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Improving the Growth of Fennel Plant Grown under Salinity Stress using some Biostimulants

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ABSTRACT

The efficiency of some biostimulants, as natural and safe compounds for humans and environment, were studied on alleviation the adverse effect of salinity on *Foeniculum vulgare* (fennel). Seaweed extract (1.5, 3 and 4.5 cm L^{-1}), amino acids (1, 2 and 3 cm L^{-1}) and dry yeast (5, 10, 15, 20 and 25 g L^{-1}) were used, as foliar application. Humic acid (1, 2 and 3 g L^{-1}) was used, as foliar application and soil drench. Humic acid at 3 g L^{-1} increased significantly most of the studied traits, when added as a soil application. Most of the studied traits increased gradually with increasing the concentration of dry yeast. The concentrations of dry yeast (20 and 25 g L^{-1}) were the most effective treatments, as compared with other studied-substances for overcoming the negative effect of salinity. Enhancing plant growth under salinity stress, was combined with increasing the accumulation of potassium and reducing the sodium ions.

Key words: *Foeniculum vulgare,* humic acid, dry yeast, seaweed, amino acids, essential oil

INTRODUCTION

Foeniculum vulgare (Fennel) belongs to the family Apiaceae is a medicinal herb native to the Mediterranean region. Fennel is used for various purposes i.e., in the food, cosmetic and medical industries. The essential oil of fennel has a valuable antioxidant, antibacterial, anticancer and antifungal activity (El-Awadi and Hassan, 2010; Bahmani *et al*., 2012).

Soil salinity affects agricultural productivity in many parts of the world (Zorb *et al*., 2004). Uncontrolled irrigation, continuous cropping, excessive fertilization and poor-quality water may be also cause salinity problems with reduction in the yield and quality of the products (Cansev and Ozgur, 2010).

Plant growth and yield are reduced in salt-affected soil because of the excess uptake of potentially toxic ions e.g. Na+ which have negative effects on plant growth.

Salt-affected farmland need more research to determine the best salt-tolerant plant species or find the natural compounds effective in reducing the harmful impact of salinity (Yamaguchi and Blumwald, 2005).

It was found that, humic acid is the major component of soil organic matter. Humic acid have 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, regulate hormone level, improve plant growth and enhance stress tolerance (Cimrin *et al*., 2010). Kulikova *et al*. (2005) pointed out that humic substances might show anti-stress effects under abiotic stress.

There are very few researches about the effect of applications of dry yeast, seaweed extract, amino acids on the salinity conditions.

Therefore, the present study aimed to investigate the efficiency of humic acid, dry yeast, seaweed extract and amino acids applications on the alleviation of the adverse effect of salinity as natural and safe compounds for humans and environment.

MATERIALS AND METHODS

Plant material and cultivation: Field experiment was carried out at the Nursery of Ornamental plants, Faculty of Agriculture, South Valley University, Qena, Egypt during the two successive seasons of 2011/2012 and 2012/2013.

The soil of the experimental field was a sandy clay loam and its characteristics are presented in Table 1.

Seeds of Fennels (*Foeniculum vulgare*) plant "local cultivar" were sown directly on 15 November 2011 and 2012 for the first and second seasons. Seaweed extract (Gifert liquid at 1.5, 3 and 4.5 cm L^{-1}), amino acids (amino power at 1, 2 and 3 cm L^{-1}) and dry yeast (5, 10, 15, 20 and 25 g L^{-1}) were used as foliar application. Humic acid (1, 2 and 3 g L^{-1}) was used as soil drench and foliar application. Plants were treated four times/season with 15 days intervals. The first addition was done after one and half month from sowing.

The experiment was carried out in a complete randomized blocks design with eighteen treatments and three replications. Each treatment had 12 plants/replicate. There were four ridges for each treatment in each replicate and three holes in each row with distance 30 cm between them, four seeds were placed in each hole and thinning was done after three weeks to maintain one plant/hole.

