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PHYSIOLOGICAL EFFECTS OF SOME ANTIOXIDANTS ON MORINGA (*Moringa oleifera, L.*) PLANT UNDER DROUGHT STRESS

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ABSTRACT

To alleviate drought stress on moringa plant, the present study was performed aiming to test the alleviating effect of ascorbic acid, salicylic acid, humic acid ,seaweeds extract on moringa trees. Results indicated that treatments had beneficial effect manifested by maintaining yield and elevating stress-related metabolites, especially phenols , proline. Ascorbic acid , humic acid and seaweed extracts were the most effective and they are recommended to be employed to mitigate water stress on moringa trees which grow under drought stress conditions.

INTRODUCTION

Drought, being the most important environmental stress, effecting growth, limits plant production and the performance of crop plants, more than any other environmental factors (Shao et al., 2009).

Moringa oleifera or drumstick tree is a tropical plant widely known to be of the greatest medicinal values (Fahey, 2005; Paliwal *et al*., 2011). It is a plant native to Pakistan , India, Bangladesh and Afghanistan and grows up to 5 or 10 meters in height. It is popularly called 'the miracle tree' with potentials for the treatment of various diseases like cancer, diabetes mellitus and hypertension (Fahey(2005); Paliwal et al(2011)).

Moringa leaves have been reported to be a rich source of □-carotene, vitamin C, protein, calcium and potassium and act as a very good source of natural antioxidants; and thus enhance the shelf-life of fat containing foods because of the presence of various types of antioxidant compounds such as ascorbic acid, flavonoids, carotenoids and phenolics (Dillard and German, 2000; Siddhuraju and Becker, 2003). In the Philippines, it is known as 'mother's best friend' because of its utilization to increase woman's milk production and is sometimes protect from anemia (Estrella *et al*., 2000; Siddhuraju and Becker, 2003).

Ascorbic acid is an antioxidant molecule that works as a primary substrate in the cyclical pathway for neutralization detoxification and detoxification of superoxide radicals and singlet oxygen radical . (Noctor and Foyer, 1998).

Salicylic acid (SA) is considered as a hormone-like substance, which act as an important role in transpiration, stomatal conductance and photosynthetic rate (Khan et al., 2003; Arfan et al., 2007), increasing antioxidative protection (Xu et al., 2008), and inhibiting Na+ and Cl_ accumulation (Gunes et al., 2007). Several lines of evidence demonstrate the alleviating role of SA during salinity (Shakirova et al., 2003) and drought stress. (Singh and Usha, 2003).

The benefits of seaweeds as sources of organic matter and fertilizer nutrients have led to their use as soil conditioners for centuries (Blunden and Gordon 1986; Metting and others 1988; Temple and Bomke 1988). Some 15 million metric tonnes of seaweed products are produced annually (FAO 2006).

O'Donnell (1973) reported that humic acid from leonardite (a naturally occurring, highly compressed and coal-like organic material , soft brown and decomposed, usually found in conjunction with deposit of lignite) exhibits auxin-like effects.

The objective of the present study was to assess the effects of selected antioxidants:{ascorbic acid (AsA)- salicylic acid(SA)- humic acid (HA)- seaweeds extract(SWE)} on some biochemical constituents on moringa trees grown under drought stress.

MATERIALS AND METHODS

Field Experiment

The present investigation was carried out in the open field at the Floriculture nuriery of the Horti.Dep.at the laboratory of Agric.Bot.Dep., faculty of Agric.Mans.Uni Egypt during 2013/2014 and 2014/2015 seasons.

Moringa (*moringa oleifera* L.) trans plants were planted on (1^{th} October) in the two successive seasons(One trans plant/hill were sown on one side of the ridge at 50 cm apart) in open field to investigate the role of selected antioxidants:{ascorbic acid (AsA)- salicylic acid(SA)- humic acid (HA)- seaweeds extract(SWE)} on growth, yield, some biochemical constituents to mitigate or alleviate the harmful effect of drought stress condition on moringa plants.

The trans plants was planted in clay loamy soil and the analysis of the soil used are preseuted in table (1) in the both seasons.

