Research Article

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Indole-acetic acid oxidase enzyme activity in three wheat cultivars under salt stress conditions at the early seedling stage

Abstract

Indole-acetic acid enzyme activity in three wheat cultivars differing in their salt response was studied at the early seedling stage. It was found that the IAA oxidase enzyme activity gradually decreased with increasing EC levels in both the salt-sensitive cultivar IWP-72 and moderately salt-tolerant cultivar Sharbati sonora while in the tolerant cultivar HD-2160 the enzyme activity increased till 96 hours up to 12 EC while at 120hours at all EC levels the activity decreased. The magnitude was, however, higher in the salt-sensitive cultivar. The IAA oxidase activity increased with advancement in seedling age but the degree of increase varied with the cultivars. Whereas in the tolerant and moderately tolerant cultivars a sharp increase was observed at 72 and 96hours which later declined at 120hours, on the other hand, in the sensitive cultivar it increased from 24hours reaching a peak level at 120hours. Also from the observations it is noticed that IAA oxidase enzyme activity was affected more in the salt-sensitive cultivar (IWP-72) as compared with the moderately salt-tolerant (Sharbati sonora) and the salt-tolerant cultivar (HD-2160).

Keywords: wheat (*triticum aestivum* L), NaCl salt stress, Salt-tolerant cultivar (HD-2160), moderatety salt-tolerant cultivar (Sharbati sonora), salt-sensitive cultivar (IWP-72), IAA oxidase enzyme activity

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Ravi Sharma

Department of Post-graduate Studies, K R College Mathura, India

Correspondence: Ravi Sharma, Department of Post graduate studies, KR College Mathura, India, Email drravisharma327@yahoo.com

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Introduction

Plant germination and growth is regulated by the balance of plant hormones such as IAA, GA, CK etc.,[1–5] and any disturbance in the balance of plant hormones retard the plant growth in which IAA plays a predominant role whose level, of course, is maintained endogenously by the enzyme activity of IAA oxidase.[4–6] Several workers[7–22] have shown genotypic variation among the same species of crop plants in relation to salt stress. In the present work an attempt has been made to find out a relationship existing between salt tolerance and sensitivity with IAA oxidase enzyme activity, if any, in three cultivars of wheat, *salt-tolerant* (HD-2160), *moderately salt-tolerant* (Sharbati sonora) and *salt-sensitive* (IWP-72). Thus, the objective of the study is to correlate relationship between salt tolerance and IAA oxidase enzyme activity.

Materials and methods

Forty two wheat cultivars (*Triticum aestivum* L) procured from Wheat Directorate, Cummings Laboratory, Division of Genetics and Plant Breeding, Indian Agricultural Research Institute, New Delhi and Chandra Sekhar Azad University of Agriculture and Technology, Kanpur (UP), India[22] were subjected to screening for salt resistance by Garrad's Technique[23] modified by Sarin et al.,[24] and Sharma[8,22] and as per method of Sheoran et al.,[25] The shoot and root lengths of seedlings were recorded at definite interval of 24hours using test tubes of uniform size (30ml capacity) fitted with rolls of filter paper folded at the top into a cone to support the seeds. The tubes were filled to one-third part with the test solutions so that the solution might not come in direct contact with the growing roots and to ensure that the salt solution being supplied to the roots through capillary action of the filter paper. Distilled water (represented the mean loss of water from the blanks) was added to each test tube after every 24hours of interval in order to maintain salt concentration near the target levels throughout the germination period. The seeds were initially sterilized with 0.1 percent mercuric chloride ($HgCl_2$) solution and later washed thoroughly with distilled water. Three seeds per tube were then transferred to the edge of the filter paper cone and were allowed to grow between the filter paper roll and the wall of the test tube in dark growth chamber at 25±20C. Fifteen replicates (five tubes each having three seeds) were maintained for each treatment including the controls (half-strength Hoagland solution grown). Observations on the influence of salinity levels at 4, 8, 12 and 16 EC dsm^{-1} of salt solution and the controls on the total length of shoot and root at early seedling stage were recorded at 24hour intervals from 48 hours after sowing up to the end of 120hours under green safe light. The relative tolerance of different cultivars was evaluated on the basis of the percentage reduction in shoot growth at 12 EC.[22]

