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Full Length Research Paper

The use of organic and inorganic cultures in improving vegetative growth, yield characters and antioxidant activity of roselle plants (*Hibiscus sabdariffa* L.)

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This study was conducted at the Experimental Farm of the Faculty of Agriculture, in May during the two seasons of 2008 and 2009 on roselle plants (*Hibiscus sabdariffa* L.). The objective was to improve the vegetative growth, yield characters and antioxidant activity of plants growing under different organic and inorganic media conditions in response to the spray of amino acids, humic acids and micro elements. The results showed great similarity which had been noticed with the majority of the studied characters in both seasons. The highest values of plant height, number of branches per plant, stem diameter, fresh and dry weights of leaves and branches per plant, number of days to flowering, number of fruits per plant, fresh and dry weights of sepals per plant and seed yield per plant were obtained when the plants were grew in a soil mixed with compost or magnetic iron and sprayed by humic acid in comparison with the rest of the treatments. Comparing the values of the previous characters when compost plus humic acid was used to that of magnetic iron plus humic acid, it could be stated that these values were greater with the first treatment than that of the second one in both seasons. The lowest values of the characters were noticed always with the mixture of compost or magnetic iron with amino acids or with micro elements, although these values were still higher than that of the compost or a single magnetic iron, or that of the control treatments in both seasons. The best scavenging activity against DPPH radical was observed with plants treated with compost plus humic acid and this correlated with the total anthocyanin content.

Key words: Roselle plants, antioxidant activity, compost, amino acid, magnetic iron, micro elements.

INTRODUCTION

Roselle plants (*Hibiscus sabdariffa* L.) belong to the family Malvaceae, known commonly as "karkade" in Egypt and most Arab countries (Mohamed et al., 2007). The part of the flower used by customers is the dried and fleshly calyces which have large quantities of organic acids (that is, oxalic, malic, citric and tartaric acids). The calyces have, also, vitamin C and the properties of therapeutic and diuretic acids, in addition to two types of anthocyanins, namely: hibiscin (delphinidin) and gossyptin (cyanidin) (Peng-Kong et al., 2002).

The plant is cultivated in the tropical and subtropical countries as one of the most important medicinal plants. The drink of "karkade" made of calyx has many medicinal uses. It is said to be a folk remedy for cancer. Its soporific action has a favorable effect on the functions of the stomach possession. It kills various types of bacteria and micro-organisms (Aziz et al., 2007), and as such, decreases blood pressure and causes relaxation of the rest parts of the body (Muller and Franz, 1992). The red beverage is also used in jams, tea pies, deserts and sauces. The flowers of ‘roselle’ are suitable for use as natural food coloring agents. Seeds of "Karkade" plant are a good source of lipid-soluble antioxidant and particularly ɤ-tocopherol (Sanyo, 1981).

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Organic fertilizers are very safe for human health and environment. It is made by recycling organic material as plant and animals waste, and food scraps in a controlled process. Recently, several of these fertilizers have been used in a wide range around the world and organic compost is one of them. Compost enhances the environmental sustainability of agriculture by decreasing chemical inputs and increasing soil organic matter (Mathur et al., 1993). As a matter of fact, it is used to improve soil properties, water retention capacity, draining, pH and better availability of soil microorganism (Khandar and Nigam, 1986; Herrera et al., 1997). Adding different organic compost to the soil caused remarkable improvement of different growth characters, yield and chemical constituents of various medicinal and aromatic plants (that is, on peppermint) (Tara et al., 1996), on *Rosmarinus officinalis* and *Tagetes erecta* (Khalil, 2002).

Compost application to sandy soil significantly increased both dry matter production of sepals and number of roselle plant fruits (Kandil et al., 2002). It is used to increase anthocyanin and ascorbic acid contents in addition to a reduction of the acidity and glucose in sepals (Postma et al., 2003). Humic acid is an organic substance naturally occurring in soils, coal and peat which results from the decomposition of organic matter, particularly the dead plants (El-Ghamry et al., 2009).

