ISSN NO. 2320-5407

Journal homepage: ***http://www.journalijar.com***

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH

RESEARCH ARTICLE

RESPONSE OF WHEAT PLANT TO SOIL SALINITY AND FOLIAR APPLICATION TREATMENTS OF ORGANIC COMPOUNDS.

A.M. Sabbour, Elham F. Gomaa and Shimaa A. Shaaban*.

Botany Department, Faculty of Agriculture, Cairo University, Giza, Egypt.

Manuscript Info

Manuscript History:

Received: 14 January 2016
Final Accepted: 22 February 2016
Published Online: March 2016

Key words:
Wheat, Salinity, Salicylic acid, Glycine betain, Humic acid.

***Corresponding Author**

Shimaa A. Shaaban.

Abstract

A pot experiment was carried out under different soil salinity (0, 2500, 5000 and 6500ppm), to investigate the effect of foliar application of salinity relief organic compounds; salicylic acid (0.15, 0.25 g/l), glycine betaine (0.6, 0.9 g/l) and humic acid (0.25, 0.35 g/l) sprayed twice (30 and 60 days after sowing) on morphological traits and growth parameters of wheat (*Triticum aestivum* L.) var.“Gemiza7”. The interaction between the organic compounds and the adopted soil salinity was investigated. The results indicated that there are negative relationships between salt stress degree and plant growth characters i.e. plant height, number of tillers per plant, average leaf area and shoot fresh and dry weight. The three applied organic compounds significantly increase the averages of the morphological studied characters. Relative to the control, the average scored increases in average plant height due to organic acids treatments were, 10.7, 11.3 and 12.2% for salicylic, glycine betaine and humic acid treatments, respectively. The corresponded recorded percentages for average number of tillers were, 17.5, 40.0 and 10.0% for the same organic acids treatments arranged in the same order. Same trends were obtained in case of average leaf area. The average scored increases, relative to the control, in average plant fresh and dry weights due to organic acids treatments were, 5.1, 5% for (SA), 19.5, 22.7% for (GB) and 8.1, 6.3% for (HA) treatments arranged in the same order. The most common outcome was the compensating and salinity osmolytes effect on the reduction occurred due to salinity of the studied morphological traits.

Introduction:-

Wheat (*Triticum aestivum* L.) is cereal crop belongs to family poaceae. The world production of wheat in 2013 was around 9.5 million tons (FAO stat, 2015). The nutritional value of wheat (protein) is higher than maize and rice. Moreover, wheat is considered as a main component in Egyptians food. In addition, it is classified as a moderate salt tolerant crop (Mass & Hoffman, 1977). Salt stress is abiotic stress. Soil salinity is characterized by high amounts of Na^+, K^+, Ca^{2+}, Mg^{2+} and Cl^- which inhibited growth and productivity of the plant due to accumulation of these salts in the root zoom and affected in the absorption of water and nutrients. Salicylic acid (SA) is an endogenous growth regulator of phenolic nature, which participates in the regulation of physiological processes in plant. SA can be used as a signal molecule to investigate plant defense to abiotic stress. SA increasing the antioxidative enzyme activity in wheat seedling (Erdal *et al*., 2011) and seemed to be important protectants against drought stress in maize (Rao *et al*, 2012). Glycine betaine (amino acid) is an osmoprotectant that has a vital role in enhancement the growth and development of plants exposed to abiotic stresses such as drought, temperature and salinity stress, (Quan *et al*., 2004) and (Moharramnejad *et al*., 2015). Humic matter is the major component of soil organic matter (Chen and Aviad, 1990). In addition to, it can ameliorate negative soil properties; improve the plant growth and uptake of nutrients (Asik *et al*., 2009). The objective of this study was to determine the effect of soil salinity treatments on some morphological traits of wheat plants and to evaluate the compensating effect of three organic compounds, Salsalic acid, Glycin betain and Humic acid on relief the negative effects of salinity.