Three selected cultivars *viz*., *salt-tolerant* (HD-2160), *moderately salt-tolerant* (Sharbati Sonora) and *salt-sensitive* (IWP-72) from the entire screening were studied for IAA oxidase enzyme activity under salt-stressed conditions. The seeds were germinated and seedlings grown in sterilized petridishes on moistened filter paper kept in a dark growth chamber at 25±20C. The 'treated sets' contained the salt (NaCl) solution at different EC (4, 8, 12 and 16) levels and the 'controls' half-strength Hoagland solution. Samples were collected at 24hour intervals from 48hours after sowing up to the end of 120hours. The seedlings were raised according to the method described previously[4,26] and IAA oxidase enzyme activity was determined according to Rabin et al.,[27] technique as described by Witham *et al*.,[28] and Sharma *et al*.,[4] The enzyme assay was conducted in cold room. One g of the seedlings was homogenized with 10 ml of cold distilled water in a chilled mortar. The slurry was passed through a layer of cheese cloth. The filtrate thus obtained was centrifuged at 10,000rpm for 15minutes. To the supernatant excess of acetone was added so that the final acetone concentration was brought to 40 percent by volume. It was centrifuged at 1,000 rpm for 15minutes. After discarding the supernatant the pellet of precipitate was re-suspended in 4ml of 0.2M phosphate citrate buffer (pH 5.6)* containing 0.5ml10-4M $MnCl_2$ and 0.5ml 10-3M 2,4 dichlorophenol. The precipitate was shaken vigorously to dissolve it and the resulting solution was used as enzyme preparation. The reaction mixture containing 2 ml of the enzyme preparation, 7ml of 0.2M phosphate citrate buffer (pH 5.6) and 1ml of indole-acetic acid (200µg/ml) was incubated for one hour at 300C. After incubation residual IAA was estimated by taking 1ml of the reaction mixture and adding 4ml Salkowski reagent and was left to stand for 30minutes at room temperature. Pink colour of IAA was read at 540nm against a reagent blank. The results are expressed as *µg IAA destroyed per g fresh wt per hr*.

*Phosphate citrate buffer (0.2M pH 5.6): was prepared from-**A**. 19.21g citric acid dissolved in 1000ml of distilled water; **B**. 53.65g sodium hydrogen phosphate ($Na_2HPO_4.7H_2O$) dissolved in 1000 ml of distilled water. Working Solution was prepared by mixing 21.0ml of solution **A** with 29.0 ml of **B** diluted to a total of 100ml and adjusted pH to 5.6. All parameters were analyzed by ‘Analysis of Variance’ (ANOVA) method as given by Panse et al.,[29]

Results

Wheat seedling growth

In the screening of the forty two wheat cultivars for salinity tolerance at the early seedling stage shoot and root lengths under varying salinity levels (0, 4, 8, 12 and 16 dsm^{-1}) induced by NaCl were observed. In the ANOVA analysis all the main effects *viz*., variety (V), treatment (T) and seedling age (D) and their interactions (Vx D;V x T; D x T and V x D x T) were found to be highly significant at 0.01 probability with significant differences noticed in the shoot and root growths of all the cultivars studied.[22] With this, relative shoot and root growths of the cultivars showed that shoot growth was affected more as compared with root growth under salt stress. On the other hand, all the cultivars showed an increase in shoot and root growths with seedling age. It was evident that the different cultivars exhibited marked differences in their early seedling growth with increasing age of the seedling and that with advancement of seedling age the effect of salt declined and that, in general, tolerance to salinity increased (Figure 1). As indicated earlier[22] only 11 cultivars showed less than 60 percent reduction in shoot growth while majority of the 31 cultivars had more than 60 percent reduction at 16 EC. This is in contrast with root growth where almost a reverse trend was noticed, i.e., out of the 42 cultivars only 15 showed more than 60 percent reduction at 16 EC whereas 27 had less than 60 percent reduction (Table 1). The observations recorded clearly indicated that the shoot is more sensitive to salt stress than the root and that shoot growth is a better index of relative salt tolerance of different cultivars of the same species at early seedling stage with this also 12 EC salinity level was found to be a critical level for majority of the cultivars. Thus, on the basis of the percent reduction in shoot growth at 12 EC level over respective control all the cultivars were categorized into three groups, *viz*., *salt-tolerant*, *moderately salt-tolerant* and *salt-sensitive*, showing less than 40%, 40–60% and more than 60% reduction respectively (Table 2).