Humic acid provides numerous benefits to crop production. It has been reported to influence the plant growth both directly and indirectly. The indirect effects of humic acid compounds have been attributed to the improvement of physical, chemical and biological conditions of soil. It breaks up clay and compacted soils, assists in transferring micronutrients from the soil to the plant, enhances water retention, increases seed germination rates, improves nutrient absorption, plant growth and penetration and stimulates the development of microflora populations. The direct effects on plant growth is to the increase the cell chlorophyll content, the acceleration of the respiration process, hormonal growth responses, increasing substances penetration to plant membranes, affect the dry matter production and the uptake of nutrients by plants (Mallikarjuna et al., 1987). Also, humic acid has positive effects on the promotion of root development. It increases the root/shoot ratio as well as the production of thin lateral roots of some plants (Tattini et al., 1990, 1991).

De Souza et al., (2005) showed that the magnetic treatments led to a remarkable increase in plant root and stem length as well as fresh and dry weight during the nursery period. These initial effects are very positive since they appear to induce an improved capacity for nutrient and water uptake, providing greater physical support to the developing shoot. Iron (Fe) is a cofactor for approximately 140 enzymes that catalyze unique biochemical reactions. Hence, iron fills many essential roles in plant growth and development, including chlorophyll synthesis, thylakoid synthesis and chloroplast development (Miller et al., 1995).

The objective of this study was to improve the vegetative growth, yield parameters and antioxidant activity of roselle plants grew under different organic and inorganic media conditions in response to the spray of amino acids, humic acids and micro elements.

MATERIALS AND METHODS

Chemical reagents

The following chemical compounds were used in this study and were purchased from Sigma Chemical Co. (St. Louis, MO, USA): 1, 1-diphenyl-2-picrylhydrazyl radical (DPPH), butylated hydroxytoluene (BHT), butylated hydroxytanisole (BHA) and methanol solvent (HPLC grade).

Field experiment

The field experiments were carried out at the farm of Agricultural Researches Station, Wadi El-Natrown Area, Faculty of Agriculture, Cairo University, during May for two seasons (2008 and 2009). The experiment had nine treatments: control with normal mineral fertilizer (NPK); compost and compost plus (humic acid, amino acid and micro elements); magnetic iron (as microelements fertilizer) and magnetic iron plus (humic acid, amino acid and micro elements). Seeds of *Hibicus sabdariffa* L. plants were sown in hills 50 cm in-between and at 3 seeds per hill; 5 rows, 10 m in length and 1.5 m in width.

The used recommended doses of compost (3 ton/fed) and magnetic iron (100 kg/fed) were added before planting. After one month from planting, the seedlings were thinned to one plant/hill. The plants were sprayed twice at monthly intervals starting with thinning (from July to September) by humic acid at 2.0 cm/L (commercial name is Helpstar; 12% humic acid, 3% folic acid and 16% organic matter), amino acid at 1.0 cm/L (commercial name is Amica; 10% free amino acid, 14% CaO, 5% total nitrogen and 7% organic matter) and micro elements (mix) at 0.75 kg/fed (commercial name is Micromix; 6% iron, 3% Zn, 1.2% Cu and 3% Mn). An NPK fertilizer with a ratio (2:1:1) representing the traditional fertilization in most nurseries, was added. The normal agricultural procedures recommended for roselle plants were applied. The experiment layout was a randomized complete block design, with three replicates of each treatment. Data were subjected to convenient statistical analysis methods for calculations of means, variance and standard error according to MSTATC software. Mean separations were estimated by calculating LSD values at 5% level according to Snedecor and Cochran (1980).

Determination of titratable acidity and pH

The pH and titratable acidity were determined according to the standard method as described by Kirk and Sawyer (1997).

Determination of total nitrogen

The determination of total nitrogen was carried out according to micro-Kjeldahl method. The crude proteins were calculated by multiplying the total nitrogen percent by the factor of 6.25 (AOAC, 1990).

Determination of phosphorus

The total phosphorus in different samples were extracted as reported

By Soltanpour (1985) and determined spectrophotometrically according to the procedures of Olsen and Watanab (1965).

Determination of potassium

The total potassium in the tested samples was determined by flame photometric according to APHA method (APHA, 1992).

Analysis of anthocyanin content

Anthocyanin content was extracted by using acidified methanol (1%HCl). The absorbance of the clear filtered pigment solution was measured spectrophotometrically at 535 nm using the molar absorption coefficient (29 500 M^{-1} cm^{-1} of cyaniding 3-glycoside) as described by Stickland and Sunderland (1972).