All plants received recommended dose of fertilization. Plants were fertilized with NPK at 100, 150 and 100 kg fed $^{-1}$, respectively. The sources of NPK fertilizer were ammonium sulphate (20.6% N), Calcium super phosphate (15.5% P_2O_5) and potassium sulphate (48% K_2O).

Phosphorus fertilizer was added as one dose before planting during the soil preparation. The amount of nitrogen fertilization was added at two equal batches, the first one was added after thinning with all amount of potassium and after two weeks from the first addition, the second amount of nitrogen was added. Plants were irrigated by the available ground water which have EC value 7.12 dS m^{-1}.

Table 1: Some physical and chemical characteristics of the used soil

Properties	Values
Physical properties	
Sand (%)	64.91
Silt (%)	13.49
Clay (%)	21.6
Soil texture	Sandy clay loam
SP (%)	32.0
Chemical properties	
pH	8.05
E_{ce} (dS m^{-1})	3.68
CaCO (%)	6.9
Ca^{++} (meq L^{-1})	13.76
Mg^{++} (meq L^{-1})	11.79
K^{+} (meq L^{-1})	0.37
Na^{+} (meq L^{-1})	12.97
CO_3^{-2}+HCO_3^{-} (meq L^{-1})	13.76
$SO^{=}_4$ (meq L^{-1})	7.71

SP%: Saturation percentage

Morphological estimation: The morphological characters such as plant height, stem diameter, number of branches, fresh and dry weights of vegetative growth and fresh weight of roots were estimated at flowering stage. Flowering date (mean days from sowing to opening the flowers) was calculated. The number of umbels/plant and fruits weight/plant was estimated after maturity.

Biochemical estimations: Essential oil percentage was determined in the fruits using water distillation methods according to British Pharmacopoeia, 1963. Proline was determined according to Bates *et al*. (1973). Sodium and Potassium were determined using the method of Humphries (1956).

RESULTS AND DISCUSSION

Concerning seaweed extract treatments, plants treated with 4.5 cm L^{-1} significantly increased plant height, stem diameter, dry weight of vegetative growth and roots fresh weight in the second season compared to control as shown in Table 2. The highest fruits weight/plant, essential oil percentage was significantly increased in the plants treated with seaweed extract at the concentrations of 3 and 4.5 cm L^{-1} in both seasons as shown in Table 3. Table 4 illustrates that, sodium and proline were decreased significantly using all concentrations of seaweed, while potassium was slightly increased.

This result may be due to that seaweed extracts contain various betaines. Betaines serve as a compatible solute that alleviates osmotic stress induced by salinity (Khan *et al*., 2009). Seaweed extracts improve nutrient uptake by roots, thereby causing enhanced general plant growth and vigor. Also, yield increases in seaweed-treated plants are thought to be associated with the

Table 2: Effect of seaweed extract, amino acids, humic acid and active dry yeast on the plant height, stem diameter, number of branches, fresh and dry weight of vegetative growth and fresh weight