Materials and methods:-

This study was carried out during the two winter seasons 2012 and 2013 in the Agricultural experimental station, Faculty of Agriculture, Cairo University. Giza, Egypt. Plastic pots (30 cm in diameter)were filled with clay loam soil obtained from farm of faculty of agriculture ,Giza. Chemical analyses of soil was determined according to methods reported by Jackson(1973). Seeds of wheat cultivar “Gemiza7” were sourced from Department of Crop Plants, Agricultural Reasearch Center, Giza, Egypt and sown in pots containing mixture soil 2:1(clay and sand) soil. The experimental work included twenty eight treatments. Sail salinity was used for four concentration 0, 2500, 5000 and 6500ppm.Soil salinity was made by adding mixture of sodium chloride, Calcium Chloride and magnesium salphate at the ratio of 1:1:0.5. The following three osmo protectant organic compounds namely; Salsalic acid was used in concentrations (0.15, 0.25 g/l) and Glycine betaine was used in adose (0.6, 0.9 g/l) and Humic acid were used in concentrations (0.25, 0.35 g/l). These compounds Salsalic (SA), glycine betaine (GB) and humic acid (HA) were spraied twise the 1st at 30 days plant age and the 2nd in 60 days old. The experimnt layout was complete randomized block design (CRBD) with three replicates. In both seasons data were recorded at heading stage on the following growth and morphological trais, average plant height, average number of tillers per plant, average leaf area and average plant dry and fresh weight. Data recorded on average five plants per replicat sampling bases and an appropiate (Combined Analysis of Variance over the two seasons) procedures were used according to the software MSTATC. Means separations were done according to LSD at 5% level of certinity as described by Snedecor and Chochran (1980).

Results and Discussions:-

It was planned to study the morphological traits and growth parameters of wheat plants grown under four saline conditions; 0, 2500, 5000 and 6500 and their response to the foliar application of salinity relief organic compounds; salicylic acid (0.15g/l and 0.25g/l), glycine betaine (0.6 g/l and 0.9 g/l) and humic acid (0.25 g/l and 0.35 g/l) and the interaction between compounds.

Effect of soil saline conditions on morphological traits:-

The statistical analysis proved significant effects due to the studied factors; seasons, salinity levels and the applied organic salinity relief compounds, salicylic, glycine and humic acids, as well as their interactions. Since, seasons showed significant effect, the results will be discussed for each season separately. The factors under study are; four salinity levels; 0, 2500, 5000 and 6500 ppm and the three applied organic .Relative to the control, combined data over seasons proved that, the average plant height, number of tillers per plant and average leaf area were reduced by 9.1, 27.4 and 13.1% as an average due to saline treatments. The corresponded reduced percentages due to the highest salinity treatment 6500 ppm were, 18.3, 52.7 and 28.1% for the same traits, Table (2). Relative to the control, the average reductions in average plant height due to 2500, 5000 and 6500 salinity levels were, 6.8, 11.2 and 18.3%, respectively. The recorded reductions below the control, in average number of tillers due to soil salinity conditions were, 14.5, 45.4 and 52.7% for 2500, 5000 and 6500 ppm, respectively. It was also, realized that the occurred reduction in the morphological traits due to saline conditions was gradually increased by increasing salinity levels. This recorded decline due to saline conditions might be due to fewer water uptake and essential nutrients due to higher concentration of salts present in the root zone, which may causes imbalances in osmotic pressure and ion toxicity, Kumar et al. (2012). It was also reported by Kurum et al. (2013) that the toxic effect of salts as well as inhibition of cytokinesis and cell expansion that stimulate the growth and increase in hormones that hinder growth can cause shorter root and shoots. Moreover, Shahid et al.(2011) stated that, the recorded inhibitions in growth attributes like germination percentage, shoot and root length, plant height, pod weight, pod length, photosynthesis rate and stomata conductance were severely decreased with salinity. Salinity may directly or indirectly inhibit cell division, cell enlargement, which reflects in reduction of plant height. In addition, Raza et al., (2014) reported that the reduction of shoot height may be due to dehydration of protoplasm, less relative turgidity associated with turgor loss and decreased cell expansion and cell division. Hussein and Abou-Baker (2014) in Moringa plants found that there are negative relationship between salt stress degree and plant growth characters i.e. plant height, leaves area and dry weight of root, stem and leaves, which decreased as the salt concentration increased in the diluted seawater.

