil application followed by 20 m^3 compost fed^{-1}(C_2) and lately 20 m^3 compost fed^{-1} (C_1), respectively.

Regarding the individual effect of boron foliar spraying on N, P and K percentages as well as B and Fe concentration (mg kg^{-1}), data in the same Table (5) indicate that the values of all above mentioned nutritional contents in eggplant fruits were significantly increased as the levels of B were increased. In this connect; the highest values were realized for the plants treated with boron foliar spraying at rate of 200 mg B L^{-1} (B_2) while, the lowest one was obtained for B_0 treatment (0.0 mg B L^{-1}). As for individual effect of iron element on the values of all above mentioned nutritional contents in eggplant fruits; data in the same Table (5) indicate that the values of all above mentioned nutritional contents in eggplant fruits were significantly increased as the levels of iron were increased except the values of boron concentration (mg kg^{-1}) in fruits which significantly increased with increasing iron rate from 0.0 to 200 mgL^{-1}(Fe_1 treatment) and then significantly decreased with increasing addition of iron to 400 mgL^{-1}(Fe_2 treatment). In this connect; the highest values of all above mentioned nutritional elements ,except boron concentration (mg kg^{-1}), in eggplant fruits were realized for the plants treated with iron foliar spraying at rate of 400 mg Fe L^{-1} (Fe_2) while, the lowest one was recorded for the Fe_0 treatment (0.00 mg Fe L^{-1}). On the other hand; the highest values of boron concentration (mg kg^{-1}) in fruits were realized for the plants treated with iron foliar spraying at rate of 200 mg Fe L^{-1} (Fe_1) while, the lowest one was found at the Fe_0 treatment (0.0 mg Fe L^{-1}) . The same trend was true during the second season.

The interaction effect between the treatments under investigation are presented in Table (6). It could be observed that; the values of N, P and K % as well as B and Fe (mg kg^{-1}) in fruits of eggplant were significantly affected due to the application of all investigated treatments , where the application of compost at a rate of 40 m^3 fed^{-1} (C_3) with combination between boron at a rate of 200 mg L^{-1} (B_2) and iron at a rate of 200 mg L^{-1} (Fe_1) produced higher values of aforementioned nutritional contents in fruits, except Fe concentration (mg kg^{-1}) in both investigated seasons which recorded the highest values at C_3 (40 m^3 animal compost fed^{-1}) ×B_2 (200 mg B L^{-1})×Fe_2 (400 mg Fe L^{-1}) treatment, while the lowest values of all aforementioned nutritional contents in fruits were recorded at control treatment [C_0 (without animal compost) × B_0 (without B application) ×Fe_0 (without Fe application)]. In this connect, under C_1 and C_2 treatments (20 and 30 m^3 animal compost fed^{-1},respectively), the highest values of all aforementioned nutritional contents in fruits were at [B_2 ×Fe_2] treatment, while the lowest values were at [B_0× Fe_0] treatment. Under C_3 treatment (40 m^3 animal compost fed^{-1}), the highest values of all aforementioned nutritional contents in fruits were obtained, except Fe concentration (mg kg^{-1}), was at [B_2 ×Fe_1] treatment, while the lowest values were at [B_0× Fe_0] treatment. As for Fe concentration (mg kg^{-1}) in 1st and 2nd seasons; the highest values were found at [B_2 ×Fe_2] treatment, while the lowest values were recorded at [B_0× Fe_0] treatment. The increase of application of iron caused reduction for most of nutritional contents in fruits .The present results agree with those obtained by Sharma and Brar (2008); Agbo *et al.* (2012); Bozorgi (2012); Abd El-Gawad and Osman (2014) and Hussein and Muhammed (2017).

(iii) TPC, Anthocyanin and TSS.

Data illustrated in Tables (7 and 8) show the effect of animal compost, boron, iron and their interactions on total phenolic compounds fruit content (TPC) (mg/g Dw), anthocyanin fruit content (mg/100g Fw) and TSS (%) of eggplant fruits as influenced by different levels of animal compost, boron and iron as well as its interactions

Data in Table (7) indicate that applying animal compost to the soil before sowing at rate of 20, 30 and 40 m^3 fed^{-1}pronouncedly affected the TPC (mg/g Dw), anthocyanin (mg/100g Fw) and TSS (%) of eggplant fruits during both seasons . In this respect, the TPC (mg/g Dw), anthocyanin (mg/100g Fw) and TSS (%) of eggplant fruits significantly increased with the increase of addition level of animal compost, where the highest values of aforementioned traits were found due to the addition of 40 m^3 animal compost fed^{-1} (C_3) as soil application followed by 30 m^3 animal compost fed^{-1}(C_2) and 20 m^3 animal compost fed^{-1} (C_1), respectively, this effect was the same during the two seasons of the experiment.