	Plant height (cm)		Stem diameter (cm)		No. of branches		Fresh weight of vegetative growth (g)		Dry weight of vegetative growth (g)		Fresh weight of roots (g)	
	Season		Season		Season		Season		Season		Season	
Treatments	First	Second	First	Second	First	Second	First	Second	First	Second	First	Second
Control												
0.0	79.9^{de}	70.0^{gh}	0.43^{fg}	0.41^{f}	10.0^{defg}	9.6^{de}	27.4^{d}	26.3^{k}	5.02^{d}	4.90^{hi}	5.50^{cde}	4.0^{fg}
Seaweed (cm L^{-1})												
1.5	79.5^{e}	66.6^{h}	0.37^{gh}	0.43^{ef}	7.3^{h}	8.0^{e}	20.0^{d}	27.0^{k}	3.88^{d}	4.30^{i}	4.98^{def}	5.0^{ef}
3.0	81.5^{de}	76.6^{fg}	0.37^{gh}	0.46^{def}	8.0^{gh}	8.0^{e}	22.5^{d}	29.2^{ijk}	4.45^{d}	4.80^{hi}	5.00^{def}	5.3^{e}
4.5	83.6^{cde}	81.0^{ef}	0.40^{fgh}	0.49^{cde}	8.0^{gh}	8.6^{de}	23.7^{d}	31.6^{ijk}	4.63^{d}	6.80^{f}	5.80^{cd}	6.0^{cde}
Amino acids (g L^{-1})												
1.0	80.8^{de}	71.6^{gh}	0.38^{gh}	0.53^{c}	7.4^{h}	9.0^{de}	18.5^{d}	34.2^{hij}	4.72^{d}	6.13^{fgh}	5.00^{def}	7.0^{bc}
2.0	88.3^{cd}	76.0^{fg}	0.48^{ef}	0.52^{cd}	9.5^{efgh}	9.6^{de}	31.2^{d}	33.8^{hij}	5.44^{d}	6.60^{fg}	5.40^{cde}	5.6^{e}
3.0	84.3^{cde}	95.5^{bc}	0.43^{fg}	0.61^{b}	9.2^{fgh}	10.0^{de}	28.2^{d}	38.1^{fgh}	4.60^{d}	7.00^{f}	5.10^{def}	5.9^{de}
Humic acid (spray) (g L^{-1})												
1.0	81.9^{de}	85.6^{de}	0.41^{fgh}	0.62^{b}	8.8^{fgh}	9.0^{de}	26.1^{d}	35.7^{ghi}	4.34^{d}	5.27^{ghi}	4.00^{ef}	3.9^{g}
2.0	85.1^{cde}	83.6^{de}	0.45^{fg}	0.62^{b}	10.1^{defg}	10.0^{de}	29.3^{d}	37.8^{gh}	4.80^{d}	6.80^{f}	5.90^{cd}	6.9^{bcd}
3.0	90.8^{c}	100.0^{ab}	0.48^{ef}	0.71^{a}	11.5^{bcde}	10.3^{de}	35.0^{cd}	43.6^{ef}	6.51^{cd}	7.53^{ef}	6.70^{c}	7.4^{b}
Humic acid (soil) (g L^{-1})												
1.0	85.4^{cde}	97.3^{ab}	0.33^{h}	0.62^{b}	8.8^{fgh}	10.0^{de}	26.6^{d}	40.1^{fg}	4.26^{d}	5.00^{hi}	3.66^{f}	6.8^{bcd}
2.0	89.1^{cd}	100.0^{ab}	0.40^{fgh}	0.63^{b}	9.7^{efg}	10.5^{de}	38.8^{cd}	40.4^{fg}	4.96^{d}	7.20^{f}	5.26^{cde}	7.1^{b}
3.0	103.1^{b}	103.5^{a}	0.61^{bcd}	0.74^{a}	10.7^{cdef}	11.0^{cd}	55.5^{bc}	60.0^{c}	11.80^{b}	13.00^{b}	5.70^{cd}	7.2^{b}
Active dry yeast (g L^{-1})												
5	105.1^{ab}	81.5^{ef}	0.56^{de}	0.47^{cdef}	12.8^{bc}	11.0^{cd}	56.0^{bc}	48.0^{e}	9.16^{bc}	9.00^{de}	5.81^{cd}	5.4^{e}
10	113.7^{a}	97.3^{ab}	0.57^{cd}	0.51^{cd}	12.2^{bcd}	11.0^{cd}	52.5^{bc}	54.5^{d}	10.48^{b}	10.20^{cd}	5.66^{cd}	7.3^{b}
15	11.5^{ab}	90.0^{cd}	0.67^{ab}	0.61^{b}	13.0^{b}	18.5^{a}	61.3^{b}	63.0^{c}	10.89^{b}	11.00^{c}	8.70^{b}	9.1^{a}
20	107.7^{ab}	73.6^{g}	0.65^{abc}	0.64^{b}	13.3^{b}	13.5^{bc}	70.8^{ab}	72.0^{b}	12.04^{b}	13.00^{b}	8.53^{b}	9.5^{a}
25	108.5^{ab}	75.5^{fg}	0.73^{a}	0.71^{a}	17.0^{a}	16.0^{ab}	88.7^{a}	87.9^{a}	24.68^{a}	22.93^{a}	10.60^{a}	10.0^{a}
$LSD_{0.05}$	8.8**	6.7**	0.09**	0.07**	2.3**	2.7**	21.2**	5.8**	3.41**	1.52**	1.59**	1.1**