Measurement of DPPH free-radical scavenging activity

Quantitative measurement of radical scavenging properties was determined by the method of Blois (1958). The reaction mixture contained 50 µl of methanolic extract samples (or 80% MeOH as a blank) and 1 ml of 0.04% (w/v) solution of DPPH in methanol. Different standard antioxidants; butylated hydroxytoluene (BHT) and butylated hydroxylanisole (BHA) were used for comparison or as a positive control. Discoloration was measured at 517 nm after incubation for 30 min. Measurements were performed at least in triplicate. The actual decrease in absorption induced by the test compounds was compared with the positive controls.

Vegetative growth and yield characters

For recording the data, six plants from each treatment were randomly chosen and the following variables were recorded: plant height (cm), number of branches/plant, stem diameter (cm), fresh and dry weights of leaves and branches, number of days to flowering, number of fresh fruits/plants, dry weights of sepals, seed yield per plant, antioxidant activities, anthocyanin contents, NPK percentages, titeratable acidity and pH values.

The results were discussed from different points of view. First, the effects of the single, compost or magnetic iron were discussed when the iron was added to the soil on the vegetative growth and yield characters of the control treatment (soil treated with regular mineral fertilizer) in both seasons.

Secondly, the effects of adding humic acid, amino acid and micro elements, as foliar sprays, to either compost or magnetic iron on the previous characters of the compost or magnetic iron (the single) were discussed. Thirdly, the effects of adding these acids and elements individually to compost and the same components to magnetic iron (that is, compost plus humic acid and magnetic iron plus humic acid) were discussed. Finally, the addition of the best mixture to the soil or as foliar sprays could be recommended to improve the vegetative growth, yield characters and the oxidative activities of roselle plants.

RESULTS AND DISCUSSION

Vegetative growth behaviors

Plant height, number of branches per plant and stem diameter

The data in Table 1 shows that the plant height, number of branches per plant and the stem diameter had the highest values when compost or magnetic iron was added to the soil compared to the values of the control treatment (soil treated with only mineral fertilizer) in the first and second seasons. The effect of these compounds gave the highly significant values of plant height and number of branches per plant.

The values obtained from the previous characters were the highest with compost plus humic acid when compared to those either with compost only or with amino acid or micro elements in both seasons. Although the values obtained for the number of branches per plant and stem diameter were the lowest when compost plus amino acid or micro elements was used than those with compost alone in both seasons, still, it was higher than that of the control treatment.

The three studied characters had the same trend, previously mentioned, when magnetic iron was mixed with humic acid. As such, the highest values of these characters were obtained when compared to those with magnetic iron alone or mixed with amino acid or micro elements. Number of branches per plant had the lowest values with magnetic iron plus amino acid or micro elements when compared to either magnetic iron alone or plus humic acid in both seasons.

Comparing the values of the studied characters with humic acid when added to the compost to that with magnetic iron, it could be noticed that these values were the highest with the first treatment, except with the stem diameter values, where the values were the highest with the second treatment in both seasons.

Finally, from the aforementioned results, the highest values of the studied characters were achieved when the soil was mixed with compost and the plant was sprayed by humic acid, followed by magnetic iron plus humic acid, then either by compost or magnetic iron alone in both seasons. These results were in harmony with those obtained by Adani et al. (1998) on tomato, Naguib (2003) on *Chamomille recutita*, Aly (2003) on *Lupinus termis*, and Khalil and El-Sherbeny (2003) on *Mentha* spp. Consequently, they reported that the humic acid stimulated the plant's growth.

The reason for the high values of the studied characters, when compost plus humic acid was used due to the important role of compost on soil properties, was moisture retention and better nutrient availability resulting in good plant growth production. Humic acid stimulates plant growth by the assimilation of major and minor elements, enzyme activation, changes in membrane permeability, protein synthesis and the activation of biomass production (Ulukan, 2008). Russo and Berlyn (1990) reported that, humates (granular and liquid forms) can reduce plant stress that involved plant diseases as well as enhance plant nutrient uptake.