Concerning the influence of boron and iron foliar spraying on TPC (mg/g Dw), anthocyanin (mg/100g Fw) and TSS (%) of eggplant fruits, data in the same Table (7) indicate that all different rates of boron and iron elements pronouncedly affected the TPC (mg/g Dw), anthocyanin (mg/100g Fw) and TSS (%) of eggplant fruits during both seasons of experimentation. As for boron foliar application influences, the values of all aforementioned traits were significantly increased as the levels of B were increased, where treatments sequence disendingly was the B_2 (200mgL^{-1}) > B_1 (100mgL^{-1}) > B_0 (0.00mgL^{-1}). As for the influence of iron; the values of all aforementioned traits were significantly increased as the levels of Fe were increased, where treatments sequence from top to less was the Fe_2 (400mgL^{-1}) > Fe_1 (200mgL^{-1}) > Fe_0 (0.00mgL^{-1}).The differences between these values were significant during both seasons of the experimentation.

The interaction effect among the treatments under study on TPC (mg/g Dw), anthocyanin (mg/100g Fw) and TSS (%) of eggplant fruits are presented in Table (8). It could be observed that; the values of TPC (mg/g Dw), anthocyanin (mg/100g Fw) and TSS (%) of eggplant fruits were significantly affected due to the addition of all investigated treatments, where the highest values in both studied seasons were at [C_3 (40 m^3 animal compost fed^{-1}) × B_2 (200 mg B L^{-1})×Fe_2 (400 mg Fe L^{-1})] treatment, while the lowest values were at control treatment [C_0 (without animal compost) × B_0 (0.00 mg B L^{-1}) ×Fe_0 (0.00 mg Fe L^{-1})].

Data in the same Table, also reveal that; spraying boron at rate of 200 mg B L^{-1} (B_2) along with spraying iron at rate of 400 mg Fe L^{-1} gave higher TPC (mg/g Dw), anthocyanin (mg/100g Fw) and TSS (%) in eggplant fruits at any level of animal compost compared to that same animal compost level without applying both boron and iron application. For example, under C_1 treatment (20 m^3 animal compost fed^{-1}),the highest values of TPC (mg/g Dw), anthocyanin (mg/100g Fw) and TSS (%) of eggplant fruits were found at [B_2 (200 mg B L^{-1})×Fe_2 (400 mg Fe L^{-1})] treatment, while the lowest values were obtained at [B_0 (0.0 mg B L^{-1})× Fe_0 (0.00 mg Fe L^{-1})] treatment. This trend was realized under both other levels of animal compost (C_2 and C_3 treatments) but the values were increased as the levels of animal compost were increased. The present results are in agreement with those obtained by Sharma and Brar (2008); Agbo *et al.* (2012); Bozorgi (2012); Abd El-Gawad and Osman (2014); and Hussein and Muhammed (2017).

Yield and its components

Listed data presented in Tables (9 and 10) indicate the values of early yield (ton fed^{-1}) ,No. of fruits $plant^{-1}$, total yield (ton fed^{-1}) and No. of fruit $plant^{-1}$ of eggplant as influenced by different levels of animal compost, boron and iron as well as its interactions in the two seasons of 2018 and 2019.

