IJABBR- 2014- eISSN: 2322-4827

International Journal of Advanced Biological and Biomedical Research

Journal homepage: www.ijabbr.com

Original Article

Roll of Gibberlic Acid and Sprimidin on Germination of Spring Cultivars of Wheat Under Salinity Stress

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ARTICLE INFO

Article history:
Received: 07 July, 2014
Revised: 27 July, 2014
Accepted:18, August, 2014
ePublished: 30 Septemebr, 2014

Key words:
Wheat
Germination
Sprimidin
Gibberlic Acid
Salinity

ABSTRACT

Objective: In order to Investigate effects of Gibberlic acid (GA3) and Sprimidin Poly Amine on Germination of three Cultivars of Wheat under Salinity Stress. **Methods:** The experiment was conducted as factorial based on completely randomized design with four replicates in Agronomy and plant breeding laboratory of Agricultural department of Islamic Azad University, Varamin-Pishva branch in spring of 2014. The first factor was salinity with four levels (S1: 3.87 ds/m, S2: 5.95 ds/m, S3: 10.25 ds/m and S4: 12.87 ds/m) and the second factor was three cultivars of spring wheat including V1: Tajan, V2: Arg and V3: Pishtaz and the third factor 4 levels of hormone including H0: control (not application of hormone), H1: GA3 100 mg/L, H2: sprimidin 5 mmol/L and H3: GA3 100 mg/L + sprimidin 5 mmol/L. coleoptile and cleorhiza length, cleorhiza number, coleoptiles, cleorhiza and seedling dry weight, tissue water content (TWC), germination percent and number of damaged seeds were measured. **Results:** Analysis of variance showed that coleoptile and cleorhiza length, cleorhiza number, seedling and cleorhiza dry weigth affected by salinity, hormone and cultivar treatment at 1% of probability level. There are no significant differences for other properties. Results of this experiment indicated that even application of these treatments, development processes of germination under salinity stress decreased greatly.

1. INTRODUCTION

Yield of wheat plant reduced under environmental stress, significantly. Responses of plants to these stresses depend on kind, time and severity of stress, growth stage and time of occurrence (Angelove, 2003). Seed germination is one of the most important stage in growth cycle of plant which guaranteed success of plant stability and final yield. Three discrete stages during germination are 1) seed turgidity which water absorbed by seed 2) dilatory stage which enzymes activated and meristemic activities started and 3) growth with elongation of rootlet and plumule and their exist from seed crust. These processes conducted by outside water. Rate and speed of germination reduced as potential of outside water decreased. It is a threshold value of water potential which germination not occurred lower than it (Stavir and Kaure, 2000). The ways which made plant compatible to stresses like salinity, drought, cooling and heat, affect the growth and production of plant. In response to theses stresses, plants make compatible themselves using different mechanisms like changing in morphological and

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improvement pattern and physiological and biochemical responses (Sarapatka *et al.,* 2004). All of plant hormones affected by osmosis stresses. It is obvious that the level of indigenous phytohormones change under unfavorable condition of environment. Decreasing cytokinines and GA3 and increasing ABA reported in many species (Hare and Staden, 1997; Tsonev and Popova, 1998). However there is low data on mechanisms of hormone balance in plants, but it is clear that concentration of cytokinines and other growth regulators affect their synthesize and metabolisms, oppositely. So, exogenous treatment of growth regulators as a opposite agent on plants under stress, could be a way for improvement of effects of abiotic environments stresses (Ranjan and Prasad, 2003). A growth regulator is an organic compound (more than a nutrient) which made, suppressed or changed qualifications of growth and improvement in very low concentration (lower than 1 mmol). Growth suppressors are organic compound which avoid the growth and had no range for inducement. So, all of hormones (natural products of plant) are plant growth material but its convert is not true. There are hundreds of synthesized compound which act as growth regulators, while there are not hormone. Control of growth and improvement by hormone to what extent related to: 1) changes in hormone concentration and 2) changes in tissue susceptibility following hormone application. The second one supported by (Trewavas, 1983; Basalah and Mohammad, 1999; Trewavas ,1981; Hisamatsu *et al*., 2000).

Tajan Wheat

Tajan Cultivar (pedigree: Bow S / Nkt S) obtained from International Center of Wheat and Maize Breeding (CIMMYT). Potential of yield, resistance against yellow and brown rust, spike fusarium and toleration to germination on the spike made it a suitable cultivar for cultivation in valley area of Khazar banks. Tajan with recorded yield of 7.3 Ton/ha and average yield of 6.3 ton/ha was superior to Falat cultivar up to 18%. The seeds of Tajan were solid and brown. Tahjan with Protein of 12% had well quality for baking different kinds of bread. 90-95 cm height made it resistance to lodging. Early maturity and toleration to spike germination were reported for Tajan Cultivar, also.