In the two growing seasons moringa plants were sprayed three times every year (two years) at vegetative growth stage with each of the selected antioxidents as follows :

1- Tap water.(control)
2- Ascorbic acid (AsA , 250 mg/l).
3- Salicylic acid (SA , 250 mg/l).
4-Humic acid (HA , 1000 mg/l)
5- Seaweeds extract (SWE, 1000 mg/l)

The 1^{th} spraying was took place till drepping at 1^{th} june with using . Automatic atomizers and adding tween 20 as a wetting agent" (0.05 %).

moringa plants were sprayed at 1^{th} june , 1^{th} augast and 1^{th} october .Two samples were taken at 30^{th} October every year to determnate moringa growth.

Irrigation Intervals:

Three irrigation intervals were applied for experimental units of Moringa plants as follow:

1-Irrigation every 30 days (control)

2- Irrigation every 60 days [level 1].

3- Irrigation every 90 days [level 2].

Lay out of the experiment:

Each irrigation treatment was performed in separate experiment .Every experiment was carried out in complete block design with three replication . The plots were occupied with the applied antioxidants (foliar treatment)

SAMPLING DATES:

Two samples were taken at 30th October every year to determinate the following characters:

Biochemical constituents:

Photosynthetic Pigments

Fresh leaf samples (0.5gm from the 3rd terminal leaf)were extracted by methanol for 24 h at laboratory temperature after adding trace from sodium carbonate (Robinson et al,1983), then chlorophylls a, b, total and carotenoids were determined spectrophotometrically (spekol Π) (at wave lengthes 452, 650, 665nm) and calculated by equation introduced by Mackinny (1941).

Total ascorbate (vitc):

(Vit C) content was determined by using the die 2,6 dichlorophenol indophenol method as mg/ 100 gm fresh weight as described by Rangana (1979)

Total phenols determination:

Total phenole estimation was carried out with the Folin-ciocalteau reagent according to Malick and Singh (1980). Phenols produce blue-coloured complex and react with phosphomolybdic acid in Foli-Ciocalteau reagent in alkaline medium. The absorbance of mixture was measured using spectrophotometer at 650 nm against a reagent blank. A standard curve was prepared using different concentrations of catecol and then, total phenols was expressed as g phenols / 100g material

Proline concentration:

Plant samples were extracted proline made to react with ninhydrine in acidic condition (pH 1.0) to form the chromphore (red colour) and estimated using spectrophotometer at wave length 540 nm> the amount of the proline was determined against the standard curve of Toluine and expressed as microgram.g^{-1} (Mg). Bates etal., (1973).

Calcium and fe content:

For determination of macro and micro elements; 0.2g crude dried kept powder from each sample was wet digested with a mixture of concentrated perchloric acid and sulphoric acid, then heated until become clear solution (Peterburgski, 1968) after digestion the cleaned solution was quantitavely transferred into 50 ml measuring flask with distlled water and kept for determinations.

Total Ca were estimated Flamephotometrically using Ienway Flamephotometer model Corning 400 according to Peterburgski; 1968.

Total Fe were estimated using atomic absorption spectrophotometer (A Perkin-Elmer, Model 2380.usa) according to the methods of Chapman and Pratt (1961).

Table (1). Mechanical and chemical analysis of the used soil.

Coarse sand %	**10.7**
Fine sand %	27.3
Silt %	24.8
Clay %	33
$CaCO_3$ %	2.8
Organic matter %	2.0
Total N%	0.12
Available P ppm	12
Exchangeable K ppm	218
TSS %	0.21

*** Mechanical analysis followed the pipette method using sodium hydroxide as a dispersing agent (Piper, 1950). Other soil chemical analysis were carried out according to Jackson (1973).**

RESULTS

Chemical compositions

1. Photosynthetic pigments:

Data in Table (2) and Fig. (1) show the effect of water stress levels, applied antioxidant, , (ascorbic acid(AS), salicylic acid (SA) , humic acid (HA) ,seaweeds extract (SWE))and their combination on total cholorophyll concentration of moringa leaves at vegetative growth stage .

Data indicate that increasing water stress levels the total cholorophyll was increased in leaves of moringa plants comparing with full irrigation level1(30 day) at vegetative growth stage . The highest water stress (level 2) gave the highest conc.of total cholorophyll content in leaves of moringa plants.

Moreover, all applied antioxidants increased total cholorophyll conc. In the leaves especially under water stress levels comparing with control. .Humic acid(HA) gave the highest values in this respect followed by seaweeds extracts(SWE) and ascorbicacid (AsA).

