Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.7285

ISSN: 2320 – 7051

Int. J. Pure App. Biosci. **6 (6):** 1210-1217 (2018)

Short Communication

International Journal of Pure & Applied Bioscience

OPEN ACCESS

Effect of Various Concentrations of Salicylic Acid on Germination, Nitrate Reductase Activity and Nitrate Content of Rice Varieties HUBR 10-9 and HUR 105

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Received: 22.10.2018 | Revised: 28.11.2018 | Accepted: 10.12.2018

ABSTRACT

In the present piece of work, rice genotypes HUBR 10-9 and HUR 105 were selected to see the effect of seed priming on germination of rice. Seeds of selected genotypes were primed with six different concentrations of salicylic acid. Some selected parameters like germination percentage, α amylase activity, soluble and insoluble sugar content, nitrate reductase activity and nitrate content were found to improve with priming treatments in respect to non primed control set. It has been observed that 0 .75 mM salicylic acid were found best for the studied parameters except insoluble sugar in respect to other concentrations as well as non primed control sets in both the varieties.

Key words: *α Amylase activity; Nitrate reductase activity; Nitrate content.*

INTRODUCTION

Seed priming technology offers a number of beneficial effects to agriculture sector. Seed priming is used to improve germination, reduces the duration of germination and improves plant establishment in field and finally yield of many important crops. Fast and uniform emergence under field conditions are important to achieve maximum yield and quality, priming makes it. One of the short-term and most pragmatic approaches to overcome poor crop establishment and water-stress effects in direct seeded rice (DSR) is seed priming, which involves partial hydration to a point where germination-related metabolic processes begin, but radical emergence does not occur. Seed priming in mustard (*Brassica juncea* cv. Kranti), with solution of nitrate salts [(Mg $(NO_3)_2$, Ca $(NO_3)_2$ and KNO_3)] and distilled water; represented that nitrate treatments significantly increase plant height, number of leaves per plant, leaf area, leaf area index and net assimilation rate as compared to distilled water in normal as well as late sowing condition. The plant growth regulators (PGRs) like kinetin, GA, Salicylic acid, Brassinosteroids and Jasmonic acid are also used as seed primers and noted to improve germination, growth and development, stress ameliorating characters and grain yield.

Cite this article: Kumar, M., Singh, R.P. and Bose, B., Effect of Various Concentrations of Salicylic Acid on Germination, Nitrate Reductase Activity and Nitrate Content of Rice Varieties HUBR 10-9 and HUR 105, *Int. J. Pure App. Biosci.* **6(6):** 1210-1217 (2018). doi: http://dx.doi.org/10.18782/2320-7051.7285

Lee *et al*.[11] found that GA_3 and kinetin treatments were most effective for improving the emergence rate of rice. Primed seeds of wheat usually exhibit increased germination rate, greater germination uniformity, and sometimes greater total germination percentage[13]. Therefore on the basis of above in present work screening of the used salicylic acid was done to find out the best suitable concentration for priming purpose of rice seeds by analyzing the germination related physiological and biochemical parameters.

MATERIAL AND METHODS

The study regarding germination was carried out in the seed priming Laboratory of Department of Plant Physiology, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. For the screening of salicylic acid best concentration, seeds primed with six different concentrations (0.5, 0.75, 1, 1.5, 2 and 2.5 mM) and the best concentration 0.75mM concentration of salicylic acid was selected on the basis of germination study. Petri dish technique was introduced to carry out the germination studies. Petri dishes having 3.0 inches diameter were used for experimental purpose. Water and alcohol were used to wash and sterilize the petri dishes respectively and that was followed by autoclaving and oven drying. Whatman no.1 filter paper was used in the petri dishes during germination. On the filter paper a thin layer of cotton was placed in petri dishes. Twenty primed seeds were placed equidistantly in each petri dish. The control nonprime seeds were also sterilized and placed in the same way in petri dish. Each petri dish provided with 5 mL of distilled water containing primed and non primed seeds. After that all these petri dishes were kept at room temperature in the laboratory. Germination percentage and vigor index were calculated by the using following formula

$$\textbf{Germination \%} = \frac{\text{No.of seeds germinated}}{\text{No.of seeds present in petridish}} \times 100$$

Vigor index = germination % × Dry wt. of seedling

Dry weight of seedling: Dry weight of seedlings were taken by the help of weighing machine for this sample were kept in preset oven at 100-110°C for killing purpose after that it was placed at 60±2°C till to get stable weight.