Humic acids are excellent foliar fertilizer carriers and activators. Application of humic acids in combination with trace elements and other plant nutrients, as foliar sprays, can improve the growth of plant foliage, roots and fruits the leaves, an increase in the carbohydrates content of the

Table 1. Effect of different organic and non organic compounds on vegetative growth characteristics of roselle plants, during the 2008 and 2009 seasons.

Treatment	Plant height (cm)	Number of branch/plant	Stem diameter (cm)	Fresh weight (g)		Dry weight (g)	
				Leaf/plant	Branch/plant	Leaf/plant	Branch/plant
2008 season							
Control	152.8±3.70	9.267±0.32	1.600±0.10	161.20±4.83	203.3±6.35	25.67±0.38	43.47±2.09
Compost	174.1±3.5	14.03±0.55	1.800±0.10	170.1±2.55	248.2±7.09	27.64±0.75	50.77±0.96
Compost+ humic acid	183.8±3.72	15.80±0.56	1.967±0.21	195.7±5.03	293.2±3.15	31.34±0.32	60.55±0.96
Compost+ amino acid	162.6±1.63	13.20±0.30	1.733±0.15	188.7±1.66	279.6±7.29	28.75±1.10	56.82±1.84
Compost+ micromix	157.3±1.89	11.33±0.51	1.600±0.10	182.8±2.95	251.1±5.08	28.26±1.18	52.14±1.36
Magnetic iron	163.8±3.50	13.80±0.52	1.567±0.06	176.3±2.35	249.3±5.33	27.34±0.78	52.73±4.29
Magnetic iron +humic acid	177.00±1.36	15.57±0.65	2.133±0.32	191.40±3.31	277.5±2.07	30.78±0.43	56.5±1.11
Magnetic iron + amino acid	166.70±0.98	13.30±0.36	1.933±0.06	184.20±4.11	282.1±5.96	29.74±0.66	56.43±0.82
Magnetic iron +micro mix	169.4±0.86	11.03±0.15	1.767±0.06	180.00±2.78	266.8±0.95	28.26±0.53	56.39±1.85
L.S.D (5%)	4.79	0.67	0.20	5.19	6.41	1.34	3.34
2009 season							
Control	150.4±0.48	8.93±0.55	1.533±0.15	162.8±2.33	205.6±4.94	25.33±0.80	43.14±2.62
Compost	173.3±2.53	13.7±0.82	1.667±0.12	170.5±2.04	251.2±2.25	28.64±1.2	51.10±0.99
Compost+ humic acid	187.50±1.68	16.13±0.86	2.1±0.35	198.4±2.43	293.5±2.58	32.34±1.41	60.55±0.96
Compost+ amino acid	163.90±3.26	12.87±0.65	1.8±0.1	189.4±1.01	282.3±3.13	29.08±1`.63	57.15±1.94
Compost+ micromix	157.3±2.61	11±0.85	1.633±0.06	185.1±3.05	252.8±3.09	28.59±1.55	52.48±1.05
Magnetic iron	166.8±1.57	14.13±0.06	1.6±0.00	177.00±3.63	251.3±2.50	27.00±0.61	54.39±4.08
Magnetic iron +humic acid	176.5±1.95	15.9±0.89	2.23±0.31	192.4±2.31	277.9±1.85	30.45±1.00	57.5±2.01
Magnetic iron + amino acid	168.00±1.34	13.97±0.81	1.93±0.06	184.6±4.12	283.4±4.55	29.07±1.71	55.43±0.92
Magnetic iron +micro mix	168.7±2.40	11.37±0.72	1.73±0.06	181.00±1.32	267.1±1.48	28.59±0.92	57.06±0.71
L.S.D (5%)	3.90	1.12	0.26	4.78	5.16	2.24	3.61

leaves and stems occurs (El-Ghamry et al., 2009).

Fresh and dry weights of leaves and branches

The data in Table 2 indicate that the fresh and dry weights of leaves and branches per plant had the highest values when the plant was grown in a soil mixed with compost or magnetic iron compared to that of the control treatment in both seasons. The effect of compost or magnetic iron was highly significant with the fresh and dry weights of branches rather than of leaves.