Table (2): Effect of water stress levels and applied antioxidants, AS , SA , HA , SWE as well as their interactions on concentrationTotal Cholorophyll (mg/ gm F.W) in leaves of moringa plants at vegetative growth stage during 2015 season.

Characteristics / Treatments (mg/l)	TOTAL CHOLOROPHYLL — Water levels: CONTROL	%	LEVEL(1)	%	LEVEL(2)	%	MEAN	%
Control	12.40	100	10.00	81	5.00	40	9.13	74
Salicylic Acid (SA) (250gm/l)	16.60	134	12.10	98	7.00	56	11.90	96
Ascorbic Acid (AS) (250gm/l)	17.60	142	13.80	111	7.20	58	12.87	104
Humic Acid (HA) (1000mg/l)	20.20	163	14.20	115	8.20	66	14.20	115
Sea weeds extract (SWE) (1000gm/l)	18.20	147	13.60	110	7.50	60	13.10	106
MEAN	16.62	134	12.58	102	6.84	55	12.01	97

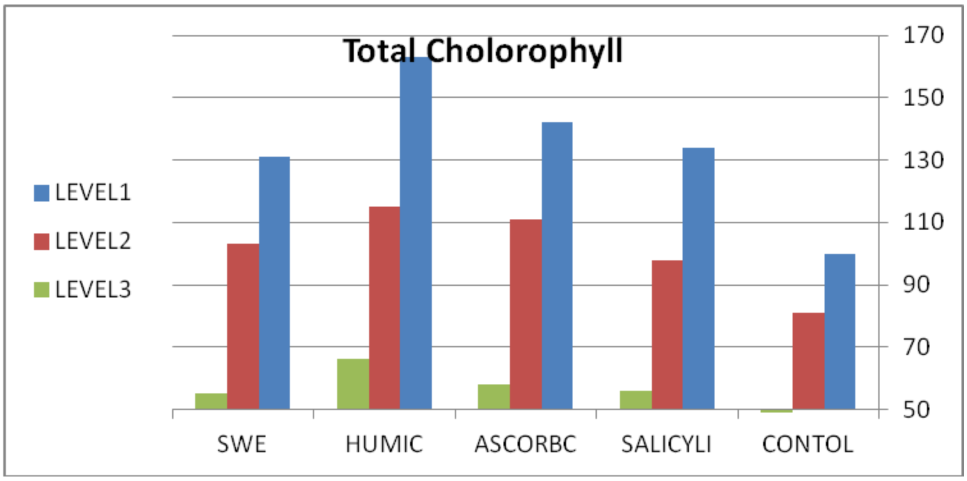

Figure (1): Effect of water stress levels and applied antioxidants, AS , SA , HA , SWE as well as their interactions on Total Cholorophyll (Mg/Gm F.W)) in leaves of moringa plants at vegetative growth stage during 2015 season.

L_1 : Water level (control, 30 days) L_2 : Water level (moderate, 60 days) L_3 : Water level (severe, 90 days)

2. Proline content:

Data in Table (3) and Fig. (2) show that water stress levels increased proline conc. in leaves of moringa plants comparing with control . The highest water stress level gave the highest increased in proline content in leaves of moringa plants.

Antioxidant application showed an additive effects on proline conc.to thak of water stress . Also, Humic acid (HA) gave the highest values of proline conc. followed by seaweeds extract(SWE) in moringa plants grown under water stress levels .

Table (3): Effect of water stress levels and applied antioxidants, AS , SA , HA , SWE as well as their interactions on proline conc.(mg/g) (MG/100GM) in leaves of moringa plants at vegetative growth stage during 2015 season.

Characteristics / Treatments (mg/l)	PROLINE (mg/g f.wt) — Water levels: CONTROL	%	LEVEL(1)	%	LEVEL(2)	%	MEAN	%
Control	11.39	100	11.07	97	10.15	89	10.87	95
Salicylic Acid (SA) (250gm/l)	12.63	111	11.96	105	11.22	99	11.94	105
Ascorbic Acid (AS) (250gm/l)	12.95	114	12.20	107	11.47	101	12.21	107
Humic Acid (HA) (1000mg/l)	13.98	123	13.02	114	12.19	107	13.06	115
Sea weeds extract (SWE) (1000gm/l)	13.27	117	12.48	110	11.72	103	12.49	110
MEAN	10.30	107	11.79	123	13.63	142	11.91	124