Arg Wheat

Arg Cultivar is new, tolerated to salinity cultivar which is appropriated in salty soil and moderated climate. Arg Cultivar with 1-66-22/Inia pedigree is hybrid between Inia Wheat, (CIMMYT) originated with well quality, as male parent and salinity tolerated line 1-66-22 as female parent. The average yield of Arg during compatibility experiments was 5.470 tone/ha in salinity stress (Ec_{water}=8-12ds/m , Ecs_{oil}=9-14ds/m). The yield of this Cultivar increased 820, 971 and 508 kg to Kavir, Roshan and Bam, respectively and 766 kg (16.3%) to control. In research experiment- adapting and researching-extension, the Arg Cultivar was superior against seed yield of control cultivar of salty moderated area including Bam, Kavir, Roshan and Neishaboori with yield average of 3.95 and 4.232 Ton/ha and 16 and 13%, respectively. High yield, well compatibility in moderated climate with salty water and soil, resistance to lodging, seed abscission and high quality are Arg cultivar properties. This Cultivar had significant revolution in wheat production in salty water and soil parts.

Pishtaz Wheat

Pishtaz Cultivar obtained by crossing an improved line (1-27-6275/Cf1770), which later named Alvand, with resistance to yellow rust line, A1dan/Ias58, which originated from Brazil, in 1999. Selection steps of Pishatz were implemented in two generation in year, between Iranshahr and Clardasht station. Resistance to disease and favorable baking quality, made Pishtaz named and introduced in 1381. Pishtaz had the highest yield, so that the average yield of 7396 kg and record of 9646 kg/ha reported for this cultivar.

2. MATERIALS AND METHODS

This experiment was conducted in Agronomy and plant breeding laboratory of Agricultural department of Islamic Azad University, Varamin-Pishva branch in spring of 2014. The experiment was conducted as factorial based on completely randomized design with four replicates. The first factor was salinity with four levels (S1: 3.87 ds/m, S2: 5.95 ds/m, S3: 10.25 ds/m and S4: 12.87 ds/m) and the second factor was three cultivars of spring wheat including V1: Tajan, V2: Arg and V3: Pishtaz and the third factor 4 levels of hormone including H0: control (not application of hormone), H1: GA3 100 mg/L, H2: sprimidin 5 mmol/L and H3: GA3 100 mg/L + sprimidin 5 mmol/L.

Germination Experiment

After weighting the above hormone, they poured in container volume: 50 ml. GA3 and Kin solved in NaOH (1N). An aliquot of control water (obtained from well) poured to each hormone treatments to reach the interested volume. Different levels of salinity were obtained from agricultural wells of Gomrod, in Gome Province. 10 seeds of Tajan cultivar were placed in Petri dishes which covered with filter paper, regularly. Then 10 ml of the treatments added to each Petri dishes. To avoid respiration and transpiration, the door of Petri dishes covered with parafilm. The samples were transferred to germinator without any light in 20 °C and 50% humidity. 7 days later, the length of coleoptile and cleorhiza, number of radicle and length of longest radicle and plumule measured. Then the coleoptile and cleorhiza of each petri placed in separated paper and placed in the pocket and all information of Petri written of it. On each pocket, the fresh weight (FW) of coleoptile and cleorhiza added, also. Then two papers pressed to each other and all samples transferred to oven at 70 °C for 48 h, then the dry weight (DW) of them measured. The cultured seeds were maintained at 25±1 and absolutely no light. After 7 days, number of germinated seeds, radicle and plumule length, coleoptile length, fresh and dry weight of seedlings measured. Tissue Water Content calculated using the following formula: TWC= ((FW-DW)/FW)×100. The collected data analyzed using SPSS, SAS and MSTAT-C softwares. The means were separated using Duncan Multiple Range Tests at 5% of probability level.

Coleoptile Length

Analysis of variance showed that coleoptile length was affected by salinity, hormone and cultivar at 1% of probability level (Table 1). Also there was significant difference among salinity × hormone, salinity × hormone, salinity × cultivar and salinity × cultivar × hormone at 1% of probability level (Table 1). The longest coleoptile was in salinity of 3.87 ds/m with 6.85 cm, while the lowest was in salinity of 12.87 ds/m with 4.49 cm (Table 2). The longest coleoptile was seen in Pishtaz with 5.68 cm, and the shortest was in Arg with 5.04 cm (Table 3). The longest coleoptile was GA3 100 mg/L with 5.84 cm and the shortest was in sprimidin 5 mmol/L with 5.01 cm (Table 4). The longest coleoptile was in salinity of 3.87 ds/m and Pishtaz with 6.87 cm, while the shortest was in Arg and salinity of 12.87 ds/m with 3.96 cm (Figure 1). The longest coleoptile was in salinity of 3.87 ds/m and GA3 100 mg/L with 8.46 cm, while the shortest was in salinity of 10.25 ds/m and GA3 100 mg/L + Sprimidin 5 mmol/L with 3.83 cm (Figure 2). The longest coleoptile was in Pishtaz treated with salinity of 3.87 ds/m and GA3 100 mg/L with 9.5 cm (Figure 3), while the shortest was in Arg treated with salinity of 10.25 ds/m and GA3 100 mg/L + sprimidin 5 mmol/L with 3.33 cm (Figure 4). These results were in agreement with Hollington, 2000 ; Iqbal *et al.,* 2005a.