The values of the fresh and dry weights of leaves and branches were remarkably increased when compost plus humic acid was used as opposed to that with compost alone or mixed with amino acid or micro elements in the first and second seasons. The lowest values of these characters were noticed with compost plus micro element; however, these values were still higher than that of the compost or the control treatments in both seasons.

Regarding the effect of magnetic iron on the fresh and dry weights of leaves and branches, the same previous trend of compost was observed. The lowest values of the studied characters, in both seasons, were observed with magnetic iron alone compared to the other magnetic treatments.

When the values of these characters were compared with the usage of compost plus humic acid to that with magnetic iron plus humic acid treatment, it could be stated that these values exceeded

Table 2. Influence of different organic and non organic compounds on flowering and fruiting of roselle plants, during the 2008 and 2009 seasons.

Treatment	Number of days to flowering		Number of fruit/plant		Fresh weight of sepal/plant (g)		Dry weight of sepals/plant (g)		Seed yield per plant (g)	
	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
Control	170.9±1.56	169.3±4.20	22.53±2.19	23.53±1.01	65.47±5.06	67.47±2.83	7.94±0.58	8.273±0.62	21.30±1.41	22.30±2.98
Compost	157.2±1.49	157.6±1.98	34.08±3.12	35.08±1.46	81.54±3.29	81.87±2.91	11.36±0.57	11.7±0.22	40.97±1.78	41.63±1.94
Compost +humic acid	149.3±1.15	150.9±3.81	57.57±2.58	58.9±2.33	124.00±2.88	125.6±0.02	19.32±0.61	19.66±0.18	49.07±2.97	50.40±1.04
Compost + amino acid	151.2±1.77	151.5±1.99	53.16±5.42	60.16±2.04	112.6±3.04	112.9±2.55	15.72±0.3	16.39±1.19	29.73±0.80	30.07±1.02
Compost+ micromix	159.2±3.16	160.6±0.95	49.35±0.79	50.02±1.92	94.83±4.27	97.5±1.62	12.95±0.26	13.28±0.32	27.13±1.66	27.80±1.01
Magnetic iron	160.8±0.62	161.5±0.67	50.57±0.94	51.24±0.90	88.85±2.90	90.19±0.59	10.53±0.49	10.86±0.77	30.93±1.40	31.93±1.91
Magnetic iron +humic acid	150.5±0.87	150.5±0.87	54.49±0.79	55.16±1.49	118.3±2.47	119.3±1.11	15.07±0.36	14.74±0.34	41.80±1.08	42.13±1.34
Magnetic iron+ amino acid	152.2±1.68	152.9±1.95	50.81±1.05	51.48±2.2	110.1±0.58	110.8±1.65	12.83±0.71	12.5±0.13	36.62±0.79	36.96±0.55
Magnetic iron +micro mix	156.8±1.91	156.4±2.24	48.07±1.97	49.4±0.64	103.7±3.15	105.4±1.64	12.83±0.72	12.49±0.14	39.43±0.81	40.10±1.65
L.S.D (5%)	3.04	4.29	4.57	2.55	3.57	3.36	0.976	0.875	2.72	2.59

the first treatment than that of the second one in both seasons. These results matched those reported by Arancon et al. (2006) on Marigold and pepper, where the plant growth increased in response to treatments with 50 to 500 mg kg^{-1} humic acids.

Comparing the effects of magnetic iron plus amino acid or micro elements to that of compost plus the same treatments, it could be noticed that in the first and second seasons, the values of the fresh weight of leaves were higher with compost plus amino acid or micro elements than that with magnetic iron plus the same compounds. Moreover, the values of fresh weight of branches were the highest with magnetic iron plus amino or micro elements than that with compost plus the same treatments.

Concerning the values of dry weights of leaves and branches, no significant difference could be noticed in the usage of compost or magnetic iron mixed with either amino acid or micro elements, or magnetic iron with the same treatments in both seasons.

Flowers and fruits characters

Number of days to flowering

The data in Table 1 show that, roselle plants, in both seasons, achieved the flowering stage earlier when they grew in a soil treated with compost or magnetic iron plus humic acid, followed by amino acid and then micro elements, than those plants with other treatments. Flowering was delayed in the control plants of roselle than any of the other used treatments, followed by magnetic iron and then compost alone in both seasons.