Biochemical parameters:

A - amylase activity of rice endosperm was estimated by the method of Bernfeld[5]. Method of Dubios *et al*.[8] was used for estimation of soluble and insoluble sugar content in the rice endosperm of germinating seeds. The activity of nitrate reductase enzyme and nitrate content of endosperm, collected from germinating rice seeds, were determined by the method of Srivastava[17] and Cataldo *et al*.[6] respectively.

Statistical Analysis

Experiment was carried out under Factorial Completely Randomized Design (CRD) and significance was tested by f test[7].

RESULT

Germination Percentage (%):

Table 1 depicted the data of germination percentage of non primed(T_1) and salicylic acid(T_2) primed seeds having different concentrations [C_1,C_2,C_3,C_4,C_5 and C_6 represented 0.5, 0.75, 1, 1.5, 2 and 2.5 mM concentrations of salicylic acid]; this study was done at 18, 24, 36, 48 and 60h during germination. Maximum germination percentage was found in T_2C_2 set in respect to others concentration of salicylic acid as well as non primed control (T_1) in both the varieties. However variety V_1 showed more germination % as compared to variety V_2. The data was found statistically significant.

Vigor index:

Data (Table-2) regarding vigor index of rice seedling depicted that seed primed with salicylic acid showed more vigor index over non primed control one and maximum vigor index was noted in set T_2C_2. However variety

V_2 exhibit more vigor index as compared to variety V_1. The data was found statistically significant for most of the factors.

α- amylase activity(µg maltose h^{-1} g^{-1} FW)

Table-3 represented α-amylase activity, determined at 72 and 96 h in endosperm of seeds. The α- amylase activity was found more at 72 h as compared to 96 h endosperm of germinating seeds and highest α-amylase activity was noted in set T_2C_2. In between varieties, V_1 showed more α- amylase enzyme activity compare than V_2. Factor T and C were found statistically significant at each studied hours.

Soluble and insoluble sugar(mg g^{-1}dw)

Soluble and insoluble sugar contents were determined in endosperm of seeds, obtained from non primed (T_1) and salicylic acid (T_2) primed seeds (Table-4). Soluble sugar content was noted to raise with rising time of germination but a decrement noticed at same period in the contents of total insoluble sugar. Data depicted that salicylic acid primed set T_2C_2 have more soluble content over other used concentration of salicylic acid as well as non primed set at both the studied hours i.e. 72 and 96. The trend was found similar in both varieties. However reduction in insoluble sugar content was noted with the increasing hours of germination in both primed and non primed sets. It was also noted that use of salicylic acid primed seeds (T_2C_2) significantly improved the degradation rate of insoluble sugar, resulted a reduction in its amount in endosperm during germination over all used concentrations of salicylic acid and non primed control (T_1) set. Variety V_2 showed more insoluble sugar content in comparison to V_1 variety. The trend was found similar for both varieties at each studied hours i.e. 72 and 96. Data was found statistically significant for each studied hours.

Nitrate reductase activity

Data regarding nitrate reductase has been presented in table:5; the data was recorded at 96 h in endosperm of germinating rice seeds. Data depicted that activity of nitrate redutase was found more in primed sets over non primed control set and maximum nitrate redutase activity were noted in salicylic acid (T_2C_2) over all used concentrations of salicylic acid and non primed control set. However variety V_2 showed less nitrate reductase activity compare than variety V_1. All the studied factors were found statistically significant.

Nitrate content

Table-6 represents nitrate content, recorded at 96 h in endosperm of seeds. Data reflected that primed sets have more nitrate content over non primed control and maximum nitrate content was recorded in salicylic acid (T_2C_2) over all used concentrations of salicylic acid and non primed control set. Same trend was found in both varieties. However variety V_2 showed less nitrate content compare than variety V_1. All the studied factors were found statistically significant.