Dry yeast on the plant height, stem diameter, number of branches, fresh and dry weight of vegetative growth and fresh weight of roots of Foeniculum vulgare plants under salinity stress, values in the same column not followed by the same letter are significantly different at the 5% level of probability, **Significant at p = 0.01

Table 3: Effect of seaweed extract, amino acids, humic acid and active dry yeast on the flowering date, number of umbels/plant, fruits weight/plant and essential oil percentage of *Foeniculum vulgare* plants under salinity stress

	Flowering date (days)		No. of umbels/plant		Fruits weight/plant (g)		Essential oil percentage (%)	
	Season		Season		Season		Season	
Treatments	First	Second	First	Second	First	Second	First	Second
Control								
0.0	106.1^{def}	113.8^{abc}	8.7^{cde}	8.0^{ghi}	5.7^{k}	6.0^{h}	0.33^{i}	0.32^{ef}
Seaweed (cm L^{-1})								
1.5	109.6^{bcde}	109.0^{bcde}	6.1^{e}	7.4^{i}	7.9^{ghi}	7.1^{g}	0.25^{j}	0.26^{f}
3.0	108.8^{cdef}	116.5^{ab}	6.5^{e}	7.7^{hi}	8.0^{ghi}	7.4^{g}	0.63^{f}	0.98^{ab}
4.5	112.3^{bc}	111.0^{abcd}	6.9^{de}	7.8^{hi}	8.3^{fgh}	8.5^{f}	1.16^{a}	1.20^{a}
Amino acids (g L^{-1})								
1.0	110.4^{bc}	112.0^{abcd}	6.0^{e}	7.8^{cde}	7.0^{j}	6.9^{g}	0.75^{de}	0.55^{cde}
2.0	111.8^{bc}	106.7^{cde}	7.8^{de}	8.1^{fghi}	9.0^{f}	7.2^{g}	1.0^{b}	0.60^{cd}
3.0	116.8^{a}	105.0^{de}	7.1^{de}	9.1^{defg}	7.2^{ij}	7.4^{g}	0.5^{h}	1.00^{ab}
Humic acid (spray) (g L^{-1})								
1.0	112.1^{bc}	107.6^{cde}	7.1^{de}	8.7^{efgh}	8.0^{ghi}	7.5^{g}	0.47^{h}	0.47^{def}
2.0	111.9^{bc}	105.8^{de}	8.1^{de}	9.2^{def}	8.5^{fg}	8.3^{f}	0.57^{g}	0.56^{cde}
3.0	113.0^{ab}	102.2^{e}	8.4^{cde}	10.4^{bc}	9.0^{f}	8.8^{f}	1.0^{b}	1.02^{ab}
Humic acid (soil) (g L^{-1})								
1.0	117.3^{a}	108.6^{bcde}	6.4^{e}	8.7^{efgh}	6.0^{k}	7.1^{g}	0.5^{h}	0.58^{cde}
2.0	112.5^{bc}	107.4^{cde}	7.4^{de}	9.3^{cde}	7.5^{hij}	7.1^{g}	0.8^{d}	0.79^{bc}
3.0	112.2^{bc}	105.9^{cde}	9.8^{bcd}	10.9^{b}	11.0^{e}	10.7^{e}	1.11^{a}	1.13^{a}
Active dry yeast (g L^{-1})								
5	110.6^{bc}	118.9^{a}	11.9^{ab}	9.9^{bcd}	15.5^{d}	15.2^{d}	0.6^{fg}	0.58^{cde}
10	109.9^{bcd}	118.8^{a}	10.0^{bcd}	8.6^{efgh}	19.0^{c}	15.4^{d}	0.7^{e}	0.70^{cd}
15	108.6^{cdef}	116.1^{ab}	11.4^{abc}	13.2^{a}	16.0^{d}	18.5^{c}	0.8^{d}	0.81^{bc}
20	104.7^{f}	108.9^{bcde}	13.7^{a}	10.2^{bcd}	23.0^{b}	25.2^{b}	0.9^{c}	0.99^{ab}
25	105.5^{ef}	104.2^{de}	13.7^{a}	13.6^{a}	26.0^{a}	28.0^{a}	1.0^{b}	1.00^{ab}
$LSD_{0.05}$	4.2**	8.0*	4.8**	0.9**	0.9**	0.8**	0.06**	0.27**