Data in Table (9) indicate that applying animal compost to the soil before sowing at rate of 20 ,30 and 40 m^3 fed^{-1}pronouncedly affected the values of early yield (ton fed^{-1}), No. of fruits $plant^{-1}$, total yield (ton fed^{-1}) and No. of fruit $plant^{-1}$ of eggplant during both seasons of experimentation. In this respect, the values of early yield (ton fed^{-1}) ,No. of fruits $plant^{-1}$, total yield (ton fed^{-1}) and No. of fruit $plant^{-1}$ of eggplant significantly increased with the increase of adding level of animal compost, where the highest values of early yield (ton fed^{-1}) ,No. of fruits $plant^{-1}$, total yield (ton fed^{-1}) and No. of fruit $plant^{-1}$ of eggplant were found due to the addition of 40 m^3 animal compost fed^{-1} (C_3) as soil application followed by 30 m^3 animal compost fed^{-1}(C_2) and 20 m^3 animal compost fed^{-1} (C_1), respectively. Treatments sequence from disndingly was the C_3 (40 m^3 fed^{-1}) > C_2 (30 m^3 fed^{-1}) > C_1 (20 m^3 fed^{-1}), such effect was the same during the two seasons of 2018 and 2019.

Concerning the influence of boron and iron foliar spraying on aforementioned traits, data in the same Table (9) indicate that all different rates of boron and iron elements pronouncedly affected the values of early yield (ton fed^{-1}), no. of fruits $plant^{-1}$, total yield (ton fed^{-1}) and no. of fruit $plant^{-1}$ of eggplant during both seasons of experimentation. As for the boron foliar application influences, the values of all aforementioned traits at different growth stages were significantly increased as the levels of B were increased, where treatments sequence from top to less was B_2 (200mgL^{-1}) > B_1 (100mgL^{-1}) > B_0 (0.00mgL^{-1}). As for the influence of iron; the values of all aforementioned traits at different growth stages were significantly increased as the levels of Fe were increased, where treatments sequence from top to less was Fe_2 (400mgL^{-1}) > Fe_1 (200mgL^{-1}) > Fe_0 (0.00mgL^{-1}).The differences among these values were significant during both seasons of the experimentation.

The interaction effect among the treatments under study on the values of early yield (ton fed^{-1}), no. of fruits $plant^{-1}$, total yield (ton fed^{-1}) and n. of fruit $plant^{-1}$ of eggplant are presented in Table (10). It could be observed that; the values of early yield (ton fed^{-1}), no. of fruits $plant^{-1}$, total yield (ton fed^{-1}) and no. of fruit $plant^{-1}$ of eggplant were significantly affected due to application of all investigated treatments, where the highest values in both studied seasons were obtained at [C_3 (40 m^3 animal compost fed^{-1}) × B_2 (200 mg B L^{-1})×Fe_2 (400 mg Fe L^{-1})] treatment, while the lowest values were obtained at control treatment [C_0 (without animal compost) × B_0 (0.00 mg B L^{-1}) ×Fe_0 (0.00 mg Fe L^{-1})]. Data in the same Tables, also reveal that; spraying boron at rate of 200 mg B L^{-1} (B_2) with spraying iron at rate of 400 mg Fe L^{-1} gave higher values of early yield (ton fed^{-1}), no. of fruits $plant^{-1}$, total yield (ton fed^{-1}) and no. of fruit $plant^{-1}$ of eggplant at any level of animal compost compared to that same animal compost level without both boron and iron application. For example, under C_1 treatment (20 m^3 animal compost fed^{-1}), the highest values of the values of early yield (ton fed^{-1}), no. of fruits $plant^{-1}$, total yield (ton fed^{-1}) and no. of fruit $plant^{-1}$ of eggplant were obtained at [B_2 (200 mg B L^{-1})×Fe_2 (400 mg Fe L^{-1})] treatment, while the lowest values were obtained at [B_0 (0.0 mg B L^{-1})× Fe_0 (0.00 mg Fe L^{-1})] treatment. This trend was realized under other two levels of animal compost (C_2 and C_3treatments), but the values were increased as the levels of animal compost were increased.

Results obtained were in harmony with the results of Khedr *et al.* (2004), who suggested that fruit set percentage; total yield and fruit quality were improved by spraying of eggplants with 50 mg B/L. Beside, Houimli *et al.* (2016) who found that foliar applications of iron showed positive effect on fruit number and yield of medium and large sized tomatoes fruits. Thus, these processes will lead to an increment of crop yield and productivity. The present results agree with those obtained by Sharma and Brar (2008); Agbo *et al.* (2012); Bozorgi (2012); Abd El-Gawad and Osman (2014); Hussein and Muhammed (2017).

Table 3 : Effect of compost, foliar spraying with boron and iron on average fruit weight (g), fruit diameter and length (cm) of eggplant during 2018 and 2019 seasons.