The reason for the decrease in the days to flowering, when compost or magnetic iron plus humic acid was used, was due to the properties of humic acids that have a direct positive effect on plant growth (Frgbenro and Agboola, 1993; Stevenson, 1994). Humic acids stimulated seed germination and both plant root and shoot growth which caused the plants to grow rapidly to flowering. The effect was usually more prominent with roots resulting in an increased efficiency of the root system and causing high plant yields. On the contrary, roselle plants grow in a soil mixed with mineral fertilizers (Dmitrier et al., 2003; Achuo et al., 2004).

Number of fruits per plant

Relative to the compost alone, the data in Table 1 show that, the highest numbers of fruits per plant were ob-tained when compost plus humic acid (57.57) was used in the first season and compost plus amino acid (60.16), followed by compost plus humic acid (58.90) used in the second season compared to the rest of the treatments.

Concerning the addition of magnetic iron to the soil, the highest number of fruits per plant was 54.49 and 55.16 when humic acid was added to magnetic iron, followed by magnetic iron alone (50.57 and 51.24) or with amino acid(50.81 and51.48) compared to the number of fruits of the control plant (22.53 and 23.53) in both seasons, respectively. The lowest number of fruits per plant

(34.08 and 35.08) was achieved when compost was used alone, followed by magnetic plus micro mix (48.07 and 49.4) in both seasons. However, the results reported by Arancon et al. (2006) on *Capsicum annuum grossum* cv. King Arthur and on *Tagetes patula* cv. *Antigua Gold* F1 were supported by these results.

The reason for obtaining a great number of fruits per plant with compost plus humic acid or amino acid is due to their effect on plant growth stimulation through increased cell division, as well as optimized uptake of nutrients and water (Atiyeh et al., 2002; Abd-El- Kareem, 2007; Chen et al., 2004), the regulation of the hormone level, improvement of plant growth and enhancement of stress tolerance (Piccolo et al., 1992).

Fresh and dry weights of sepals per plant

In Table 2, the fresh and dry weights of sepals per plant are represented. Relative to compost alone, the data revealed that these characters have the same previous trend like the other vegetative characters. The highest values of either fresh weight (124.00 and 125.60 g) or dry matter (19.32 and 19.66 g) were obtained when compost plus humic acid was used, followed by that of amino acid and that of micro mix, in both seasons, respectively.

The same trend occurred when the use of magnetic iron plus humic acid was compared to the magnetic iron alone. The highest values of fresh and dry weights were 118.30 and 119.3 g and 15.07 and 14.74 g, in both seasons, respectively.

Seed yield per plant

The data in Table 2 show the seed yield per plant. Again, the trend mentioned earlier with the other characters occurred with this character, where the highest values of seed yield per plant were observed with plants treated by compost plus humic acid compared to the other treatments. These values were 49.07 and 50.40 g in the first and second seasons. The lowest values (27.13 and 27.80 g), although still greater than the control (21.30 and 22.30 g), were noticed in the compost plus micro mix.

Regarding the magnetic iron treatment, it could be stated that, the highest values of this character (41.80 and 42.13 g), in both seasons were achieved when magnetic iron plus humic acid was used, followed by magnetic iron plus micro mix (39.43 and 40.10 g), compared with either the magnetic iron alone (30.93 and 31.93 g) or with control (21.30 and 22.30 g). The obtained results were in harmony with that reported by Scheuerell and Mahaffee (2006). They stated that humic acid (HA) is a suspension, based on potassium humates, which can be applied as a plant growth stimulant or soil conditioner for enhancing natural resistance against plant diseases and pests which consequently increase the yield of plant. Shaaban et al. (2009) found that decreased soil NPK fertilizers application on wheat plants to 25% and the use of humic acid as foliar application led to the highest biological yield/feed.

Antioxidant activity

The 1, 1 diphenyl-2-picrylhydrazyl (DPPH) radical is a stable radical with maximum absorbance at 517 nm and can readily undergo reduction by an antioxidant. Due to the ease and convenience of this reaction, it now has widespread use in the free radical-scavenging activity assessment (Brand-Williams et al., 1995). The radical-scavenging activity of roselle plant extract, as shown in Table 3, expressed the percentage reduction of the initial DPPH absorption by the tested compound.