Cleorhiza Length

Analysis of variance showed that cleorhiza length was affected by salinity, hormone and cultivar at 1% of probability level (Table 1). Also there was significant difference among salinity × hormone, salinity × cultivar and salinity × cultivar × hormone at 1% of probability level (Table 1). The longest cleorhiza was in salinity of 5.95 ds/m with 5.44 cm, and the shortest was in salinity of 3.87 ds/m with 3.43 cm (Table 2). The longest cleorhiza was in Tajan with 5.64 cm, and the shortest was in Arg with 3.82 cm (Table 3). The longest cleorhiza was in not application of hormone with 6.69 cm, and the shortest was in GA3 100 mg/L + sprimidin 5 mmol/L with 3.43 cm (Table 4). The longest cleorhiza was in Tagan treated with salinity of 5.95 ds/m with 6.19 cm, while the shortest was in Pishtaz treated with salinity of 3.87 ds/m with 2.6 cm (Figure 5). The longest cleorhiza was in salinity of 5.95 ds/m and not application of hormone with 8.62 cm, and the shortest was in salinity of 10.25 ds/m and GA3 100 mg/L + sprimidin 5 mmol/L with 2.56 cm (Figure 6). The shortest cleorhiza was in Pishtaz treated with salinity of 3.87 ds/m and GA3 100 mg/L + sprimidin 5 mmol/L with 1.96 cm (Figure 7). The longest cleorhiza was in Tajan treated with salinity of 10.25 ds/m and not application of hormone with 9.91 cm (Figure 8). These results were in agreement with Das, 2002; Iqbal *et al.,* 2006.

Cleorhiza Number

Analysis of variance showed that cleorhiza number affected by salinity, salinity × hormone, salinity × hormone ($P<0.01$) and salinity × hormone × cultivar ($P<0.05$) (Table 1). It was no significant difference among cultivar, hormone and their opposite effect (Table 1). The maximum of cleorhiza number was in salinity of 3.87 ds/m with 5.09, and the minimum was in salinity of 10.25 ds/m with 4.66 (Table 2). The maximum of cleorhiza was in Arg treated with salinity of 3.87 ds/m with 5.1, while the minimum was in Arg treated with salinity of 10.25 ds/m (Figure 9). The maximum of cleorhiza number was in GA3 100 mg/L and salinity of 3.87 ds/m with5.16 and the minimum was in salinity of 10.25 ds/m and GA3 100 mg/L + sprimidin 5 mmol/L with 4.43 (Figure 10). The maximum of cleorhiza was in salinity of 3.87 ds/m and GA3 100 mg/L with 5.41 (Figure 11), The minimum of cleorhiza was in tajan treated with salinity of 5.95 ds/m and not application of hormone with 4.1 (Figure 12). These results were in agreement with Groppa *et al.,* 2008; Bouchereau, 1999; Iqbal *et al.,* 2010.

Cleorhiza Dry Weight

Analysis of variance showed that cleorhiza dry weight was affected by salinity, hormone, salinity × hormone and salinity × cultivar × hormone at 1% of probability level (Table 1), and cultivar, salinity × hormone and

salinity × cultivar at 5% of probability level at 1% of probability level. The highest dry weight of cleorhiza was in salinity of 5.95 ds/m with 0.047 g and the lowest was in salinity of 12.87 ds/m with 0.039 g (table 2). The highest of dry weight was in Arg and Pishtaz, while the lowest was in Tajan with 0.039 g (Table 3). The highest dry weight was in not application of hormone with 0.05 g and the lowest was in GA3 100 mg/L + sprimidin 5 mmol/L with 0.03 g (Table 4). The highest dry weight was in Arg treated with salinity of 5.95 ds/m with 0.05g, while the lowest was in Tajan treated with salinity of 10.25 ds/m with 0.02 g (Figure 13). The highest dry weight was in salinity of 5.95 ds/m and not application of hormone with 0.06 g, while the lowest was in salinity of 10.25 ds/m and GA3 100 mg/L + sprimidin 5 mmol/L with 0.02 g (Figure 14). The highest cleorhiza dry weight was in Pishtaz which treated not by any hormone with 0.05 g and the lowest was in Tajan treated with GA3 100 mg/L + sprimidin 5 mmol/L with 0.03 g(Figure 15). The highest dry weight was in Arg treated with salinity of 5.95 ds/m and not application of hormone with 0.07 g (Figure 16). The lowest of dry weight was in Tajan treated with salinity of 10.25 ds/m and GA3 100 mg/L + sprimidin 5 mmol/L with 0.02 g (Figure 17). These results were in agreement with Hanzawa *et al.,* 2000; Atia *et al.,* 2009; Ismail, 2003.