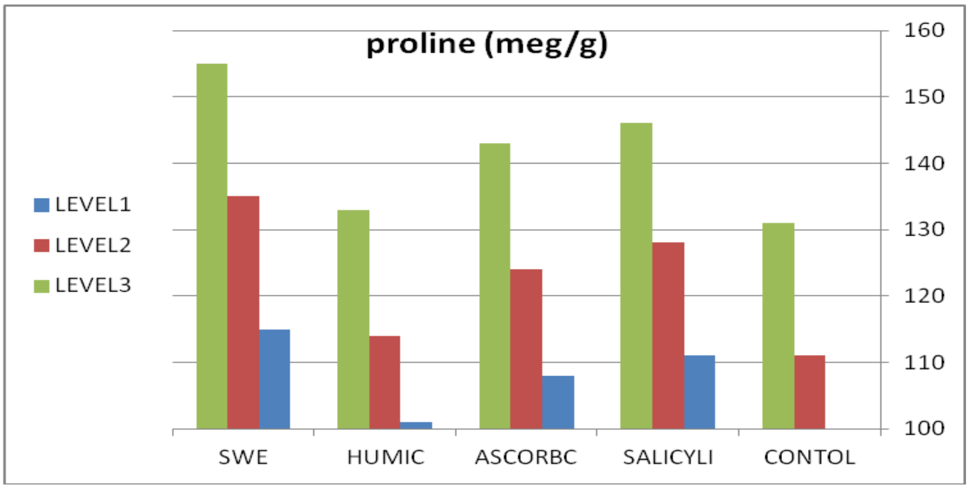

Figure (2): Effect of water stress levels and applied antioxidants, AS , SA , HA SWE as well as their interactions on proline conc. (mg/g) (MG/100GM) in leaves of moringa plants at vegetative growth stage during 2015 season.

L_1 : Water level (control, 30 days) L_2 : Water level (moderate, 60 days) L_3 : Water level (severe, 90 days)

3.Total phenols content:

Data in Table (4) and Fig. (3) show that all applied antioxidants and water stress levels as well as their combinations increased the cons. of total phenols in moringa plant, It could be show that humic acid (HA) treatment gave the best results in this respect

Table (4): Effect of water stress levels and applied antioxidants, AS , SA , HA , SWE as well as their interactions on Total Phenols (mg/g) in leaves of moringa plants at vegetative growth stage during 2015 season.

Characteristics	TOTAL PHENOLS (mg/g) Water levels							
	CONTROL		LEVEL(1)		LEVEL(2)		MEAN	
Treatments (mg/l)		%		%		%		%
Control	33.41	100	35.16	105	38.09	114	35.55	106
Salicylic Acid (SA) (250gm/l)	34.56	103	36.39	109	39.57	118	36.84	110
Ascorbic Acid (AS) (250gm/l)	34.87	104	36.72	110	39.90	119	37.16	111
Humic Acid (HA) (1000mg/l)	35.79	107	37.86	113	40.93	123	38.19	114
Sea weeds extract (SWE) (1000gm/l)	35.16	105	37.12	111	40.22	120	37.50	112
MEAN	34.52	103	36.4	109	39.47	118	36.79	110

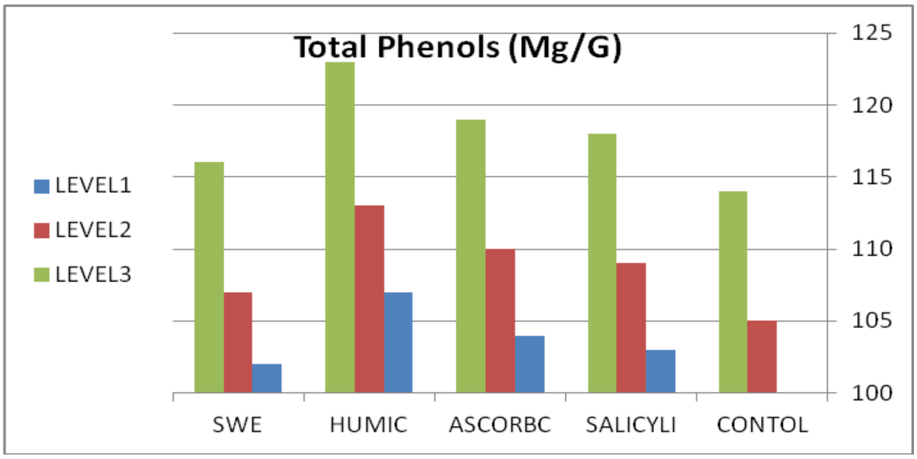

Figure (3): Effect of water stress levels and applied antioxidants, AS , SA , HA , SWE as well as their interactions on Total Phenols (Mg/G) in leaves of moringa plants at vegetative growth stage during 2015 season.