Further, the different rates of shoot growth of the three groups as affected by increasing level of salinity showed a gradual decline in both the salt tolerant and moderately salt–tolerant cultivars. On the other hand, the salt–sensitive cultivars had a sharp decline in growth with increasing salt concentrations. With this the relative comparison of seedling growth between three wheat cultivars studied indicated better performance of HD–2160 (salt-tolerant) at almost all levels of salinity when compared with controls. It showed highest tolerance to salinity (i.e., 85.219 percent), IWP-72 (salt-sensitive) showing highest inhibition (i.e., only 7.818 percent) and Sharbati sonora (moderately salt-tolerant) showing (48.574) percent shoot growth at 12 EC over control (Figure 2).

It is evident from the Tables 3 and Table 4 that the IAA oxidase enzyme activity gradually decreased with increasing salt stress created by NaCl in both the salt-sensitive cultivar IWP-72 and moderately salt-tolerant cultivar Sharbati sonora while in the tolerant cultivar (HD-2160) the enzyme activity increased till 96hours up to 12 (dsm^{-1}) EC salinity level, but at 120hours at all EC levels the activity decreased, although, the magnitude of the enzyme activity was higher in the sensitive cultivar IWP-72. The IAA oxidase activity increased with advancement in seedling age with varying degree in the three cultivars. Whereas in the tolerant and moderately tolerant cultivars a sharp increase was observed at 72 and 96hours declining later at 120hours, on the other hand, in the sensitive cultivar enzyme activity increased from the very beginning at 48hours reaching peak level at 120 hours. Also from the observations it is noticed that IAA oxidase enzyme activity was affected more in the salt-sensitive cultivar (IWP-72) as compared with the moderately salt-tolerant (Sharbati sonora) and the salt-tolerant cultivar (HD-2160). As shown in the Table 5 in the three cultivars there is direct correlation found in the shoot growth, root growth and IAA oxidase enzyme activity as with increasing salt concentration there is decrease in root and shoot growth and also the enzyme activity. On the other hand, with seedling age as the root and shoot growth increased the IAA oxidase activity also increased but till 96hours and at 120hours it slightly declined (Table 6).

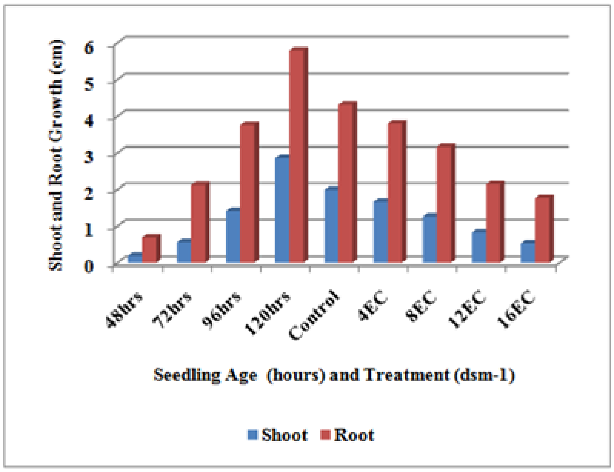

Figure 1 Relative shoot and root growths of certain wheat (*Triticum aestivum* L) Cultivars under salt stress at the early seedling stage (Sharma, 2015).

Table 1 Shoot and root growth of forty two wheat cultivars at different salinity levels