Values in the same column not followed by the same letter are significantly different at the 5% level of probability, *,**Significant at p = 0.05 and 0.01, respectively

hormonal substances present in the extracts especially cytokinins (Norrie and Keathley, 2005). Seaweed extracts seems to mediate stress tolerance by enhancing K+uptake (Khan *et al*., 2009).

With respect to amino acids applications, the concentration of 3 cm L^{-1} increased significantly plant height in the second season compared to control (95.5, 70 cm, respectively). All the concentrations of amino acids increased significantly stem diameter, fresh weight of vegetative growth and roots in the second season. Essential oil percentages were increased significantly in the first season using all concentrations. A significant increase was observed in the fruit weight/plant for both seasons compared to control. Sodium and proline content were significantly decreased using all concentrations of amino acids in both seasons.

Tao *et al*. (2008) pointed out to the enhancement in plant growth after amino acid treatments as a result of protein synthesis. Amino acids act as a precursors or activators of phytohormones and growth substances (El-Awadi and Hassan, 2010).

Regarding the effect of the humic acid, it can be seen that its addition to the soil had more stimulation effect on plant growth and yield compared to the foliar application. The high concentration of humic acid (3 g L^{-1}) increased significantly most of the studied traits when added as a soil application compared to the control.

Foliar application of humic acid at all concentrations had a significant effects on the plant height, stem diameter, fresh and dry weight of vegetative growth in the second season except for the concentration of 1 g L^{-1} with respect to dry weight of vegetative growth. Application of humic acid at 3 g L^{-1} as a spray increased significantly plant height and fruits weight/plant and proline in both seasons.

Table 4: Effect of seaweed extract, amino acids, humic acid and active dry yeast on the proline, Na and K and content of *Foeniculum vulgare* plants under salinity stress

	Proline (mg g^{-1} DW)		Na^+ (mg g^{-1} DW)		K^+ (mg g^{-1} DW)	
	Season		Season		Season	
Treatments	First	Second	First	Second	First	Second
Control						
0.0	3.97^{a}	3.47^{a}	2.4^{a}	1.7^{a}	18.1^{h}	9.7^{h}
Seaweed (cm L^{-1})						
1.5	3.99^{a}	2.7^{c}	2.2^{c}	1.5^{b}	18.5^{gh}	10.0^{gh}
3.0	2.39^{d}	2.35^{de}	2.3^{b}	1.5^{b}	18.8^{fgh}	11.9^{de}
4.5	1.95^{gh}	2.19^{f}	2.1^{d}	1.4^{bc}	20.4^{bcdef}	12.4^{ab}
Amino acids (g L^{-1})						
1.0	3.14^{b}	3.01^{b}	2.3^{b}	1.5^{b}	18.7^{fgh}	10.1^{fgh}
2.0	2.39^{d}	2.77^{c}	2.1^{d}	1.4^{bc}	19.5^{defgh}	11.0^{efg}
3.0	2.95^{c}	2.33^{de}	2.2^{c}	1.4^{bc}	20.2^{bcdefg}	11.6^{de}
Humic acid (spray) (g L^{-1})						
1.0	2.29^{de}	2.40^{d}	2.1^{d}	1.5^{b}	19.2^{efgh}	11.0^{efg}
2.0	2.17^{ef}	2.28^{ef}	2.1^{d}	1.4^{bc}	19.6^{cdefgh}	11.7^{de}
3.0	1.93^{gh}	1.89^{g}	2.0^{e}	1.3^{cd}	21.0^{abcde}	13.3^{bc}
Humic acid (soil) (g L^{-1})						
1.0	2.11^{f}	2.38^{de}	2.1^{d}	1.4^{bc}	19.7^{cdefgh}	11.3^{def}
2.0	1.83^{h}	2.22^{f}	2.1^{d}	1.3^{cd}	19.7^{cdefgh}	12.2^{cde}
3.0	1.83^{h}	1.64^{h}	1.9^{f}	1.2^{d}	21.1^{abcd}	13.3^{bc}
Active dry yeast (g L^{-1})						
5	2.05^{fg}	1.99^{g}	2.0^{e}	1.2^{d}	21.1^{abcd}	13.2^{bc}
10	1.57^{i}	1.48^{i}	1.9^{f}	1.2^{d}	21.2^{abcd}	14.1^{ab}
15	1.53^{i}	1.36^{j}	1.9^{f}	1.2^{d}	21.4^{abc}	14.2^{ab}
20	1.36^{j}	1.16^{k}	1.9^{f}	1.2^{d}	21.9^{ab}	14.4^{ab}
25	1.19^{k}	1.01^{l}	1.8^{g}	0.9^{e}	22.3^{a}	14.7^{a}
$LSD_{0.05}$	0.13**	0.11**	0.1**	0.2**	1.9**	1.3**