Effect of organic compounds treatments on wheat morphological traits:-

Data presented in Table (2) illustrate the effect of the applied organic compounds, Salicylic, glycine betaine and humic acid on the averages of morphological characters; the average plant height, number of tillers per plant and average leaf area of wheat plants grown under different soil saline conditions. It is clear that, in both seasons, the three applied organic compounds significantly affect the averages of the studied characters.

The main effect of these compounds was to compensate the reduction occurred due to salinity on the studied morphological traits. Relative to the control, the average scored increases in average plant height due to organic acids treatments were, 10.7, 11.3 and 12.2% for salicylic, glycine betaine and humic acid treatments, respectively. The corresponded recorded percentages for average number of tillers were, 17.5, 40.0 and 10.0% for the same organic acids treatments arranged in the same order. Same trends were obtained in case of average leaf area; where, relative to the untreated control, the obtained alternations in the recorded parameters due to organic acids treatments were, 7.6, 1.0, and -15.3% for 2500, 5000 and 6500 ppm, respectively. So, it could be stated that as an averages, all organic compounds treatments, relatively did no compensate the reduction occurred in average area due to 6500 ppm salinity. Nawaz and Ashraf (2010) found that the adverse effects of salt stress on maize plants were alleviated by the exogenous application of GB at different growth stages, which up-regulated photosynthetic capacity and the activities of some antioxidant enzymes. Combined analysis of variance proved that humic acid treatments confirmed to be the most suitable compound that could compensate the reduction effect of salinity on average wheat plant height. Where, humic acid treatments caused 12.2 and 10% increases in average plant height and average number of tillers over the control. The other two organic compounds salicylic and glycine betaine scored an intermediate increments 10.7,11.3% and 17.5,40% in average plant height and number of fertile tillers as compared with humic acid treatments. In this concern, Asik et al, (2009) mention that, humic substances improve the plant growth and the uptake of essential elements so it used to ameliorate negative effect of saline soil. Turan et al. (2011) found that Humic substances, holds positively charged molecules of soil surface that can be absorbed by the plant's roots and helps to improve micronutrient exchange. With regard the interaction effect of salinity and the applied organic compounds. It is obvious that, the highest applied salinity conditions 6500 ppm caused significant reduction in the averages of the traits under study. Relative to the control, humic acid (0.35 g/l) treatment resulted in significant increase in the averages of the studied traits. Where, plant height increased by, 13.1, 13.0 and 22.5% for 2500, 5000 and 6500 ppm salinity levels, respectively. The obtained compensating percentages in number of tillers per plant due to the same treatment were, 10.6, 56.6 and 42.3% for the same treatment under the same salinity conditions arranged in the same order. In the meantime, the average compensated percentages in averages of the three studied traits due to Humic acid 0.35 g/l treatment with 6500 ppm salinity level were, 22.5, 38.5 and 28.9 % for average plant height, number of tillers and average leaf area, respectively. Whereas, the combined data of average plant height showed 11.4, 9.9 and 20.5% increments due to salicylic, glycin and hummic acid treatments. Same trends with different extents of increments in average plant height were detected with average number of tillers per plant and average leaf area, Table (2). The negative relationship between increasing salinity and average plant height, number of fertile tillers per plant and average leaf area could be improved by applying the three organic compounds under investigation. So, it could be stated that as the applied salinity treatment increased the resulted reduction in morphological traits increased and applying each of the three studied organic compounds that could compensate the bad effects of salinity. Sakamoto and Murata (2002) suggests that glycine betaine (GB), an amphoteric quaternary amine, plays an important role as a compatible solute in plants under various types of environmental stress, such as high levels of salts and low temperature. Plant species vary in their capacity to synthesize GB and some plants, such as spinach and barley, accumulate relatively high levels of (GB) in their chloroplasts while others, such as Arabidopsis and tobacco, do not synthesize this compound.