Coleoptile Dry Weight

Analysis of variance showed that coleoptile dry weight affected by salinity at 5% of probability level and no by cultivar, hormone, salinity × cultivar, salinity × hormone, cultivar × hormone and salinity × cultivar × hormone treatment (Table 1). The highest dry weight of coleoptile wasin salinity of 3.87 ds/m with 0.083 g and the lowest was in salinity of 10.25 ds/m with 0.047 g (Table 2). These results were in agreement with Moschou *et al.,* 2008; Afzal, 2005; Kasinathan, and Wingler, 2004.

Seedling Dry Weight

Analysis of variance showed that seedling dry weight affected by salinity and cultivar at 5% of probability level and no by other treatments (Table 1). The highest dry weight of seedling was in salinity of 3.87 ds/m with 0.12 g and the lowest was in salinity of 10.25 ds/m with 0.08 g (Table 2). The highest dry weight of seedling was in Arg with 0.11 g and the lowest was in Tajan with 0.08 g (Table 3). These results were in agreement with Liu *et al.,* 2008; Akhiyarova *et al.,* 2005; Khan , 2004.

TWC, Germination Percent, Damaged Seeds

Analysis of variance showed that TWC, germination percent, damaged seeds not affected by salinity, hormone, cultivar and their opposite effect (Table 1). These results were in agreement with Tang *et al.,* 2005; Akman, 2009; Olszewski, 2002.

3. Discussion

In hard condition of environment, there is often a permanent stress. Even in environments which growth of plant is very high, there are some stresses which no because of biotype condition, but related to biosensors. There are different kinds of semi permanent stresses which occurred in favorable condition. In stressful condition, plants do so that severed or distributed effects of stress. There are avoidance from stress in plant, but if stress reached to cell content, cell content reacted and at first made tolerance and then compatibility. Progress in succession is not similar in all cases. There are some complexities during stress, for example maybe made loose of energy resource and stress severity which maybe changed along the time. Opposite effect of these factors caused changes in metabolic balance. Therefore it caused changes in general appearance of plant. Application of exogenous treatment of hormone and poly amine sprimidin could not reduced the effects of salinity in salinity upper than 3.87 ds/m in theses cultivars and development processes of germination properties affected by different levels of salinity, greatly.

Table 1.

Analysis of Variance for Studied Traits of Wheat Variety under Salt Stress

S.O.V.	DF	Length of Coleoptil	Length of Coleorhiza	Number of Coleorhiza	Dried Weight of Coleorhiza	Dried Weight of Coleoptil	Dried Weight of Seedlings	Interstitial Water Content of Seedlings	Percentage of Germination	Percentage of Damage Seeds
Salinity	3	54.475**	36.911**	1.80**	0.001**	0.013*	0.018*	50.246ns	278.299ns	2.783ns
Variety	2	6.565**	53.670**	0.258ns	0.001*	0.011ns	0.016*	42.968ns	285.938ns	2.859ns
Hormone	3	5.805**	102.677**	0.279ns	0.002**	0.0003ns	0.001ns	68.917ns	301.910ns	3.01ns
Salinity. Variety	6	1.225**	3.307*	0.292*	0.000*	0.006ns	0.005ns	64.493ns	51.215ns	0.512ns
Salinity . Hormone	9	8.137**	17.104**	0.290*	0.001**	0.007ns	0.009ns	45.564ns	200.521ns	2.005ns
Variety. Hormone	6	0.548ns	1.375ns	0.162ns	0.000*	0.005ns	0.004ns	11.513ns	137.326ns	0.894ns
Salinity. Variety Hormone	18	1.149**	2.123*	0.210*	0.000**	0.005ns	0.006ns	66.398ns	152.604ns	0.993ns
Error	144	0.391	1.275	0.120	0.000	0.005	0.005	43.237	153.646	1.536
%CV	-	10	8	9	10	7	12	9	11	7

ns: Non significant, ** and * significant at 0.01 and 0.05 probability levels, respectively.

Table 2.

Means Comparison for Studied Traits.