Values in the same column not followed by the same letter are significantly different at the 5% level of probability, **Significant at p = 0.01

The mechanism of humic acid in promoting plant growth have been proposed, humic substances may enhance the uptake of nutrients and reduce the uptake of some toxic elements (Cimrin *et al*., 2010). Delfine *et al*. (2005) reported that humic acid can be used as a growth regulator to regulate hormone level, improve plant growth and enhance stress tolerance.

With regard to dry yeast application, most of the studied traits increased gradually with increasing the concentration of dry yeast.

The results show that treated plants with the high concentrations of dry yeast (20 and 25 g L^{-1}) was the most effective treatments compared with other studied-substances for overcoming the negative effect of salinity (Table 2-4).

The concentration of 25 g L^{-1} increased significantly all studied traits in both seasons compared to the control except for plant height in the second season. Fruits weight/plant and essential oil were increased by approximately five times and three times than the control, respectively.

The stimulation effect of dry yeast on plant growth, fruits yield and oil production may be due to the fact that active dry yeast is rich with amino acids, vitamins and proteins (Selim *et al*., 2013). Dry yeast also had stimulatory effects on cell division and enlargement, protein and nucleic acid synthesis and chlorophyll formation and act as a source of cytokinins (El-Lethy *et al*., 2011).

All treatments decreased significantly proline content compared to the control (plants grown under saline water only). Where, proline was accumulated in the plant organs grown under salt stress as a sink for energy to regulate redox potential, as a hydroxy radical scavenger, a solute that protects macromolecules against denaturation (Tammam, 2003).

Table 4 showed that, improvement the plant growth of fennel using dry yeast and other substances as mentioned above was combined with enhancing the accumulation of potassium ions and reduction of sodium ions (toxic elements). This results suggested the role for alleviation salt stress deleterious in the fennel plant. Humic acid and dry yeast alleviate the reductive effect of osmotic stress by increasing the content of K^+ and that governs the tissue extensibility by maintaining the turgid of plant tissues under stress conditions. These results confirmed with the finding of Tuteja (2007).

CONCLUSION

It can be concluded that, sprayed fennel plants with active dry yeast at all concentrations especially at 25 g L^{-1} was the most effective substances to alleviate the negative effect of salinity that would inhibit plant growth of fennel plant due to its ability to alleviate the adverse effect by restoring the ion balance.

REFERENCES

Bahmani, K., A. Izadi-Darbandi, A.A. Jafari, S.A.S. Noori and M. Farajpour, 2012. Assessment of genetic diversity in Iranian fennels using ISSR markers. J. Agric. Sci., 4: 79-84.