Effect of soil saline conditions on growth parameters:-

Data presented in Table (3) show average plant fresh and dry weights as affected by different soil salinity conditions and treated by three organic compounds with two concentrations. It is clear that increasing salinity levels resulted in outstanding reductions in average plant fresh and dry weights. The calculated reductions percentages in average plant fresh weight were 14.6, 30.9 and 43.5% for 2500, 5000 and 6500 ppm, respectively. The corresponding reduction percentages for average plant dry weight were, 14.8, 30.6 and 42.1%. The effect of salt stress was completely inhibitory at 2500, 5000 and 6500 ppm salinity concentrations. So it could be concluded that average plant fresh and dry weight of wheat plant decreased considerably under saline conditions compared with non-saline one. Moreover, it is noticed that as the soil salinity increased the more outstanding decreases were found in growth attributes. This result is similar to those reported by Kaydan et al. (2007) whom reported that plant dry weight decreased under salinity condition compared with non-salinity condition, Datta et al, (2009) reported that soil salinity is a serious environmental problem that has negative effect on plant growth, production and photosynthesis. Fresh and dry plant weights decreases with salinity treatments, Zahra (2010). Turan et al, (2011) reported that high levels of salt 45 and 60 mM NaCl had negative impacts on the dry weight. The obtained data proved that different levels of salinity significantly affected the growth aspects by reducing root and shoot length. Hussein and Abou-Baker (2014) reported negative relationship between salt stress degree and plant growth characters i.e. plant height, leaves area and dry weight of root, stem and leaves, which decreased as the salt concentration increased in the diluted seawater.

Effect of organic compounds treatments on growth parameters:-

The effect of the applied organic compounds, Salicylic acid (SA), Glycine Betaine (GB) and Humic acid (HA) on the averages of growth parameters; average plant dry and fresh weights of wheat plants grown under different soil saline conditions. Data in Table (3) proved that, in both seasons, the three applied organic compounds significantly affect the averages of the studied characters. The most common outcome was the compensating and salinity osmo protectant effect on the reduction occurred due to salinity of the studied morphological traits. The average scored increases, relative to the control, in average plant fresh and dry weights due to organic acids treatments were, 5.1, 5% for (SA), 19.5, 22.7% for (GB) and 8.1, 6.3% for (HA) treatments arranged in the same order. It was found that foliar application of (GB) on control plants showed significant increases in average plant dry and fresh weight compared to those grow under saline conditions. In contrast, under saline conditions there was no positive effect on plant dry and fresh weights due to (SA) treatment. The maximum significant increase in plant dry weight was recorded by (SA 0.25 g/l) with 5000ppm salinity level. In this respect, Turkyilmaz (2012) on wheat plant reported that the adverse effect of salinity stress alleviated by application of salicylic- and gibberellic acids. Reversely, Abdel-Hakim et al. (2012) reported that, using salicylic acid (SA) as foliar applications affect the plant growth positively when it was used in low concentrations and negatively when the higher concentrations were used.

With regard the interaction between soil salinity and the applied organic compounds. It could be stated that, in both seasons, the highest applied salinity conditions 6500 ppm caused significant improvements in all plant growth attributes. Relative to the control, the inhibited percentages due salinity 6500 ppm were, 43.6 and 40.6% for both fresh and dry weights, respectively. However, the combined data over the two seasons, showed that the average compensating percentages in plant fresh and dry weight due to the applied organic compounds with 6500 ppm treatments were, 5.0, 2.5% for (SA) average treatment and 19.2, 16,9 for (GB) average treatment and 8.1, 8.8% for (HA) average treatment for fresh and dry weights, respectively (table, 3). Same trends with different extents of increments in average plant fresh and dry weight were detected with 2500 and 5000 ppm salinity treatments. It is also, noticed that, the 1st applied concentration of both (GB) and/or (HA) treatments either under salinity or non-salinity conditions were not showed any positive effect on average plant fresh and dry weight. This was in harmony with Liu (1998) who reported that the application of humic acid during salinity stress did not increase the uptake of N, P, K and Ca. Also, he reported that foliar application of humic acid increased the average plant fresh and dry weight, N, P, K, Ca, Mg, Na, Fe, Zn and Mn amounts in plants in 60 mM NaCl when compared with control and 0.2% humic acid treatments.