Treatments	Average fruit weight (g)		Fruit length (cm)		Fruit diameter (cm)	
	1st	2nd	1st	2nd	1st	2nd
Compost levels						
C_1 (20 m^3fed^{-1})	132.06	134.76	15.14	15.49	10.70	10.99
C_2 (30 m^3fed^{-1})	134.54	135.48	15.71	16.18	11.24	11.58
C_3 (40 m^3fed^{-1})	136.60	139.27	16.53	16.98	11.83	12.12
LSD $_{at\ 5\%}$	**0.73**	**0.68**	**0.01**	**0.09**	**0.01**	**0.05**
Boron levels						
B_0 (0.0 mgL^{-1})	121.79	124.36	14.96	15.35	10.86	11.16
B_1 (100mgL^{-1})	138.96	140.36	15.88	16.30	11.33	11.63
B_2 (200 mgL^{-1})	142.46	144.80	16.54	16.99	11.59	11.90
LSD $_{at\ 5\%}$	**0.66**	**0.69**	**0.01**	**0.03**	**0.01**	**0.05**
Iron levels						
Fe_0 (0.0 mgL^{-1})	129.40	131.17	14.63	15.03	10.82	11.12
Fe_1 (200 mgL^{-1})	133.43	135.34	16.16	16.58	11.38	11.68
Fe_2 (400 mgL^{-1})	140.37	143.02	16.59	17.04	11.58	11.90
LSD $_{at\ 5\%}$	**0.61**	**0.65**	**0.01**	**0.03**	**0.01**	**0.03**

Table 4 : Interaction effects between compost and foliar application of boron and iron on average fruit weight (g), fruit diameter and length (cm) of eggplant during 2018 and 2019 seasons.

Treatments			Average fruit weight (g)		Fruit length (cm)		Fruit diameter (cm)	
			1st	**2nd**	**1st**	**2nd**	**1st**	**2nd**
Control (C0 B0 F0)			87.50	91.30	8.83	9.05	8.17	8.37
C1	B0	Fe0	113.50	118.73	12.87	13.15	9.88	10.14
		Fe1	116.47	120.21	14.77	15.11	10.52	10.81
		Fe2	130.17	131.69	15.37	15.70	10.78	11.08
	B1	Fe0	132.57	134.35	14.07	14.44	10.33	10.62
		Fe1	137.37	139.40	15.57	15.91	10.88	11.15
		Fe2	139.17	141.45	15.89	16.27	11.03	11.31
	B2	Fe0	136.17	138.43	15.07	15.40	10.63	10.93
		Fe1	140.17	143.09	16.17	16.55	11.03	11.33
		Fe2	142.97	145.50	16.47	16.90	11.19	11.51
C2	B0	Fe0	113.26	114.40	13.37	13.75	10.28	10.60
		Fe1	118.02	118.06	15.37	15.81	10.93	11.27
		Fe2	134.17	135.46	16.07	16.54	11.23	11.58
	B1	Fe0	135.57	135.96	14.77	15.18	10.93	11.22
		Fe1	140.17	139.51	16.17	16.64	11.43	11.78
		Fe2	142.17	142.70	16.47	16.98	11.63	11.97
	B2	Fe0	139.17	139.77	15.67	16.11	11.23	11.56
		Fe1	142.17	144.71	16.67	17.21	11.68	12.03
		Fe2	146.17	148.76	16.87	17.39	11.83	12.20
C3	B0	Fe0	114.97	116.27	13.87	14.29	10.83	11.09
		Fe1	119.17	120.49	16.07	16.46	11.58	11.87
		Fe2	136.37	143.96	16.87	17.39	11.68	11.97
	B1	Fe0	137.87	138.88	15.57	15.95	11.43	11.84
		Fe1	141.17	143.18	16.97	17.46	12.03	12.27
		Fe2	144.57	147.79	17.47	17.91	12.23	12.54
	B2	Fe0	141.57	143.69	16.47	16.99	11.78	12.07
		Fe1	146.17	149.37	17.67	18.10	12.33	12.57
		Fe2	147.57	149.83	17.87	18.31	12.58	12.89
LSD at 5%			1.83	1.95	0.01	0.11	0.01	0.10

Table 5 : Effect of compost, foliar spraying with boron and iron on N, P and K (%) as well as B and Fe ($mg.kg^{-1}$) of eggplant fruits during 2018 and 2019 seasons.