L_1 : Water level (control, 30 days) L_2 : Water level (moderate, 60 days) L_3 : Water level (severe, 90 days)

4.Ascorbic acid (Vit C):

Data in Table (5) and Fig. (4) revealed that all water stress levels increased total AsA contents compared with the control plants.

The data also show that all applied antioxidants increased ascorbic acid (vitc) conc. in leaves under water stress levels comparing with control. . Also, Ascorbic acid(AsA) , humic acid (HA) gave the highest values in this respect .This mean that applied antioxidants could alleviate the harmfull effect of water stress on the content of total ascorbic acid(vit c) in moringa plant.

Table (5): Effect of water stress levels and applied antioxidants, AS , SA , HA , SWE as well as their interactions on ASCORBIC ACID (mg/100gm) in leaves of moringa plants at vegetative growth stage during 2015 season.

Characteristics / Treatments (mg/l)	ASCORBIC ACID (mg/100gm) Water levels CONTROL	%	LEVEL(1)	%	LEVEL(2)	%	MEAN	%
Control	204	100	236	93	469	85	511	93
Salicylic Acid (SA) (250gm/l)	211	104	247	95	478	87	520	94
Ascorbic Acid (AS) (250gm/l)	244	120	262	95	480	87	524	95
Humic Acid (HA) (1000mg/l)	219	107	257	96	489	89	533	97
Sea weeds extract (SWE) (1000gm/l)	215	105	253	96	482	88	526	95
MEAN	217	107	249	122	284	140	250	123

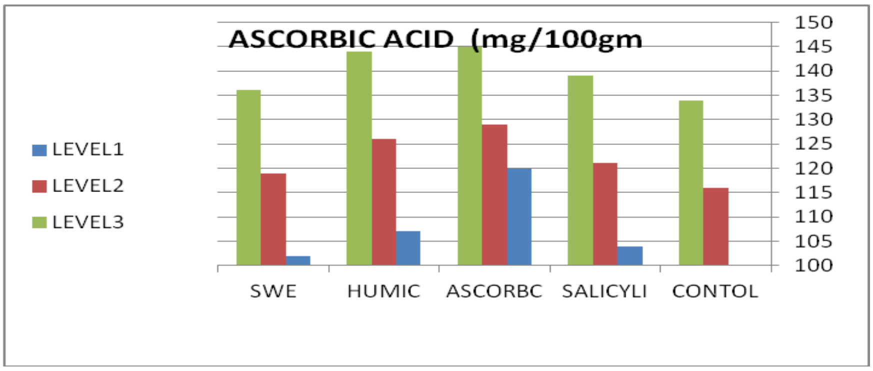

Figure (4): Effect of water stress levels and applied antioxidants, AS , SA , HA , SWE as well as their interactions on ASCORBIC ACID (MG/100GM) in leaves of moringa plants at vegetative growth stage during 2015 season.

L_1 : Water level (control, 30 days) L_2 : Water level (moderate, 60 days) L_3 : Water level (severe, 90 days)

5.CALCIUM CONTENT:

Data in Table (6,7) and Fig. (5,6) clearly indicate that different water stress levels decreased the calcium and fe content in leaves of moringa plants .Level 2 (90day) gave the highest reduction (87%) when compared with the control (100%) plants.

On the other hand, antioxidants increased calcium and fe content in leaves of moringa and humic acid(HA) gave the highest increase of calcium,fe content followed by ascorbic acid (ASA) and seaweeds extracts(SWE) specially under water stress

Table (6): Effect of water stress levels and applied antioxidants, AS , SA , HA , SWE as well as their interactions on calcium (mg/g F.W.) in leaves of moringa plants at vegetative growth stage during 2015 season.