Table1: Mechanical and chemical properities of the used soil.

Mechanical fraction %									
Coarse sand		Fine sand		Silt	Clay	Organic matter%		Caco$_3$%	
6		37		22	35	1.75		3.52	
		Cation mEg/L				Anions mEg/L			
PH	EC	Ca^{++}	Mg^{+}	Na^{+}	K^{+}	Co_3^{-}	HCo_3^{-}	So_4^{-}	Cl^{-}
7.5	1.51	5.00	4.32	5.60	1.22	-	6.16	3.08	6.00

Table 2: Average plant height, average number of tillers per plant and average leaf area of wheat plants grown under four soil salinity conditions and treated by two concentrations of Salicylic acid, Glycine betaine and Humic acid (combined data over two seasons 2012/13)

	Plant height, cm					Number of tillers/plant					Average plant leaf area,cm^2				
Treatments	Salinity levels ppm				Mean treatments	Salinity levels ppm				Mean treatments	Salinity levels ppm				Mean treatments
	Zero	2500	5000	6500		Zero	2500	5000	6500		Zero	2500	5000	6500	
Control	75.7	70.5	67.2	61.8	68.8	5.5	4.7	3.0	2.6	4.0	209.3	188.8	179.1	150.3	181.9
Salicylic 0.15 g/l	79.0	78.7	77.2	75.6	77.6	5.8	5.2	4.3	3.2	4.6	231.7	209.3	206.9	185.8	208.4
Salicylic 0.25 g/l	76.6	74.9	74.7	72.9	74.8	5.8	5.4	4.6	3.7	4.9	255.0	199.3	185.8	162.1	200.5
Av.Salicylic	77.8	76.8	76.0	74.3	76.2	5.8	5.3	4.5	3.5	4.7	243.3	204.3	196.4	173.9	204.5
Glycine 0.06 g/l	76.4	74.8	73.7	72.7	74.4	6.1	5.9	5.6	4.7	5.6	263.2	240.8	219.1	206.2	232.3
Glycine 0.09 g/l	81.5	79.7	79.1	74.7	78.7	6.3	5.9	5.7	4.6	5.6	247.1	231.7	228.5	151.6	214.7
Av. Glycine	78.9	77.3	76.4	73.7	-76.6	6.2	5.9	5.6	4.7	5.6	255.2	236.3	223.8	178.9	223.5
Humic 0.25 g/l	80.2	78.7	74.9	72.7	76.6	5.1	4.5	4.4	3.1	4.3	255.0	244.4	220.9	181.5	225.5
Humic 0.35 g/l	79.6	79.8	76.0	75.7	77.8	5.2	4.7	4.5	3.6	4.5	264.2	250.9	229.0	193.8	234.4
Av.Humic	79.9	79.3	75.4	74.2	77.2	5.2	4.6	4.5	3.3	4.4	259.6	247.7	224.9	187.6	229.9
Mean Salinity	78.6	77.1	75.0	72.8	75.9	5.7	5.2	4.7	3.7	4.8	248.3	225.3	211.4	177.2	215.6
$LSD_{5\%\ Salinity}$	0.8					0.30					9.7				
$LSD_{5\%\ Treatments}$	1.8					0.08					12.6				
$LSD_{5\%\ S\ X\ T}$	0.6					0.04					3.1				

Table 3: Average plant fresh and dry weight of wheat plants grown under four soil salinity conditions and treated by two concentrations of Salicylic acid, Glycine betaine and Humic acid (combined data over two seasons 2012/13)