S.O.V.	Length of Coleoptil (cm^2)	Length of Coleorhiza (cm^2)	Number of Coleorhiza	Dried weight of Coleorhiza (g)	Dried Weight of Coleoptil (g)	Dried Weight of Seedlings (g)
Salinity3.87(ds.m)	6.85a	3.43c	5.09a	0.044ab	0.083a	0.12a
Salinity5.95(ds.m)	5.42b	5.44a	4.70b	0.047a	0.065ab	0.11ab
Salinity10.25(ds.m)	4.72c	4.69b	4.66b	0.040b	0.47b	0.08b
Salinity12.87(ds.m)	4.49c	5.10ab	4.77b	0.039b	0.049b	0.08b

Table 3.

Means Comparison for Studied Traits.

S.O.V.	Length of Coleoptil (cm^2)	Length of Coleorhiza (cm^2)	Dried Weight of Coleorhiza (g)	Dried Weight of Seedlings (g)
Variety(Taian)	5.39b	5.64a	0.039b	0.08b
Variety(Arg)	5.04c	3.82c	0.044a	0.11a
Variety(pishaz)	5.68a	4.54b	0.044a	0.10ab

Table 4.

Means Comparison for Studied Traits.

S.O.V.	Length of Coleoptil (cm^2)	Length of Coleorhiza (cm^2)	Dried Weight of Coleorhiza (g)
Hormone(0)	5.36b	6.69a	0.05a
Hormone(Ga100mg.l)	5.84a	3.79c	0.04b
Hormone(Spermidine5mmol)	5.01c	4.75b	0.04b
Hormone(Ga100& Spermidine5mmol)	5.27b	3.43c	0.03c

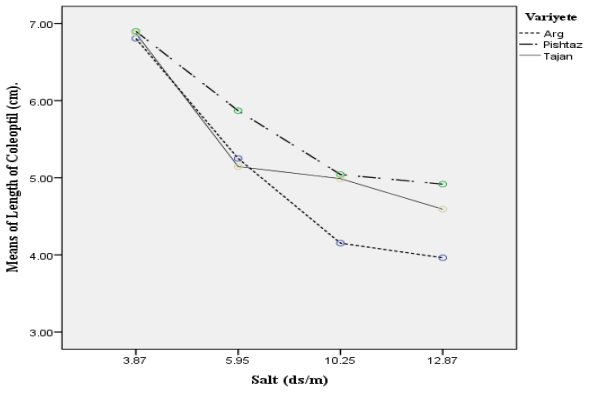

Figure 1. Means comparison of interaction for Length of Coleoptil.

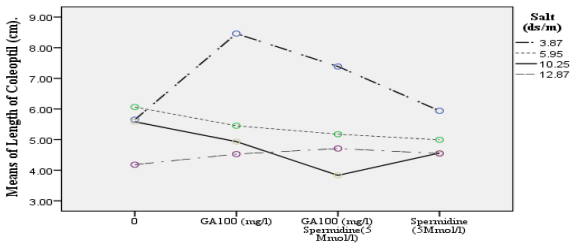

Figure 2. Means comparison of interaction for Length of Coleoptil

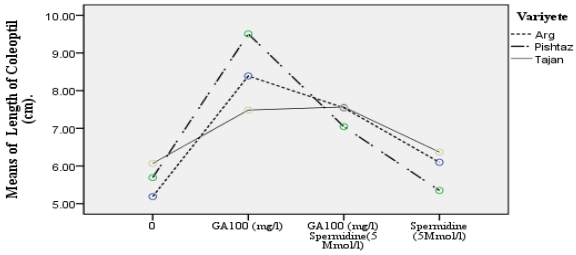

Figure 3. Means comparison of interaction for Length of Coleoptil. at Salt (ds/m) = 3.87

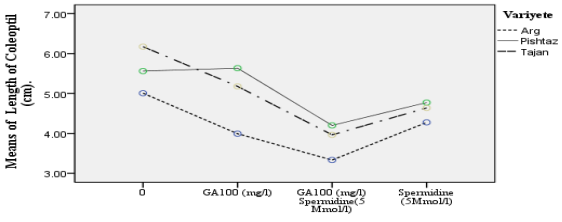

Figure 4. Means comparison of interaction for Length of Coleoptil. at Salt (ds/m) = 10.25