Characteristics / Treatments (mg/l)	Calcium (mg/100gm) Water levels CONTROL	%	LEVEL(1)	%	LEVEL(2)	%	MEAN	%
Control	551	100	513	93	469	85	511	93
Salicylic Acid (SA) (250gm/l)	561	102	522	95	478	87	520	94
Ascorbic Acid (AS) (250gm/l)	566	103	525	95	480	87	524	95
Humic Acid (HA) (1000mg/l)	577	105	532	96	489	89	533	97
Sea weeds extract (SWE) (1000gm/l)	568	103	527	96	482	88	526	95
MEAN	562	102	522	95	478	87	521	94.5

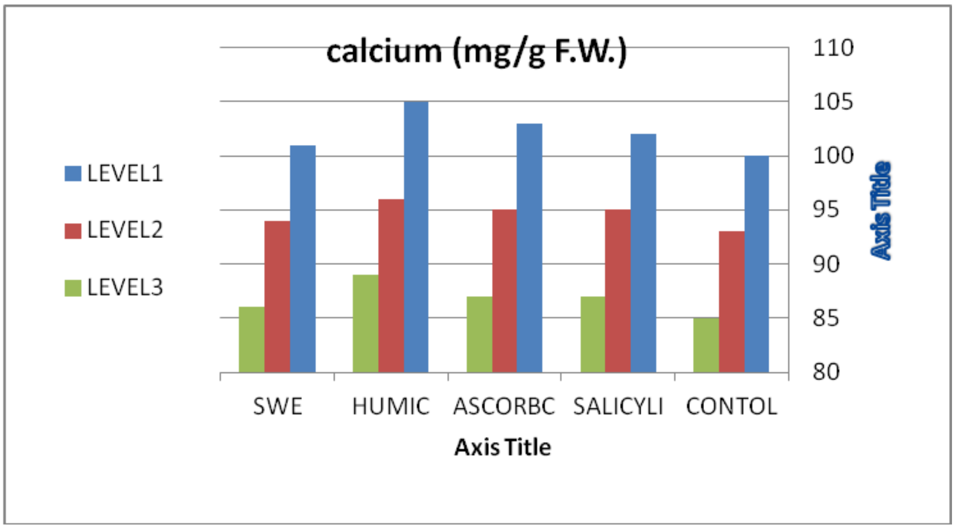

Figure (5): Effect of water stress levels and applied antioxidants, AS , SA , HA , SWE as well as their interactions on calcium (mg/g F.W.) in leaves of moringa plants at vegetative growth stage during 2015 season.

L_1 : Water level (control, 30 days) L_2 : Water level (moderate, 60 days) L_3 : Water level (severe, 90 days)

Table (7): Effect of interaction between water stress levels and applied antioxidants, AS , SA , HA , SWE as well as their interactions on fe (mg/g F.W.) in leaves of moringa plants at vegetative growth stage during 2015 season.

Characteristics	**Fe (mg/100gm) Water levels**							
	CONTROL		**LEVEL(1)**		**LEVEL(2)**		**MEAN**	
Treatments (mg/l)		**%**		**%**		**%**		**%**
Control	11.39	100	11.07	97	10.15	89	10.87	95
Salicylic Acid (SA) (250gm/l)	12.63	111	11.96	105	11.22	99	11.94	105
Ascorbic Acid (AS) (250gm/l)	12.95	114	12.20	107	11.47	101	12.21	107
Humic Acid (HA) (1000mg/l)	13.98	123	13.02	114	12.19	107	13.06	115
Sea weeds extract (SWE) (1000gm/l)	13.27	117	12.48	110	11.72	103	12.49	110
MEAN	12.58	111	11.96	105	11.16	98	11.90	105