DISCUSSION

In the present piece of work, the best suitable concentrations of salicylic acid were determined for rice seed priming using a number parameters of germination. During the study of germination percentage (Table 1.) it was recorded that salicylic acid primed sets have best results over non primed set at different studied hours. Data regarding vigor index also revealed similar pattern (Table- 2). This may appear due to enhanced mobilization of stored substance from endosperm to embryo at the time of germination in the primed seeds, which may be inducted or operative with enhanced activity of hydrolytic enzyme α-amylase. In the present occasion also the activity of α-amylase and soluble sugar contents (Table 3 and 4) in sprouting rice seeds were found to enhance in primed sets exclude insoluble sugar; a decrement in insoluble sugar content was found in primed sets at studied periods for used salicylic acid, indicated the higher rate of hydrolysis of the stored carbohydrate. Data depicted that 0.75 mM concentration of salicylic acid was found prominent for both the varieties. α –amylase enzyme plays an important role in hydrolyzing stored starch during germination[2]. In the endosperm of grain seeds, starch occurs in the form of major reserved food, so starch

hydrolysis provides essential soluble sugars in the germinating seeds which either work as substrates for respiration or change into sucrose, retranslocate towards growing embryo before the onset of photosynthesis. Hussein[10], stated that seed priming with salicylic acid enhanced germination percentage, germination speed index (GSI), seedling vigour index (SVI) and relative growth rate of okra. Seed treatment with salicylic acid improved emergence rate, emergence percentage, chlorophyll band, protein content by 130%, 82.0%, 7.9% and 1.9%, respectively, in comparison to the control set in sweet sorghum[14]. Mondal and Bose[13] observed that wheat seeds while primed either with distilled water or with $Ca(NO_3)_2$ improve the germination due to the activation/ induction of the important hydrolyzing enzyme, α –amylase. Further a possible correlation was confirmed between α –amylase activity and soluble sugar by Anaytullah and Bose[3], using primed seeds of wheat, germinating under different temperature regime.

Data regarding nitrate reductase and nitrate content in seeds during 96h of germination has been presented in table 5 and 6 respectively. The result depicted that activity of nitrate redutase was more in primed sets over non primed control set and maximum nitrate redutase activities were noted in salicylic acid (T_5C_2) as compared to used concentrations of treatments and non primed control set. However, variety V_2 showed less nitrate reductase activity as compared to variety V_1. Maximum nitrate content was found to be present in the germinating seeds of salicylic acid. Adkins *et al*.[1] working on *Avena fatua* L. and reported that nitrate and nitrite act as electron accepters may induce the seed germination. The similar result was reported by Anwar *et al*.[4] and Kumar *et al*. in rice and sesame crop respectively. Salicylic acid primed seeds also enhanced the activity of nitrate reductase in germinating seeds, which might be due to the thermogenic nature of salicylic acid itself; salicylic acid seed priming may increase the temperature in seed during germination of rice which in turn may be appropriate for the activity of nitrate reductase enzyme. However it may be the 1st report where application of salicylic acid enhances the nitrate reductase activity of germinating seeds of rice.

Table 1: Effect of Salicylic acid priming on germination percentage of seeds of rice varieties at different hours (h) of germination

Treatments	Germination %														
	18h			24h			36h			48h			60h		
	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_1	32.67	33.33	33.00	72.00	70.33	71.17	93.00	82.33	87.67	85.00	85.67	85.33	95.11	79.44	87.28
T_2C_1	**47.67**	**48.00**	**47.83**	**80.33**	**65.33**	**72.83**	**93.33**	**86.33**	**89.83**	**94.33**	**88.00**	**91.17**	**96.44**	**90.00**	**93.22**
T_2C_2	44.00	37.67	40.83	71.67	72.00	71.83	93.33	85.33	89.33	93.00	80.67	86.83	95.11	82.78	88.94
T_2C_3	44.67	31.33	38.00	79.67	47.33	63.50	89.67	80.33	85.00	88.67	77.33	83.00	90.78	79.33	85.06
T_2C_4	40.33	19.33	29.83	75.00	38.67	56.83	88.00	77.33	82.67	88.00	79.33	83.67	90.00	81.33	85.67
T_2C_5	33.33	11.67	22.50	72.67	42.67	57.67	92.00	66.67	79.33	91.67	84.67	88.17	93.56	86.78	90.17
T_2C_6	32.67	33.33	33.00	72.00	70.33	71.17	93.00	82.33	87.67	85.00	85.67	85.33	95.11	79.44	87.28
Mean	38.33	34.86		70.29	57.86		87.24	81.24		88.67	84.52		91.87	85.41	