The data from Tables 3 and 4 reported that, there are positive correlations between anthocyanin content and antioxidant activity. The values were highest during the 2009 season more than the 2008 season. The best radical scavenging activity percentages was obtained at 100 $\mu g\ ml^{-1}$ with plants treated with compost plus amino acids (85.13 and 85.80%), compost plus micro mix (81.77 and 82.43%) and then compost plus humic acid (88.0 and 89.33%) in both seasons, respectively. These values were higher than those obtained using the standard antioxidant BHA (82.1 and 82.77%) and BHT (84.7 and 85.37%), in the same order. These activities correlated with the results of the total anthocyanin content determined in roselle plant treated with compost plus amino acid (788.20 µM), compost plus micro mix (786.60 µM) and compost plus humic acid (961.70 µM).

These results may be due to the effect of humic acid (phenolic compound derivatives) as precursor for the synthesis of anthocyanidin (flavonoid structure) and as such, they correlated with the increasing anthocyanin and its antioxidant activity. Ziadi et al. (2001) and Achuo et al. (2004), reported that the foliar application of HA (25% active HA) consistently enhanced antioxidants such as α-tocopherol, α-carotene, superoxide dismutases and ascorbic acid concentrations in turf grass species. This antioxidant may play a role in the regulation of plant development, flowering and chilling of disease resistance. It can be noticed that the antioxidant results with different treatments matched those mentioned earlier with the vegetation and flowering growth study.

Nitrogen, phosphorus and potassium content (NPK) of roselle plants

The NPK contents in roselle plants treated with different organic fertilizers are shown in Table 5. The results indicated that, the nitrogen contents of plants treated with compost mixture significantly increased with the value been 1.5 and 2.5 fold of the untreated plants. Similar

Table 3. Antioxidant activity values of roselle plants at different concentrations (50 and 100 µg/ml).

Treatment	Antioxidant activity (50 µg/ml)		Antioxidant activity (100 µg/ml)	
	2008	2009	2008	2009
Control	43.47±1.82	44.47±2.71	70.4±4.64	72.43±2.25
Compost	50.83±0.87	51.50±1.28	84.53±1.26	85.87±2.75
Compost +humic acid	59.63±0.81	61.30±3.65	88.00±1.45	89.33±1.20
Compost + amino acid	65.03±3.81	68.03±2.07	85.13±0.25	85.80±0.96
Compost+ micromix	55.77±1.15	56.77±2.1	81.77±1.1	82.43±1.95
Magnetic iron	41.97±3.82	43.3±4.82	81.23±3.35	82.23±1.99
Magnetic iron + humic acid	41.63±2.95	41.97±2.47	67.33±0.67	68.33±1.46
Magnetic iron + amino acid	50.67±2.39	51.33±1.3	78.73±0.49	79.07±0.59
Magnetic iron + micro mix	41.63±0.91	42.97±1.68	70.53±1.12	70.87±0.60
BHA	60.13±1.32	60.80±0.46	82.1±1.73	82.77±0.74
BHT	60.43±0.87	61.10±1.28	84.7±1.15	85.37±1.57
L.S.D (5%)	3.42	3.72	3.41	2.51

Table 4. Anthocyanin content in different roselle plants treated with different organic and non organic compounds (determined as µM).

Treatment	Anthocyanin content (µM)	
	2008	2009
Control	612.4±2.95	613.7±3.23
Compost	838.5±3.46	840.2±4.08
Compost + humic acid	960.00±5.36	961.7±3.09
Compost + amino acid	786.2±2.06	788.2±2.87
Compost+ micromix	784.9±3.09	786.6±2.87
Magnetic iron	785.9±7.96	788.2±7.2
Magnetic iron +humic acid	914.4±5.42	915.1±4.64
Magnetic iron+ amino acid	802.2±3.01	805.9±4.76
Magnetic iron + micro mix	825.8±9.46	830.5±5.05
L.S.D (5%)	8.18	6.75

Table 5. NPK percentage of roselle plants treated with different organic and non organic compounds during the 2008 and 2009 seasons.