Treatments	N		P		K		B		Fe	
	%						$mg.kg^{-1}$			
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Compost levels										
C_1 (20 $m^3fed^{-1)}$	2.00	2.12	0.165	0.177	1.74	1.84	14.55	14.88	27.39	28.08
C_2 (30 m^3fed^{-1})	2.22	2.36	0.183	0.197	1.94	2.04	14.97	15.40	27.95	28.79
C_3 (40 m^3fed^{-1})	2.37	2.52	0.200	0.215	2.12	2.24	15.05	15.43	28.56	29.22
LSD $_{at\ 5\%}$	**0.10**	**0.11**	**0.002**	**0.001**	**0.02**	**0.03**	**0.05**	**0.06**	**0.10**	**0.09**
Boron levels										
B_0 (0.0 mgL^{-1})	1.50	1.60	0.129	0.139	1.30	1.37	13.42	13.76	27.78	28.55
B_1 (100mgL^{-1})	2.44	2.59	0.205	0.220	2.18	2.31	15.25	15.64	27.97	28.64
B_2 (200 mgL^{-1})	2.64	2.81	0.214	0.230	2.31	2.43	15.90	16.32	28.15	28.91
LSD $_{at\ 5\%}$	**0.07**	**0.07**	**0.002**	**0.002**	**0.02**	**0.02**	**0.04**	**00.05**	**0.09**	**0.05**
Iron levels										
Fe_0 (0.0 mgL^{-1})	1.82	1.93	0.154	0.165	1.58	1.67	14.00	14.36	26.22	26.88
Fe_1 (200 mgL^{-1})	2.31	2.46	0.194	0.209	2.08	2.19	15.32	15.70	27.96	28.66
Fe_2 (400 mgL^{-1})	2.46	2.62	0.200	0.215	2.14	2.26	15.26	15.65	29.71	30.55
LSD $_{at\ 5\%}$	**0.06**	**0.07**	**0.001**	**0.002**	**0.02**	**0.02**	**0.04**	**0.06**	**0.06**	**0.06**

Table 6 : Interaction effects among compost and foliar application of boron and iron on N, P and K (%) as well as B and Fe ($mg.kg^{-1}$) of eggplant fruits during 2018 and 2019 seasons.