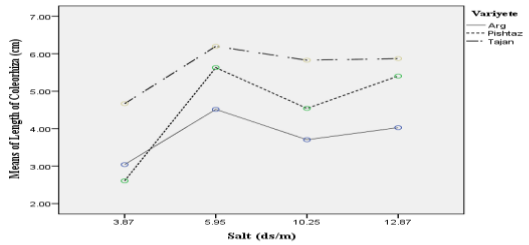

Figure 5. Means comparison of interaction for Length of Coleorhiza

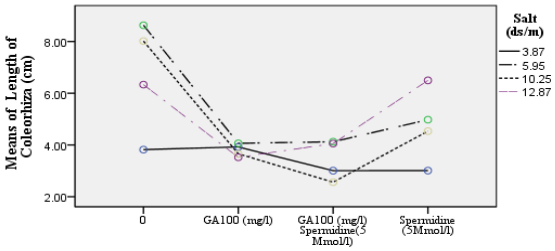

Figure 6. Means comparison of interaction for Length of Coleorhiza

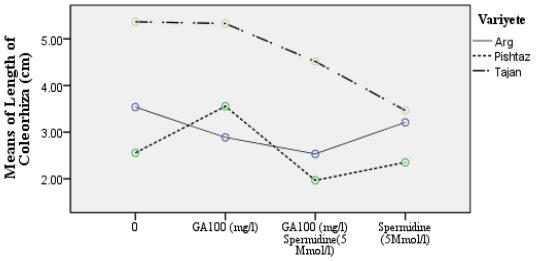

Figure 7. Means comparison of interaction for Length of Coleorhiza at Salt (ds/m) = 3.87

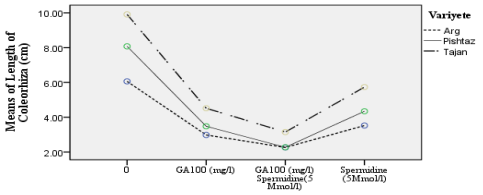

Figure 8. Means comparison of interaction for Length of Coleorhiza at Salt (ds/m) = 10.25

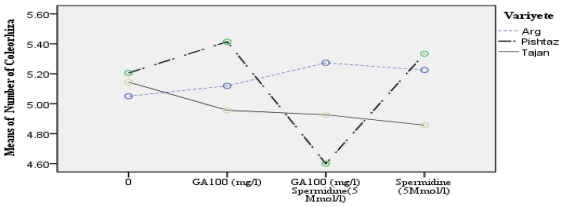

Figure 11. Means comparison of interaction for Number of Coleorhiza at Salt (ds/m) = 3.87

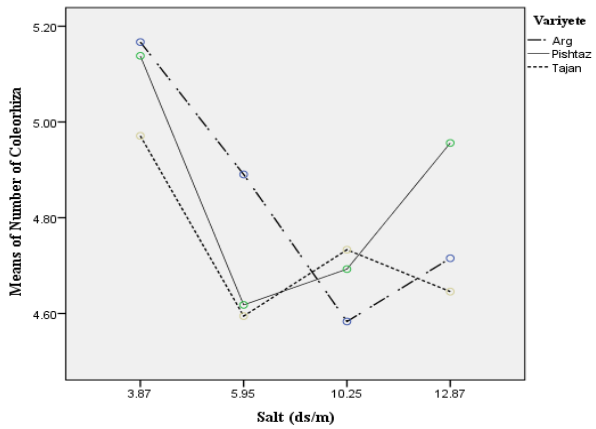

Figure 9. Means comparison of interaction for Number of Coleorhiza

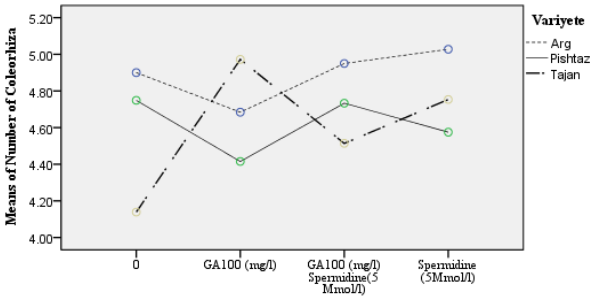

Figure 12. Means comparison of interaction for Number of Coleorhiza at Salt (ds/m) = 5.95