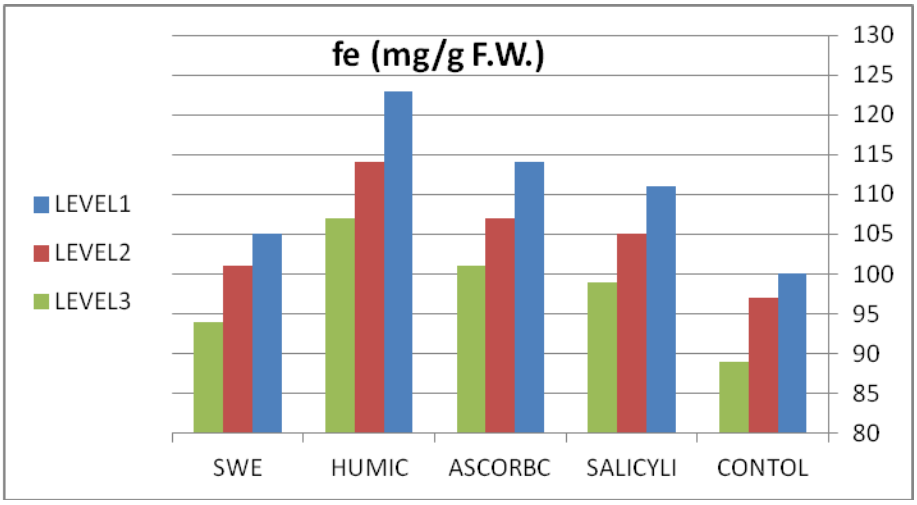

Figure (6): Effect of interaction between water stress levels and applied antioxidants, AS , SA , HA , SWE as well as their interactions on fe (mg/g F.W.) in leaves of moringa plants at vegetative growth stage during 2015 season.

L_1 : Water level (control, 30 days) L_2 : Water level (moderate, 60 days) L_3 : Water level (severe, 90 days)

DISCUSSION

Photosynthetic pigments

The results are in agreement with those obtained by Reddy, *et al.*, (2004), they exhibited that drought stress progressively decreases CO2 assimilation rates and photosynthetic pigments synthesis due to reduced stomatal conductance.

Also, Abd-Ellatif (2012) found that water stress decrease protein in pods of snap bean plant and photosynthetic pigments contents and in many species of plant was reported by Havargi (2007) on cotton, Gadalla (2010) on soybean in leaves, El-Shayb (2010) on rice and Ibrahim (2012) . The decrease in chlorophyll content under drought stress has been considered a typical symptom of oxidative stress and may be the result of chlorophyll degradation and pigment photo-oxidation(Mafakheri *et al.*, (2010) . Photosynthetic pigments are important to plants mainly for production of reducing powers and harvesting light . Both the chlorophyll a and b are prone to soil dehydration (Farooq *et al*., 2009). Carotenes form a key part of the plant antioxidant defense system (Wahid *et al.*, 2007).

Ca++ and fe++ contents:

Drought stress, in general, reduces nutrient uptake by roots and transport from roots to shoots, because of impaired active transport and restricted transpiration rates and membrane permeability resulting in a reduced root-absorbing power of crop plants (Erlandsson, 1 975) . Many solutes may be used in osmotic adjustment including inorganic ions, such as K+ , Na + and CI" (Ford and Wilson, 1981; Wyn Jones and Gorhan, 1983) and organic solutes such as amino acids especially proline and sugars (Navari-lzzo *et al.*, 1990).

In addition, Waraich *et al*.,(2012) proved that application of some nutrients as N, K, Ca and Mg reduces the toxicity of ROS by increasing the concentration of antioxidants superoxide dismutase (SOD), catalase (CAT), and peroxidise(POD) in plant cells.

Proline accumulation:

In this respect, the results may be explained by Kavi Kishor*et al*., 2005; Zlatev and Lidon, 2012) they found that to increase plant tolerance to abiotic stresses and maintain a high relative water content, plants may accumulate compounds of low molecular mass such as gibberellins (compatible osmolytes) and proline (amino acid) , possibly through buffering the cellular redox potential (Wahid and Close, 2007).

Proline contributes to maintenance of the redox balance, can regulate development, and is a component of metabolic signalling networks controlling mitochondrial functions, stress relief, and development. In addition, biosynthesis of cuticular waxes in the aerial parts of land plants is also closely associated with drought resistance responses (Lee and Suh, 2013).

Ascorbic acid (vitc) content:

It has been suggested that the formation of reactive oxygen species is an inherent consequence of metabolism and that control of their levels is essential for normal function. The toxicity of abiotic oxidative stress or an externally imposed biotic can be partly attributed to the overriding of existing resistance mechanisms. Only when those mechanisms are overwhelmed would injury occur (Doulis, 1994). This indicated that the strengthening of the defense mechanisms, through enhancing the functions of their components (such as *α*- tocopherol, ascobic acid, carotene and superoxide dismutase) may reduce or prevent oxidative injury and improve water stress resistance of plants.

Total phenols contents :

The present results agreed with those obtained by El-Shayb (2010) who clarified that irrigation intervals treatments increased phenols contents in the highest drought stress level.