Treatments			N		P		K		B		Fe	
			%						$mg.kg^{-1}$			
			1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Control (C_0 B_0 F_0)			**1.10**	**1.16**	**0.096**	**0.102**	**0.84**	**1.03**	**9.20**	**9.46**	**19.98**	**20.27**
C_1	**B_0**	**Fe_0**	1.18	1.26	0.106	0.114	1.02	1.08	11.07	11.32	25.47	26.13
		Fe_1	1.43	1.52	0.117	0.125	1.26	1.33	13.48	13.79	27.14	27.88
		Fe_2	1.48	1.58	0.130	0.141	1.31	1.38	13.94	14.25	28.97	29.78
	B_1	**Fe_0**	1.90	2.01	0.160	0.172	1.65	1.75	14.37	14.70	25.64	26.35
		Fe_1	2.38	2.55	0.194	0.207	2.05	2.17	15.55	15.89	27.35	28.02
		Fe_2	2.48	2.63	0.200	0.214	2.18	2.31	15.27	15.63	29.16	29.87
	B_2	**Fe_0**	1.97	2.09	0.165	0.175	1.71	1.79	14.81	15.13	25.86	26.46
		Fe_1	2.54	2.70	0.205	0.219	2.23	2.35	16.45	16.79	27.54	28.04
		Fe_2	2.61	2.79	0.211	0.228	2.29	2.43	16.03	16.46	29.34	30.16
C_2	**B_0**	**Fe_0**	1.26	1.33	0.111	0.119	1.08	1.14	13.20	13.57	26.03	26.92
		Fe_1	1.59	1.68	0.134	0.144	1.38	1.46	13.65	14.00	27.76	28.48
		Fe_2	1.68	1.79	0.143	0.154	1.44	1.48	14.09	14.50	29.49	30.33
	B_1	**Fe_0**	2.06	2.19	0.171	0.184	1.78	1.90	14.53	14.92	26.21	26.79
		Fe_1	2.68	2.85	0.217	0.234	2.34	2.48	15.72	16.14	27.99	28.90
		Fe_2	2.77	2.95	0.224	0.242	2.41	2.53	15.86	16.35	29.72	30.47
	B_2	**Fe_0**	2.13	2.26	0.178	0.192	1.92	2.03	14.95	15.37	26.40	27.18
		Fe_1	2.85	3.03	0.231	0.250	2.49	2.60	16.59	17.13	28.17	29.07
		Fe_2	2.94	3.12	0.237	0.255	2.57	2.73	16.16	16.63	29.79	31.00
C_3	**B_0**	**Fe_0**	1.33	1.42	0.118	0.126	1.15	1.22	13.32	13.66	26.65	27.40
		Fe_1	1.75	1.86	0.149	0.161	1.52	1.60	13.80	14.13	28.36	29.05
		Fe_2	1.84	1.99	0.153	0.164	1.57	1.69	14.23	14.62	30.12	30.94
	B_1	**Fe_0**	2.20	2.36	0.187	0.202	1.92	2.03	14.66	15.01	26.74	27.02
		Fe_1	2.33	2.50	0.243	0.261	2.63	2.77	15.87	16.34	28.58	29.22
		Fe_2	3.13	3.30	0.247	0.265	2.70	2.86	15.41	15.75	30.32	31.08
	B_2	**Fe_0**	2.30	2.45	0.188	0.202	1.99	2.11	15.10	15.52	26.99	27.65
		Fe_1	3.24	3.45	0.259	0.278	2.83	2.95	16.74	17.12	28.76	29.32
		Fe_2	3.17	3.40	0.254	0.273	2.76	2.92	16.32	16.72	30.48	31.33
LSD $_{at\ 5\%}$			**0.19**	**0.20**	**0.004**	**0.005**	**0.06**	**0.05**	**0.12**	**0.17**	**0.17**	**0.19**

Table 7 : Effect of compost, foliar spraying with boron and iron on TPC(mg/g Dw), anthocyanin(mg/100g Fw) and TSS(%) of eggplant fruits during 2018 and 2019 seasons.

Treatments	Total phenolic compounds content (TPC) (mg/g Dw)		Anthocyanin content (mg/100g Fw)		TSS (%)	
	1st	2nd	1st	2nd	1st	2nd
Compost levels						
C_1 (20 $m^3fed^{-1)}$	37.71	38.91	513.76	525.13	4.65	4.80
C_2 (30 m^3fed^{-1})	38.04	38.87	531.56	548.57	5.10	5.23
C_3 (40 m^3fed^{-1})	38.43	39.60	553.22	567.50	5.36	5.52
LSD $_{at\ 5\%}$	**0.18**	**0.16**	**3.30**	**1.67**	**0.08**	**0.01**
Boron levels						
B_0 (0.0 mgL^{-1})	36.77	37.84	503.92	517.24	4.87	4.99
B_1 (100mgL^{-1})	38.00	39.05	525.24	539.20	5.00	5.15
B_2 (200 mgL^{-1})	39.41	40.49	569.37	584.75	5.24	5.41
LSD $_{at\ 5\%}$	**0.14**	**0.15**	**2.84**	**0.50**	**0.06**	**0.01**
Iron levels						
Fe_0 (0.0 mgL^{-1})	36.81	37.90	467.39	480.07	4.76	4.90
Fe_1 (200 mgL^{-1})	38.39	39.39	554.68	569.73	5.06	5.22
Fe_2 (400 mgL^{-1})	38.97	40.09	576.47	591.40	5.29	5.43
LSD $_{at\ 5\%}$	**0.13**	**0.19**	**6.21**	**0.57**	**0.04**	**0.01**

Table 8 : Interaction effects among compost and foliar application of boron and iron on TPC (mg/g Dw), anthocyanin (mg/100g Fw) and TSS (%) of eggplant fruits during 2018 and 2019 seasons.