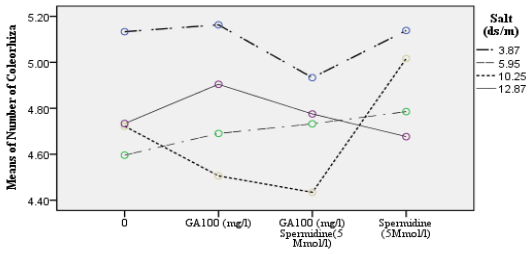

Figure 10. Means comparison of interaction for Number of Coleorhiza

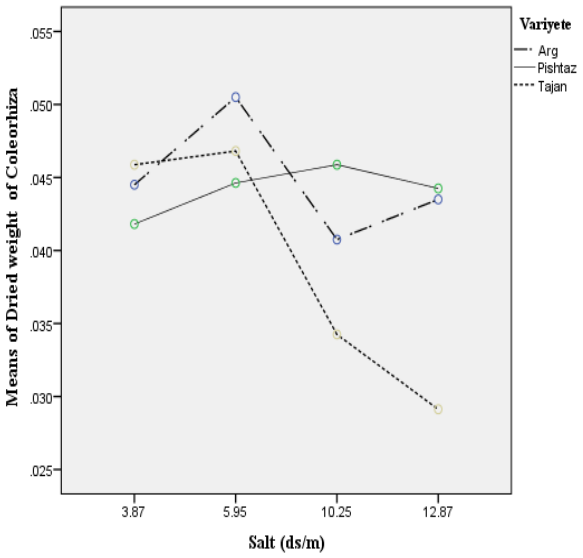

Figure 13. Means comparison of interaction for Dried weight of Coleorhiza

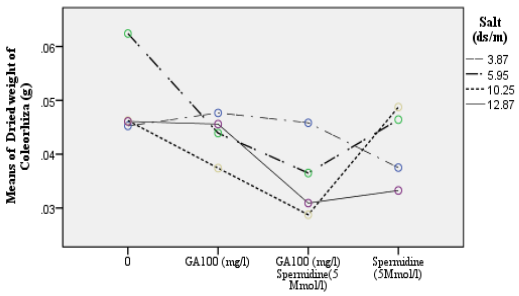

Figure 14. Means comparison of interaction for Dried weight of Coleorhiza

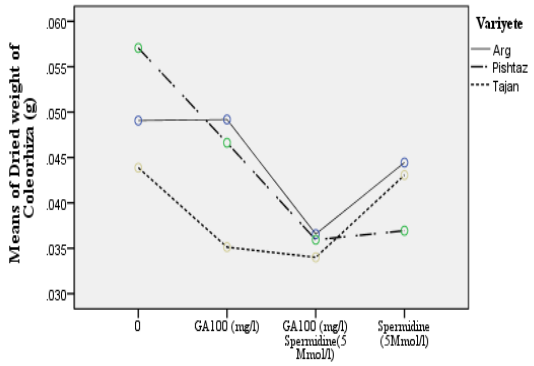

Figure 15. Means comparison of interaction for Dried weight of Coleorhiza

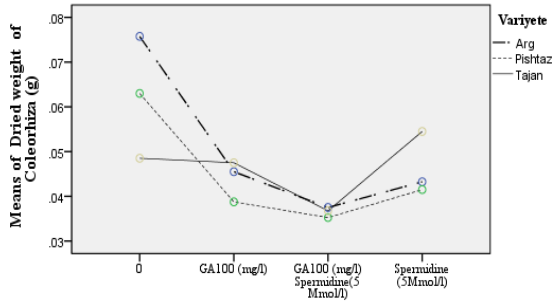

Figure 16. Means comparison of interaction for Dried weight of Coleorhiza at Salt (ds/m) = 5.95

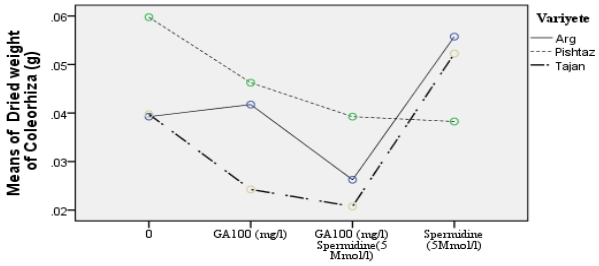

Figure 17. Means comparison of interaction for Dried weight of coleorhiza at Salt (ds/m) = 10.25

REFERENCES

Afzal I, Basra S, Iqbal A, 2005. The Effect of Seed Soaking With Plant Growth Regulators on Seedling Vigor of Wheat Under Salinity Stress. J. Stress Physiol Biochem. 1: 6-14

Akhiyarova GR, Sabirzhanova IB, Veselov DS, Frike V ,2005. Participation of plant hormones in growth resumption of wheat shoots following short-term NaCl treatment. Rus J Plant Physiol52: 788-792.

Akman Z , 2009. Effects of GA3 and kinetin pre-sowing treatments on seedling emergence and seedling growth in wheat under saline conditions. J. Anim. Vet. Adv. 8:362-367.

Angelov G. B, 2003. Isoenzyme variation of esterase and acid phosphatase and genetic affinities among *Dasypyrum villosum*. *Turkish Journal of Botany*, 27, 249-254.

AfzalI, Basra S, Iqbal A, 2005. The Effect of Seed Soaking With Plant Growth Regulators on Seedling Vigor of Wheat Under Salinity Stress. J. Stress Physiol Biochem. 1: 6-14

AtiaA, Debez A, Barhoumi Z, Smaoui A, AbdellyC, 2009. ABA, GA3 , and nitrate may control seed germination of Crithmum maritimum (Apiaceae) under saline conditions. C.R. Biol. 332, 704–710.