Characters	Average plant fresh weight, g.					Average plant dry weight, g.				
Treatments	Salinity levels ppm				Mean treatments	Salinity levels ppm				Mean treatments
	Zero	2500	5000	6500		Zero	2500	5000	6500	
Control	34.9	29.8	24.1	19.7	27.1	10.1	8.6	7.0	6.0	7.9
Salicylic 1	36.8	29.3	25.9	20.5	28.1	10.7	8.5	7.5	6.0	8.2
Salicylic 2	37.6	30.3	26.3	21.5	28.9	10.9	8.8	7.6	6.2	8.4
Av.Salicylic	37.2	29.8	26.1	21.0	28.5	10.8	8.6	7.6	6.1	8.1
Glycine 1	39.0	34.5	28.6	23.9	31.5	11.3	10.0	8.3	6.9	9.1
Glycine 2	40.4	36.4	30.6	26.1	33.4	11.7	10.6	8.9	7.6	9.7
Av. Glycine	39.7	35.4	29.6	25.0	32.4	11.5	10.3	8.6	7.2	9.3
Humic 1	35.4	31.4	25.6	20.3	28.2	10.3	9.1	7.4	5.9	8.2
Humic 2	37.2	32.3	29.2	22.7	30.4	10.8	9.4	8.5	6.6	8.8
Av.Humic	36.3	31.8	27.4	21.5	29.3	10.5	9.2	8.0	6.2	8.6
Mean Salinity	34.9	29.8	24.1	19.7	27.1	10.1	8.6	7.0	5.7	7.9
$LSD_{5\%\ Salinity}$	3.5					1.7				
$LSD_{5\%\ Treatments}$	0.8					0.2				
$LSD_{5\%\ S\ X\ T}$	1.1					0.8				

Conclusions:-

In this study, it could be concluded that salt stress induced variations in the morphological and growth traits as well as the physiology of wheat plants. Results obtained in the present work confirmed that organic compounds able to produce some positive effects in wheat (*Triticum aestivum* L.). Finally, results showed that supply of organic compounds such as (Salicylic acid, Glycine betaine and Humic acid) markedly alleviated the negative effects of a biotic stresses on wheat plants.

References:-

1. **Abdel-Hakim, W.; Moustafa, Y.M. and Gheeth, R.H.(2012):** Foliar application of some chemical treatments and planting date affecting Snap Bean (*Phaseolus vulgaris* L.) plants grown in Egypt. Journal of Horticultural Science & Ornamental Plants, 4(3):307–317.
2. **Asik, B. B.; Turan, M. A.; Celik, H. and Katkat, A. V. (2009):** Effects of humic substances on plant growth and mineral nutrients uptake of wheat (*Triticum durum* cv. Salihli) under conditions of salinity. Asian Journal of Crop Science, 1: 87-95.
3. **Chen, Y., and Aviad, T. (1990):** Effects of humic substances on plant growth. Humic substances in soil and crop sciences: Selected readings, (humicsubstances), 161-186.
4. **Datta, J.K.; Nag, S.; Banerjee, A. and Mondal, N.K. (2009):** Impact of salt stress on five varieties of wheat (*Triticum estivum* L.) cultivars under laboratory condition. Journal of applied science and Environmental Management, 13(3): 93 – 97.
5. **Erdal, S.; Aydın, M.; Genisel ,M.; Taspınar, M.; Dumlupinar, R.; Kaya, O. and Gorcek, Z.(2011).** Effects of salicylic acid on wheat salt sensitivity. African Journal of Biotechnology, 10 (30):5713-5718.
6. **FAO stat (2015)**. http://faostat3.fao.org/browse/Q/QC/E
7. **Hussein, M.M. and Abou-Baker, N.H. (2014):** Growth and mineral status of moringa plants as affected by silicate and salicylic acid under salt stress. International Journal of Plant and Soil Science, 3(2): 163-177.
8. **Jackson,M.L.(1973):** Soil chemical analysis. Printic Hall of India. Privat limited, New Delhi.p497.
9. **Kaydan, D.; Yagmur, M. and Okut, N. (2007):** Effects of Salicylic Acid on the Growth and Some Physiological Characters in Salt Stressed Wheat (*Triticum aestivum* L). Tarim Bilimleri Dergisi, 13 (2): 114-119.
10. **Kumar, R.; Singh, M. P. and Kumar, S. (2012):** Effect of salinity on germination, growth, yield and yield attributes of wheat. International Journal of Scientific & Technology research, 1.
11. **Kumar, R.; Ulukapi, K.; Aydinsakir, K. and Onus, A.N. (2013):** The influence of salinity on seedling growth of some pumpkin varieties used as rootstock. Not Bot Horti Agrobo, 41(1):219-225.