Treatments			Total phenolic compounds content (mg/g Dw)		Anthocyanin content (mg/100g Fw)		TSS (%)	
			1st	2nd	1st	2nd	1st	2nd
Control (C_0 B_0 F_0)			**28.60**	**29.48**	**400.37**	**411.29**	**3.97**	**4.07**
C_1	**B_0**	**Fe_0**	34.71	35.77	426.20	435.60	4.23	4.36
		Fe_1	37.00	38.10	497.50	508.93	4.48	4.65
		Fe_2	37.46	38.63	531.70	541.46	4.67	4.83
	B_1	**Fe_0**	36.41	37.55	445.70	455.11	4.42	4.54
		Fe_1	37.81	39.09	526.30	537.83	4.64	4.78
		Fe_2	38.54	39.85	546.60	559.48	4.86	4.97
	B_2	**Fe_0**	37.92	39.17	479.60	490.10	4.60	4.78
		Fe_1	39.68	40.91	578.30	592.12	4.86	5.03
		Fe_2	39.80	41.14	591.90	605.51	5.09	5.26
C_2	**B_0**	**Fe_0**	35.20	36.42	441.50	454.53	4.60	4.76
		Fe_1	37.40	38.35	516.20	532.60	5.00	5.09
		Fe_2	37.76	38.50	550.80	568.41	5.34	5.27
	B_1	**Fe_0**	36.90	37.68	461.80	476.50	4.69	4.87
		Fe_1	38.20	38.87	548.30	566.72	5.09	5.26
		Fe_2	38.86	39.68	563.50	581.54	5.29	5.45
	B_2	**Fe_0**	38.37	39.22	492.50	508.30	5.08	5.19
		Fe_1	39.46	39.87	596.60	616.09	5.25	5.46
		Fe_2	40.21	41.27	612.80	632.44	5.55	5.74
C_3	**B_0**	**Fe_0**	35.62	36.72	462.40	476.45	4.88	5.02
		Fe_1	37.60	38.77	538.50	551.99	5.24	5.40
		Fe_2	38.17	39.29	570.50	585.21	5.34	5.50
	B_1	**Fe_0**	37.41	38.54	482.20	494.45	5.05	5.17
		Fe_1	38.59	39.64	568.90	583.51	5.41	5.56
		Fe_2	39.28	40.55	583.90	597.68	5.58	5.77
	B_2	**Fe_0**	38.79	40.03	514.60	529.59	5.29	5.45
		Fe_1	39.76	40.92	621.50	637.75	5.58	5.75
		Fe_2	40.66	41.92	636.50	650.83	5.87	6.05
LSD $_{at\ 5\%}$			**0.38**	**0.57**	**1.62**	**1.72**	**0.12**	**0.03**

Table 9 : Effect of compost, foliar spraying with boron and iron on yield (ton fed^{-1}) and Number of fruits plant^{-1}of eggplant during 2018 and 2019 seasons.

Treatments	Early yield				Total Yield			
	Early yield (ton fed^{-1})		No. of fruit plant^{-1}		Total yield (ton fed^{-1})		No. of fruit plant^{-1}	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Compost levels								
C_1 (20 m^{3}fed^{-1})	3.38	3.41	12.96	13.15	7.44	7.65	29.67	30.04
C_2 (30 m^{3}fed^{-1})	3.89	3.98	13.93	14.15	8.80	8.87	30.07	31.30
C_3 (40 m^{3}fed^{-1})	4.61	4.72	15.59	16.30	10.55	10.82	32.22	33.15
LSD $_{at\ 5\%}$	**0.02**	**0.18**	**0.55**	**0.34**	**0.15**	**0.12**	**0.57**	**0.38**
Boron levels								
B_0 (0.0 mgL^{-1})	3.64	3.73	12.70	13.15	8.14	8.33	26.19	26.89
B_1 (100mgL^{-1})	4.04	4.08	13.85	14.11	9.10	9.24	30.52	31.56
B_2 (200 mgL^{-1})	4.20	4.29	15.93	16.33	9.54	9.78	35.26	36.04
LSD $_{at\ 5\%}$	**0.02**	**0.12**	**0.26**	**0.43**	**0.13**	**0.09**	**0.37**	**0.31**
Iron levels								
Fe_0 (0.0 mgL^{-1})	3.69	3.77	12.56	12.93	8.38	8.49	26.30	26.85
Fe_1 (200 mgL^{-1})	4.00	4.06	14.37	14.81	9.04	9.15	31.74	33.00
Fe_2 (400 mgL^{-1})	4.20	4.28	15.56	15.85	9.36	9.71	33.93	34.63
LSD $_{at\ 5\%}$	**0.02**	**0.07**	**0.38**	**0.28**	**0.14**	**0.07**	**0.44**	**0.41**

Table 10 : Interaction effects among compost and foliar application of boron and iron on yield (ton fed^{-1}) and Number of fruits plant^{-1}of eggplant during 2018 and 2019 seasons.