Basalah MO, Mohammad S , 1999. Effect of salinity and plant growth regulators on seed germination of *Medicagosativa* L. Pakistan J Biol Sci 2: 651-653

Bouchereau A, Aziz A, Larher F, Martin-Tanguy J, 1999. Polyamines and environ- mental challenges. Recent Dev. Plant Sci. 140, 103–125.

Das C, Sengupta T, Chattopadhyay S, Setua M, Das NK, Saratchandra B, 2002. Involvement of kinetin and spermidine in controlling salinity stress in mulberry (*Morus alba* L. cv. S-1). Acta Physiol Plant 24: 53-57

Groppa M. D, Benavides M. P, 2008. Polyamines and abiotic stress: recent advances. Amino Acids 34: 35-45.

Hanzawa Y, Takahashi T, Michael A.J, Burtin D, Long D, Pineiro M, CouplandG,KomedaY, 2000. *ACAULIS5*, an Arabidopsis gene required for stem elongation, encodes a spermine synthase. *EMBO J. 19*, 4248–4256.

HareP. D, W.A Cress , J. van Staden, 1997. The involvement of cytokinin in plant responses toenvironmental stress. Plant Growth Regulation. 23: 79–103

HisamatsuT, 2000. The role of gibberelllin in biosynthesis in the control of growth and flowering in Mathiola incana. Physiol. Plant., 109, 97-105.

Hollington P.A, 2000. Technological aL through sinscreening/breeding wheat varieties for salt tolerance. In: Gupta, S.K., Sharma, S.K., Tyagi, N.K. (Eds.), Pro- ceedings National Conference on Salinity Management in Agriculture, December

Iqbal M, Ashraf M, 2005a. Changes in growth, photosynthetic capacity and ionic relations in spring wheat (Triticum aestivum L.) due to pre-sowing seed treat- ment with polyamines. Plant Growth Regul. 46, 19–30

Iqbal M, Ashraf M, 2006. Wheat seed priming in relation to salt tolerance: growth, yield and levels of free salicylic acid and polyamines. Ann. Bot. Fenn. 43, 250–259.

Iqbal M, Ashraf M , 2010. Gibberellic Acid Mediated Induction of Salt Tolerance in Wheat Plants: Growth, Ionic Partitioning, Photosynthesis, Yield and Hormonal Homeostasis. Environ. Exp. Bot. doi:10.1016/j.envexpbot. 2010.06. 02.

Ismail AM , 2003. Physiological studies on the influence of cytokinin or GA3 in the alleviation of salt stress in sorghum plants. Acta Agro. Hung. 51:371-380.

Kasinathan V,Wingler A, 2004. Effect of reduced arginine decarboxylase activity on salt tolerance and on polyamine formation during salt stress in Arabidopsis thaliana. Physiol. Plant 121, 101–107.

Liu J. H, Inoue H, MoriguchiT, 2008. Salt stress-induced changes in free polyamine titers and expression of genes

responsible for polyamine biosynthesis of apple in vitro shoots. Environmental Experimental Botany62: 28-35.

Moschou P.N, Paschalidis K.A, Roubelakis-Angelakis K.A, 2008. Plant polyamine catabolism: The state of the art. *Plant Signal. Behav. 3*, 1061–1066.Olszewski, N., Sun, T.P., Gubler, F., 2002. Gibberellin signaling, biosynthesis, catabolism, and response pathways. Plant Cell 14, S61–S80.

Ranjan R, Purohit S , Prasad V , 2003. Plant Hormone: Action and Application. Agrobios(India). 243P.

Sarapatka B, Dudova L, Kroskova M,2004. Effect of pH and phosphate supply on acid phosphatase activity in cereal roots. *Biologia Bratislova*, 59, 127-131.

Stavir K,. Gupt A. K , Kaure N, 2000. Gibberelic Acid and kinetin partially reverse the effect of water stress on germination and seedling growth in chick pea. Plant growth regulation. 25: 29-33.

Tang W, Newton J. R, 2005. Polyamines reduced salt induced oxidative damage by increasing the activities of antioxidant enzymes and decreasing lipid peroxidation in Virginia pine. Plant Growth Regulation 46: 31-43.

Trewavas A, 1981. How Do Plant Growth Substances Work? Plant, Cell Environ. 4: 203-228

TrewavasA, Cleland R. E, 1983. Is Plant Development Regulated By Changes In The Concentration Of Growth Substances Or By Changes In The Sensitivity To Growth Substances Trends Biochem. Sci. 8:354-357.