Bates, L.S., R.P. Waldren and I.D. Teare, 1973. Rapid determination of free proline for water-stress studies. Plant Soil, 39: 205-207.

Cansev, A. and M. Ozgur, 2010. Grafting cucumber seedlings on *Cucurbita* spp.: Comparison of different grafting methods, scions and their performance. J. Food Agric. Environ., 8: 804-809.

Cimrin, K.M., O. Turkmen, M. Turan and B. Tuncer, 2010. Phosphorus and humic acid application alleviate salinity stress of pepper seedling. Afr. J. Biotechnol., 9: 5845-5851.

Delfine, S., R. Tognetti, E. Desiderio and A. Alvino, 2005. Effect of foliar application of N and humic acids on growth and yield of durum wheat. Agron. Sustainable Dev., 25: 183-191.

El-Awadi, M.E. and E.A. Hassan, 2010. Physiological responses of fennel (*Foeniculum vulgare* Mill) plants to some growth substances. The effect of certain amino acids and a pyrimidine derivative. J. Am. Sci., 6: 120-124.

El-Lethy, S.R., H.S. Ayad and F. Reda, 2011. Effect of riboflavin, ascorbic acid and dry yeast on vegetative growth, essential oil pattern and antioxidant activity of geranium (*Pelargonium graveolens* L.). Am. Eurasian J. Agric. Environ. Sci., 10: 781-786.

Humphries, E.C., 1956. Modern Methods of Plant Analysis. Springer, New York, pp: 468-502.

Khan, W., U.P. Rayirath, S. Subramanian, M.N. Jithesh and P. Rayorath *et al*., 2009. Seaweed extracts as biostimulants of plant growth and development. J. Plant Growth Regul., 28: 386-399.

Kulikova, N.A., E.V. Stepanova and O.V. Koroleva, 2005. Mitigating Activity of Humic Substances: Direct Influence on Biota. In: Use of Humic Substances to Remediate Polluted Environments: From Theory to Practice, Perminova, I.V., K. Hatfield and N. Hertkorn (Eds.). Chapter 14, Springer, Netherlands, ISBN: 978-1-4020-3250-9, pp: 285-309.

Norrie, J. and J.P. Keathley, 2005. Benefits of ascophyllum nodosum marine-plant extract applications to Thompson Seedless grape production. Proceedings of the 5th International Symposium on Plant Bioregulators in Fruit Production, May 29-June 2, 2005, Leuven, pp: 243-248.

Selim, S.M., M.M.A. Ebtsam, M.S.H. Tawfik and A.I. Abou-Sreea, 2013. Effect of sowing date, sow spacing and bio-ertilizer on yield and oil quality of fennel plant (*Foeniculum vulgare*, Mill.). Aust. J. Basic Applied Sci., 7: 882-894.

Tammam, A.A., 2003. Response of Vicia faba plants to the interactive effect of sodium chloride salinity and salicylic acid treatment. Acta Agronomica Hungarica, 51: 239-248.

Tan, K.H.T., 2003. Humic Matter in Soil and Environment Principles and Controversies. Marcel Dekker Inc., New York, USA.

Tao, Y., J.L. Ferrer, K. Ljung, F. Pojer and F. Hong *et al*., 2008. Rapid synthesis of auxin via a new tryptophan-dependent pathway is required for shade avoidance in plants. Cell, 133: 164-176.

Tuteja, N., 2007. Mechanisms of high salinity tolerance in plants. Methods Enzymol., 428: 419-438.

Yamaguchi, T. and E. Blumwald, 2005. Developing salt-tolerant crop plants: Challenges and opportunities. Trends Plant Sci., 12: 615-620.

Zorb, C., S. Schmitt, A. Neeb, S. Karl, M. Linder and S. Schubert, 2004. The biochemical reaction of maize (*Zea mays* L.) to salt stress is characterized by a mitigation of symptoms and not by a specific adaptation. Plant Sci., 167: 91-100.