TABLE OF C.D. AND SEM

Particulars	18h		24h		36h		48h		60h	
	C.D.	SEm(±)	C.D.	SEm(±)	C.D.	SEm(±)	C.D.	SEm(±)	C.D.	SEm(±)
Factor(V)	0.78	0.28	0.66	0.24	0.97	0.35	0.69	0.25	0.70	0.25
Factor(T)	2.47	0.88	2.10	0.74	3.07	1.09	2.18	0.78	2.22	0.79
V X T	3.50	1.24	2.97	1.05	4.35	1.54	3.09	1.10	3.14	1.11
Factor(C)	1.47	0.52	1.22	0.43	1.78	0.63	1.28	0.45	1.35	0.37
V X C	2.08	0.73	1.72	0.60	2.53	0.89	2.16	0.64	2.21	0.78
TX C	2.55	0.90	2.10	0.75	3.09	1.09	2.22	0.79	2.28	0.81
V X T X C	3.60	1.28	2.96	1.05	4.37	1.55	3.14	1.11	3.20	1.63

Where (1): V_1= HUBR-10-9, V_2= HUR-105 rice varieties
(2): T_1 and T_2 are non primed and Salicylicacid primed seeds respectively
(3): C_1,C_2,C_3,C_4,C_5 and C_6 are different concentrations (0.5, 0.75, 1,1.5, 2 and 2.5 mM) of Salicylic acid
(4) CD at 5%

Table 2: Effect of Salicylic acid priming on vigour index of rice varieties at different hours (h) of germination/seedling growth

Treatments	Vigor index								
	24h			36h			48h		
	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_1	1.02	1.27	1.15	1.47	1.58	1.52	1.74	1.76	1.75
T_2C_1	1.11	1.27	1.19	1.81	1.93	1.87	1.97	2.04	2.01
T_2C_2	**1.63**	**1.80**	**1.72**	**1.87**	**2.04**	**1.95**	**2.22**	**2.24**	**2.23**
T_2C_3	1.54	1.72	1.63	1.85	2.05	1.95	2.18	2.25	2.22
T_2C_4	1.35	1.53	1.44	1.79	1.94	1.87	2.12	2.16	2.14
T_2C_5	1.30	1.44	1.37	1.88	2.60	2.24	2.09	2.10	2.09
T_2C_6	1.24	1.34	1.29	2.43	2.11	2.27	2.16	2.20	2.18
Mean	1.31	1.48		1.87	2.04		2.07	2.11	

TABLE OF C.D. AND SEM

Particulars	24h		36h		48h	
	C.D.	SEm(±)	C.D.	SEm(±)	C.D.	SEm(±)
Factor(V)	N/A	0.02	0.12	0.04	N/A	0.01
Factor(T)	0.22	0.08	0.37	0.13	0.09	0.03
V X T	N/A	0.11	N/A	0.19	N/A	0.05
Factor(C)	0.11	0.04	0.08	0.03	0.06	0.02
V X C	N/A	0.06	N/A	0.04	N/A	0.03
TX C	N/A	0.07	N/A	0.05	0.09	0.03
V X T X C	0.27	0.16	N/A	0.07	N/A	0.05

Note: Detail of the conditions has given in table 1.

Table 3: Effect of Salicylic acid priming on α- amylase activity of endosperm of rice varieties at 72 and 96 hours (h) of germination

Treatments	**α- amylase (µg maltose h^{-1} g^{-1} FW)**					
	72h			96h		
	V_1	V_2	Mean	V_1	V_2	Mean
T_1	0.181	0.212	0.196	0.085	0.087	0.086
T_2C_1	0.214	0.200	0.207	0.096	0.090	0.093
T_2C_2	**0.218**	**0.236**	**0.227**	**0.116**	**0.102**	**0.109**
T_2C_3	0.195	0.229	0.212	0.105	0.083	0.094
T_2C_4	0.187	0.220	0.203	0.099	0.094	0.096
T_2C_5	0.179	0.144	0.162	0.092	0.087	0.089
T_2C_6	0.173	0.136	0.156	0.089	0.083	0.086
Mean	0.192	0.197		0.097	0.089	

TABLE OF C.D. AND SEM

Particulars	72h		96h	
	C.D.	SEm(±)	C.D.	SEm(±)
Factor(V)	N/A	0.005	0.005	0.002
Factor(T)	0.046	0.016	0.015	0.005
V X T	N/A	0.023	N/A	0.008
Factor(C)	0.035	0.010	0.009	0.003
V X C	N/A	0.014	N/A	0.004
TX C	N/A	0.017	N/A	0.005
V X T X C	N/A	0.024	N/A	0.008

Note: Detail of the conditions has given in table 1.