Treatments			Early yield				Total Yield			
			Early yield (ton fed^{-1})		No. of fruit plant^{-1}		Total yield (ton fed^{-1})		No. of fruit plant^{-1}	
			1st	2nd	1st	2nd	1st	2nd	1st	2nd
Control (C_0 B_0 F_0)			**1.86**	**1.95**	**6.00**	**6.67**	**4.01**	**4.10**	**14.00**	**14.33**
C_1	**B_0**	**Fe_0**	2.85	2.94	10.33	10.33	6.17	6.47	21.33	21.00
		Fe_1	3.05	3.12	12.00	12.67	6.77	6.92	26.67	27.33
		Fe_2	3.29	3.35	12.67	12.33	7.17	7.38	27.33	28.00
	B_1	**Fe_0**	3.10	2.93	11.33	11.33	7.05	7.02	24.67	25.00
		Fe_1	3.52	3.30	12.67	13.00	7.85	8.11	31.00	31.67
		Fe_2	3.69	3.80	13.67	14.00	7.73	8.20	33.33	33.00
	B_2	**Fe_0**	3.33	3.44	13.33	13.00	7.37	7.37	30.33	30.00
		Fe_1	3.70	3.81	14.67	15.00	8.27	8.30	34.67	35.67
		Fe_2	3.90	4.01	16.00	16.67	8.60	9.11	37.67	38.67
C_2	**B_0**	**Fe_0**	3.38	3.49	10.67	11.00	7.47	7.81	20.67	21.33
		Fe_1	3.60	3.65	12.67	13.00	7.97	8.01	27.67	29.00
		Fe_2	3.74	3.80	13.67	14.00	8.32	8.35	28.33	29.00
	B_1	**Fe_0**	3.68	3.77	12.33	12.00	8.39	8.31	25.67	27.00
		Fe_1	4.03	4.10	13.67	14.00	9.19	9.26	31.67	34.00
		Fe_2	4.23	4.35	15.33	15.33	9.70	9.55	32.67	34.00
	B_2	**Fe_0**	3.76	3.84	14.00	14.00	8.85	8.46	31.00	31.67
		Fe_1	4.12	4.22	16.33	16.67	9.36	9.36	34.33	36.67
		Fe_2	4.48	4.58	16.67	17.33	9.92	10.74	38.67	39.00
C_3	**B_0**	**Fe_0**	4.11	4.21	12.00	13.67	9.43	9.77	22.67	24.67
		Fe_1	4.30	4.44	14.67	15.00	9.77	9.87	29.67	30.00
		Fe_2	4.48	4.61	15.67	16.33	10.22	10.37	31.33	31.67
	B_1	**Fe_0**	4.45	4.58	12.67	14.33	10.19	10.21	27.67	28.00
		Fe_1	4.73	4.87	15.67	16.00	10.91	11.03	32.67	34.67
		Fe_2	4.91	5.05	17.33	17.00	10.87	11.43	35.33	36.67
	B_2	**Fe_0**	4.58	4.73	16.33	16.67	10.50	11.01	32.67	33.00
		Fe_1	4.91	5.04	17.00	18.00	11.32	11.44	37.33	38.00
		Fe_2	4.95	5.05	19.00	19.67	11.72	12.22	40.67	41.67
LSD $_{at\ 5\%}$			**0.07**	**0.20**	**1.13**	**0.84**	**0.44**	**0.22**	**1.31**	**1.22**

Conclusion

According to the obtained results in this investigation, eggplant 'Sawad Ellel variety' treated with compost (animal residues) before planting at a rate of 40 m^3 fed^{-1} and sprayed with combination of boron element at a rate of 200 mg L^{-1} and iron element at a rate of 400 mg L^{-1} was the best treatment that could be recommended to obtain the highest yield as well as improved eggplant fruit quality, especially TPC, TSS% and Anthocyanin of eggplant fruit in Nile Delta area.

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