Treatment	Nitrogen (N)		Phosphorus (P)		Potassium (K)	
	2008	2009	2008	2009	2008	2009
Control	0.814±0.017	0.801±0.016	0.104±0.006	0.095±0.004	1.985±0.95	1.862±0.89
Compost	2.027±0.095	2.121±0.097	0.053±0.001	0.060±0.001	0.987±0.021	0.980±0.020
Compost + humic acid	1.136±0.048	1.200±0.039	0.065±0.001	0.071±0.001	1.660±0.075	1.668±0.077
Compost + amino acid	1.274±0.053	1.300±0.059	0.169±0.009	0.172±0.009	1.286±0.056	1.31±0.061
Compost+ micromix	1.504±0.071	1.611±0.075	0.122±0.007	0.131±0.007	1.667±0.079	1.756±0.082
Magnetic iron	1.206±0.040	1.200±0.039	0.121±0.007	0.120±0.007	0.662±0.014	0.664±0.014
Magnetic iron + humic acid	1.480±0.063	1.499±0.069	0.07±0.001	0.089±0.003	1.417±0.059	1.500±0.062
Magnetic iron+ amino acid	1.370±0.059	1.399±0.062	0.133±0.007	0.140±0.008	0.524±0.010	0.623±0.016
Magnetic iron + micro mix	1.167±0.078	1.162±0.072	0.140±0.008	0.152±0.009	1.072±0.025	1.00±0.021
L.S.D (5%)	0.234	0.228	0.039	0.046	0.081	0.072

results were found with phosphorus, but did not occur with potassium. However, the increase percentages of N in plant were the highest, followed by K and then P. As the compost was very rich in NPK contents, this could explain the increase of these elements in the plants treated by this compound, which agree with the results of

Table 6. Titratable acidity and pH value of sepals' roselle plants treated with different organic and non-organic compounds.

Treatment	pH		Titratable acidity (%)	
	2008	2009	2008	2009
Control	3.56±0.21	3.45±0.20	0.75±0.078	0.77±0.078
Compost	3.60±0.23	3.54±0.21	0.73±0.078	0.74±0.078
Compost + humic acid	3.65±0.24	3.72±0.25	0.70±0.071	0.78±0.078
Compost + amino acid	3.46±0.20	3.47±0.20	0.79±0.080	0.80±0.080
Compost + micromix	3.57±0.21	3.60±0.23	0.75±0.078	0.70±0.071
Magnetic iron	3.50±0.21	3.65±0.24	0.72±0.072	0.73±0.072
Magnetic iron + humic acid	3.45±0.20	3.46±0.20	0.76±0.078	0.73±0.072
Magnetic iron + amino acid	3.45±0.20	3.55±0.21	0.76±0.078	0.75±0.078
Magnetic iron + micro mix	3.65±0.24	3.70±0.25	0.76±0.078	0.78±0.078
L.S.D (5%)	0.12	0.14	0.02	0.03

Aziz et al. (2007).

The data in Table 5 revealed that compost plus humic acid showed a significant increase in the total contents of N and P. This result was in agreement with Shaaban et al. (2009) who found that when the NPK was used as a foliar application combined with the humic acid, it increased the cell permeability which make better penetration of NPK foliar fertilizers into the leaf and then to the other organs. As such, this reflects on the improvement of root growth and its ability to absorb and assimilate nutrients and easily travel inside plant organs. Wittwer and Bukovac (1969) and Guvenc et al. (1999), found that foliar application improved root growth and led to a greater absorbing surface. These results clearly indicated that humic can be used as a foliar to increase the efficiency of nutrients' utilization.

Sepal's pH values and titratable acidity (TA)

The contents of plant acids and pH values of roselle plants are shown in Table 6. It could be noticed that the pH values of sepals ranged from 3.45 to 3.72 after treatment with different organic fertilizer in both seasons. This may be due to the influence of these treatments to produce more nitrogenous compounds which increase the pH value. On the contrary, there was no significant variation on the values of TA at different treatments. This is in accordance with that obtained by Fasoyiro et al. (2005).

Conclusion

From previous results, it could be suggested that using compost as a mixture with sandy soil and spraying the roselle plants by humic acid is considered a suitable application for improving the vegetative growth, yield production and the antioxidant activity of the plants.

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