S.No	Cultivar	Shoot growth				Root growth			
		4EC	8EC	12EC	16EC	4EC	8EC	12EC	16EC
1	HD-2236	113.561**	56.847	11.491	5.599	111.150**	84.029	22.589	12.905
2	WL-410	113.259**	74.804	43.746	18.731	114.330**	92.463	75.146	47.188
3	*Sharbati sonora	90.591	80.876	48.574	40.3	98.463	95.181	80.079	59.912
4	Moti	95.025	66.374	11.423	9.995	87.94	70.758	37.162	29.576
5	Sonalika	86.523	70.728	48.179	43.217	95.222	89.47	80.958	66.694
6	*HD-2160	95.135	91.113	85.219	82.6	94.623	83.76	77.584	71.188
7	HD-2135	73.548	52.043	35.555	9.892	81.956	65.602	43.14	28.569
8	IWP-503	80.606	59.617	29.346	13.939	93.087	80.71	60.972	31.834
9	HS-43	92.583	64.833	43.948	29.261	92.614	75.133	59.131	40.818
10	UP-262	78.452	59.844	28.956	8.15	85.716	66.802	44.781	26.168
11	HD-2177	79.002	58.31	28.527	6.716	109.224**	89.42	55.588	36.919
12	WG-1559	83.288	25.802	20.454	9.358	83.98	20.319	15.742	6.588
13	HD-2267	89.577	49.142	11.873	8.245	79.032	28.403	16.921	2.87
14	*IWP-72	82.921	39.094	7.818	5.144	84.874	48.701	14.736	5.826
15	HD-2282	95.6	89.584	57.47	35.213	95.272	93.368	65.889	56.434
16	WL-711	92.973	89.329	71.437	46.128	97.498	88.607	74.932	54.35
17	Raj-1482	96.668	71.829	38.573	32.378	96.239	78.587	48.426	44.231
18	HD-2260	77.059	72.661	70.284	22.894	92.593	89.221	77.579	40.201
19	WH-246	92.266	59.304	43.644	33.929	114.221**	77.774	56.468	49.96
20	WL-2200	62.53	112.53	46.654	35.279	84.951	105.439**	71.072	60.244
21	K-7634	96.841	92.545	80.353	52.179	85.271	90.808	80.487	59.321
22	Raj-1556	81.372	66.86	52.875	44.063	81.503	74.521	59.752	55.695
23	UP-154	90.714	75.952	60.714	49.523	91.303	86.454	75.083	68.645
24	HD-1977	83.333	54.973	43.01	40.456	88.177	54.75	48.064	41.449
25	WG-1558	94.865	71.393	43.276	35.207	130.566**	120.546**	65.282	43.319
26	HD-2204	65.638	76.945	42.878	34.948	77.622	91.666	62.237	55.594
27	WL-1531	90.816	84.081	71.02	33.061	91.401	79.841	66.907	40.895
28	K-7631	73.214	68.75	56.25	47.321	76.935	72.955	63.467	58.887
29	Raj-1409	69.243	46.546	38.98	17.708	81.585	59.013	44.596	27.941
30	Raj-1493	75.996	64.855	50.815	26.721	73.242	67.101	60.822	37.093
31	Raj-1494	44.152	39.379	28.353	11.217	58.24	42.093	35.408	22.251
32	WL-903	75.341	68.003	59.726	38.822	93.159	85.064	69.72	57.263
33	UP-171	82.361	60.073	17.195	14.612	80.992	59.594	38.173	28.072
34	HD-2275	83.125	64.034	25.738	17.329	79.938	64.834	43.078	37.768
35	HD-1593	30.959	45.903	27.746	14.944	44.547	56.477	34.855	20.465
36	HD-2252	106.760**	75.329	65.759	35.381	109.373**	76.631	71.436	42.741
37	HP-1303	86.174	56.969	54.166	39.09	79.185	68.89	67.294	42.038
38	UP-115	85.802	72.619	66.535	40.169	89.683	81.821	58.298	42.637
39	HD-1980	94.002	60.403	54.406	44.369	93.379	58.454	52.941	40.599
40	CC-464	57.12	51.009	46.866	24.08	72.834	69.253	61.864	47.878
41	HD-2009	88.962	60.902	57.321	39.097	83.056	69.413	63.068	50.406
42	Kharchia	69.192	49.329	43.035	30.542	90.201	70.451	65.195	55.269
	CD at 5% P=0.064 S.Em.±0.023						CD at 5% P=0.351 S.Em. ±0.126		

(Data expressed as percent over control) (Cultivars with asterisk* used in the present study) (Cultivars with ** showed stimulation observed in growth at moderate levels of salinity).