Wahid,(2007) ; Zlatev and Lidon, (2012) added that to alleviate cellular injury, stressed plants produce antioxidant metabolites including enzymes, phenolics, flavonoids, anthocyanins, lignins, and other molecules.

Role of antioxidant salicylic acid,ascorbic acid and humic acid and seaweeds extract on alleviating the harmful effect of water stress:

The increment of photosynthetic pigment contents in response to ascorbic acid, putrescine and potassium may be due to its a action as antioxidants and enhancing antioxidant enzymes activities for protecting chloroplast and photosynthetic system from oxidative damages by free radical (Abdul Jaleel *et al.*, 2009). Similar results are agreed with those reported by Bahadur *et al.*, (2011); Anjum *et al*., (2011) and Hanafy Ahmed *et al.*, (2010).

Our Results are in line with those obtained by Idrees et al., (2011). Hussain et al. (2008) they stated that salt and water deficit stress treatments decreased plant height, shoot fresh weight, photosynthetic pigments and potassium content while increased the contents of proline, MDA, soluble carbohydrate, total phenolic compounds, antioxidant activity and sodium. It was observed that foliar application of addition of KNO3 or SA increased the plant growth, photosynthetic pigment contents, potassium content and decreased sodium content in stressed barley plants. Foliar application of SA reduced the damaging effect of salinity on accelerated the restoration growth processes and plant growth and reversed the effects of salinity.

some studies showed that humic acid can be used as a growth regulator to regulate hormone level, improve plant growth and enhance stress tolerance (Piccolo et al., 1992).

In addition, Malik and Azam, (1985) proved that foliar spray with humic acid also increased root length and leaf area index (Figliolia et al., 1994).

O'Donnell (1973) found that humic acid from leonardite (a naturally occurring, decomposed and highly compressed , soft brown and coal-like organic material, usually found in conjunction with deposit of lignite) exhibits auxin-like effects.

The positive effects of boistimulants SWE on alleviate drought stress might be explained by Schmidt, 2005). who found that seaweed extract may enhance hydrophobic and hydrophilic antioxidant activity and thus promote growth and leaf water status. He added that antioxidant status could be manipulated with exogenous application of plant growth biostimulants (SWE) .

The increase of this antioxidant may be triggered by excess production of reactiveoxygen species in the photosynthetic apparatus under stress. Through: I)- activate root cells at the same time stimulate biosynthesis of endogenous Cytokinins from roots .

CONCLUSION

1- Foliar application of ascorbic acid proved to be effective in mitigating the drought effect on moringa trees.
2- Substances such as humic acid, seaweeds extract could be used as an economic, environment friendly method to to mitigate and partially alleviate the harmful effect of water stress and enhancing the tolerance of moringa plants .

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التأثيرات الفسيولوجية لبعض مضادات الأكسدة على نبات المورينجا النامي تحت تأثير ظروف الاجهاد المائي

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يعتبر نقص الموارد المائيه من اكبر المشكلات التى تواجه الزراعه فى العالم وفى مصر على وجه الاخص لما لها من تاثييرات سلبيه على نمو وانتاجيه النباتات. ونظرا لأهمية البحث عن وسائل لتقليل هذا الأثر السلبى على النباتات وعلى وجه الاخص نبات المورينجا كأحد النباتات الهامة وذات الفائده الطبية العظيمه فلقد أجريت هذة الدراسة بهدف تقييم الأثر المخفف لكل من حامض الأسكوربيك، حامض السالسيلك، حامض الهيوميك، ،مستخلص اعشاب البحر على اشجار نبات المورينجا تحت ظروف الاجهاد المائى . ولقد أوضحت نتائج الدراسة ان هذة المواد قد أدت غلى زيادة قدرة النباتات على تحمل الإجهاد الناشئ عن نقص الماء ، متمثلا فى زيادة المحتويات البيوكيماوية ذات العلاقة بتحمل الإجهاد، وبصفة خاصة الفينولات والبرولين، فلقد كانت معاملات حامض الهيوميك ومستخلص اعشاب البحر هى الأفضل تأثيرا فى هذا الشأن ومن ثم فإنة يمكن التوصية بتطبيق هذة المعاملات عند زراعة اشجار المورينجا المزروعه تحت ظروف الاجهاد المائي لزيادة قدرة النبات على تحمل الإجهاد.