Table 4: Effect of Salicylic acid priming on soluble and insoluble sugar contents of endosperm of rice varieties at 72 and 96 hours (h) of germination

Treatments	Sugar(mg g^{-1}dw)											
	Soluble						Insoluble					
	72h			96h			72 h			96h		
	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_1	0.197	0.144	0.170	0.230	0.202	0.216	0.415	0.453	0.434	0.313	0.315	0.314
T_2C_1	0.187	0.198	0.193	0.223	0.211	0.217	0.421	0.455	0.438	0.260	0.298	0.279
T_2C_2	**0.218**	**0.224**	**0.221**	**0.266**	**0.248**	**0.257**	**0.344**	**0.379**	**0.362**	**0.266**	**0.249**	**0.258**
T_2C_3	0.195	0.236	0.215	0.264	0.245	0.254	0.347	0.410	0.378	0.269	0.270	0.269
T_2C_4	0.179	0.199	0.189	0.245	0.238	0.242	0.365	0.389	0.377	0.271	0.283	0.277
T_2C_5	0.173	0.185	0.179	0.242	0.235	0.238	0.385	0.429	0.407	0.285	0.291	0.288
T_2C_6	0.181	0.154	0.167	0.205	0.194	0.200	0.394	0.431	0.413	0.264	0.297	0.281
Mean	0.190	0.191		0.239	0.225		0.382	0.421		0.275	0.286	

TABLE OF C.D. AND SEM

Particulars	Soluble				Insoluble			
	72h		96h		72h		96h	
	C.D.	SEm(±)	C.D.	SEm(±)	C.D.	SEm(±)	C.D.	SEm(±)
Factor(V)	0.015	0.005	0.006	0.002	0.002	0.001	0.001	0.001
Factor(T)	0.047	0.017	0.019	0.007	0.007	0.002	0.003	0.005
V X T	0.031	0.023	0.039	0.010	0.01	0.004	0.004	0.008
Factor(C)	0.027	0.010	0.016	0.006	0.028	0.010	0.025	0.009
V X C	N/A	0.013	N/A	0.008	N/A	0.014	N/A	0.013
TX C	N/A	0.017	N/A	0.010	N/A	0.017	N/A	0.016
V X T X C	N/A	0.023	N/A	0.014	N/A	0.024	N/A	0.022

Note: Detail of the conditions has given in table 1.

Table 5: Effect of Salicylic acid priming on nitrate reductase (NRA) activity in endosperm of rice varieties at 96 hours (h) of germination

Treatments	NRA at 96hrs (n mol NO_2^- h^{-1} g^{-1} FW)		
	V_1	V_2	Mean
T_1	20.37	18.1	19.23
T_2C_1	21.57	19.3	20.43
T_2C_2	**34.27**	**32**	33.13
T_2C_3	34.07	31.8	32.93
T_2C_4	32.97	30.7	31.83
T_2C_5	23.47	21.2	22.33
T_2C_6	21.37	19.1	20.24
Mean	26.87	24.60	

TABLE OF C.D. AND SEM

Particulars	96h	
	C.D.	SEm(±)
Factor(V)	1.026	0.364
Factor(T)	3.243	1.15
V X T	N/A	1.626
Factor(C)	1.901	0.674
V X C	N/A	0.954
TX C	3.293	1.168
V X T X C	N/A	1.652

Note: Detail of the conditions has given in table 1.

Table 6: Effect of Salicylic acid priming on nitrate content in endosperm of two varieties of rice at 96 hours (h) during germination

Treatments	Nitrate content at 96hrs (µg g^{-1} FW)		
	V_1	V_2	Mean
T_1	36.81	32.36	34.58
T_2C_1	36.47	34.31	35.39
T_2C_2	**49.83**	**48.56**	**49.19**
T_2C_3	44.51	43.25	43.88
T_2C_4	42.49	41.01	41.75
T_2C_5	40.51	39.15	39.83
T_2C_6	34.52	32.67	33.59
Mean	40.73	38.76	
TABLE OF C.D. AND SEM			
Particulars	C.D.	SEm(±)	
Factor(V)	0.40	0.14	
Factor(T)	1.27	0.45	
V X T	N/A	0.64	
Factor(C)	0.73	0.26	
V X C	N/A	0.36	
TX C	N/A	0.44	
V X T X C	N/A	0.63	

Note: Detail of the conditions has given in table 1.