12. **Liu C. (1998):** Effects of humic substances on creeping bentgrass growth and stress tolerance. Ph.D. Thesis. Philosophy Department of Crop Science, North Carolina State University, Raleigh.
13. **Mass, E.V. and Hoffman, G.J. (1977):**Crop salt tolerance current assessment. J. Irrig. Drain., 103: 115–34.
14. **Moharramnejad, S.; Sofalian, O.; Valizadeh, M.; Asgari, A. and Shiri, M.(2015):** Proline, glycine betaine, total phenolics and pigment contents in response to osmotic stress in maize seedlings. J. BioSci. Biotechnol, 4(3): 313-319.
15. **Nawaz, K. and Ashraf, M. (2010):** Exogenous application of glycine betaine modulates activities of antioxidants in maize plants subjected to salt stress. Journal of Agronomy and Crop Science, 196: 28–37.
16. **Quan, R.D., Shang, M., Zhang, H. (2004):** Improved chilling tolerance by transformation with betA gene for the enhancement of glycinebetaine synthesis in maize. Plant Science 166, 141–149.
17. **Rao, S. R.; Qayyum, A.; Razzaq, A.; Ahmad, M.; Mahmood, I. and Sher, A. (2012):** Role of foliar application of salsalic acid L-tryptophan in drought tolerance of maize. Journal of Animal & Plant Sciences, 22(3): 768-772.
18. **Raza, M. A. S.; Saleem, M. F.; Jamil, M. and Khan, I. H. (2014):** Impact of Foliar Applied Glycin betaine on growth and Physiology of wheat (*Triticum aestivum* L). under drought conditions. Pak. J. Agri. Sci., 51(2), 327-334.
19. **Sakamoto, A. and Murata, N. (2002):** The role of glycine betaine in the protection of plants from stress: clues from transgenic plants. Plant, Cell & Environment, 25(2): 163–171.
20. **Sakamoto, A. and Murata, N. (2002):** The role of glycine betaine in the protection of plants from stress: clues from transgenic plants. Plant, Cell & Environment, 25(2): 163–171.
21. **Shahid, M. A.; Pervez, M. A.; Balal, R. M.; Ahmad, R.; Ayyub, Ch. M.; Abbas, T. and Akhtar N. (2011):** Salt stress effects on some morphological and physiological characteristics of okra (*Abelmoschus esculentus* L), Soil Environ. 30(1): 66-73.
22. **Snedecor, G. and Cochran, W. (1980).** Statistical Methods. 7 th. . USA: Press Amer, Iowa, ed., Iowa Stat Univ.
23. **Turan, M. A.; AŞik, B. B.; Katat, A.V. and Çelik, H. (2011):**The Effects of Soil-Applied humic substances to the dry weight and mineral nutrient uptake of maize plants under soil-salinity conditions. Not Bot Hort Agrobot Cluj, 39(1):171-177.
24. **Turkyilmaz, B. (2012):** Effects of salicylic and gibberllic acids on wheat (*Triticum aestivum* L) under salinity stress. Bangladesh J. Bot., 41(1): 29-34.
25. **Zahra, Sh.; Amin, B. and Mehdi, Y. (2010**): The salicylic acid effect on the tomato (*lycopersicum esculentum* Mill.) germination, growth and photosynthetic pigment under salinity stress (NaCl). Journal of Stress Physiology & Biochemistry, 6(3):4-16.