CONCLUSION

The study comprised of screening of best suitable concentration for priming purpose, various concentration of salicylic acid were used and on the basis of % germination, vigor index, sugar metabolism (α-amylase activity, soluble and insoluble sugar contents), nitrate reductase activity and nitrate content in endosperm it has been concluded that 0 .75 mM salicylic acid were found best for the studied parameters.

REFERENCES

1. Adkins, S.W., Simpson, G.M. and Naylor, J.M., The physiological basis of seed dormancy in Avena fatua IV. Alternative respiration and nitrogenous compounds. *Physiologia plantarum*, **60(2):**234-238 (1984).
2. Akazawa, T., Hara-Nishimura, I., Topographic aspects of biosynthesis, extracellular secretion, and intracellular storage of proteins in plant cells. *Annual review of plant physiology*, **36(1)**: 441-472(1985).
3. Anaytullah, Bose.B., Nitrate-hardened seeds increase germination, amylase activity and proline content in wheat seedlings at low temperature. *Physiol Mol Biol Plants*, 1**3:**199-207(2007).
4. Anwar, S., Iqbal, M., Raza, S.H. and Iqbal, N., Efficacy of seed preconditioning with salicylic and ascorbic acid in increasing vigor of rice (Oryza sativa L.) seedling. *Pak. J. Bot*, **45(1)**: 157-162(2013).
5. Bernfeld, P., [17] Amylases, α and β. (1955).
6. Cataldo, D.A., Maroon, M., Schrader, L.E. and Youngs, V.L., 1975. Rapid colorimetric determination of nitrate in plant tissue by nitration of salicylic acid. *Communications in soil science and plant analysis*, **6(1)**:71-80.
7. Chandel, S.R.S., A Hand Book of agricultural Statistics, Achal Publication Kanpur, India, 3rd ed. (1984).
8. Dubois, M., Gilles, K.A., Hamilton, J.K., Rebers, P.T. and Smith, F., Colorimetric method for determination of sugars and related substances. *Analytical chemistry*, **28(3)**: 350-356 (1956).
9. Farooq, M., S.M.A, B., Tabassum, R., Afzal, I., Enhancing the performance of direct seeded fine rice by seed priming. *Plant Production Science*, **9(4)**: 446-456 (2006).

10. Hussein, H.J., Effect of seed priming treatment with salicylic acid on viability of okra (Abelmoschus esculentus L.) seeds. *Euphrates Journal of Agriculture Science*,**7(2)**: 1-9. (2015).
11. Lee, S.S., Kim, J.H. and Hong, S.B., Effects of priming and growth regulator treatment of seed on emergence and seedling growth of rice. *Korean Journal of Crop Science*, **44(2)** :134-137 (1999).
12. Kumar, S., Bose, B. and Pradhan, N., Potassium nitrate priming affects the activity of nitrate reductase and chlorophyll content in late sown sesame (*Sesamum indicum* L.). *Trends in Biosciences*, **7(24)** :4466-4470 (2014).
13. Mondal. S, Bose, B., Kinetics studies on α-amylase extracted from germinating wheat endosperm of primed and non-primed seeds. *Indian Journal of Agricultural Biochemistry*, **25**:137-141(2012)
14. Nimir, N.E.A., Lu, S., Zhou, G., Guo, W., Ma, B., Wang, Y., Comparative effects of gibberellic acid, kinetin and salicylic acid on emergence, seedling growth and the antioxidant defence system of sweet sorghum (Sorghum bicolor) under salinity and temperature stresses. *Crop and Pasture Science*, **66(2)**:145-157 (2015).
15. Pandey, D.,Bose, B., Influence of pre-sowing seed treatment with nitrate salts and different sowing dates on performance of mustard. *Indian Journal of Plant Physiology*, **11(3)**:261 (2006).
16. Purohit, S.D., Nagori, R., Sharma, P., Bizzare role of salicylic acid in plants. *Everyman's Science*, **4**: 241-246 (2016).
17. Srivastava, A.K. and Bose, B., Impact of Seed Hardening Treatment with Nitrate Salts on Nitrogen and Anti Oxidant Defense Metabolisms in Triticum aestivum L. Under Different Sowing Conditions. *Vegetos: An International Journal of Plant Research*, **25(1)**: 292-299 (2012).
18. Srivastava, H.S., In vivo activity of nitrate reductase in maize seedlings. *Indian journal of biochemistry*, (1974).