Citation: Sharma R. Indole-acetic acid oxidase enzyme activity in three wheat cultivars under salt stress conditions at the early seedling stage. *Adv Plants Agric Res.* 2016;4(1):215‒222. DOI: 10.15406/apar.2016.04.00123

Table 2 Relative tolerance of certain cultivars of wheat based on the percent reduction in shoot growth at 12 EC (dsm^{-1}) salinity level

Group I salt-tolerant (Less than 40% reduction)			Group II moderately salt-tolerant (40 – 60% reduction)		Group III salt-sensitive (more than 60% reduction)	
Wheat Cultivars	1. HD-2160*	85.219	1. WL-903	59.726	1. Raj-1409	38.98
	2. K-7634	80.353	2. HD-2282	57.47	2. Raj-1482	38.573
	3. WL-711	71.437	3. HD-2009	57.321	3. HD-2135	35.555
	4. WL-1531	71.02	4. K-7631	56.25	4. IWP-503	29.346
	5. HD-2260	70.284	5. HD-1980	54.406	5. UP-262	28.956
	6. UP-115	66.535	6. HP-1303	54.166	6. HD-2177	28.527
	7. HD-2252	65.759	7. Raj-1556	52.875	7. Raj-1494	28.353
	8. UP-154	60.714	8. Raj-1493	50.815	8. HD-1593	27.746
			9. Sharbati Sonora*	48.574	9. HD-2275	25.738
			10. Sonalika	48.179	10. WG-1559	20.454
			11. CC-464	46.866	11. UP-171	17.195
			12.WL-2200	46.654	12. HD-2267	11.873
			13. HS-43	43.948	13. HD-2236	11.491
			14. WL-410	43.746	14. Moti	11.423
			15. WH-246	43.644	15. IWP-72*	7.818
			16. WG-1558	43.276		
			17. Kharchia	43.035		
			18. HD-1977	43.01		
			19. HD-2204	42.878		

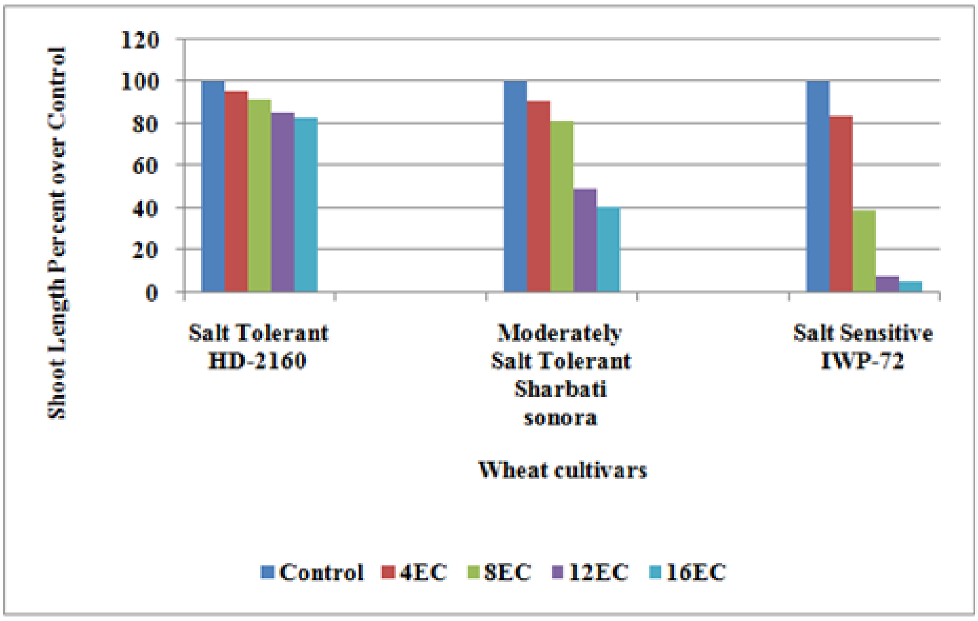

Figure 2 Relative salt tolerance of three groups (salt-tolerant, moderately salt-tolerant and salt-sensitive) Wheat (Triticum aestivum L) cultivars under salt stress at the early seedling stage (Data expressed as percent over control).

Table 3 Effect of different levels of salt stress (NaCl) exposure on shoot length, root length and IAA oxidase enzyme activity in three wheat cultivars

Variety	Treatment NaCl conc. (EC dsm^{-1})	Shoot length (cm)				Root length (cm)				IAA oxidase activity (µg IAA destroyed/g fresh wt/hr)			
		Duration (hours)				Duration (hours)				Duration (hours)			
		48hrs	72hrs	96hrs	120hrs	48hrs	72hrs	96hrs	120hrs	48hrs	72hrs	96hrs	120hrs
C1 HD-2160 (Salt-tolerant)	Control	0.27	0.49	0.95	2.56	1.14	2.3	3.7	7.36	224	262	262	248
	4 EC	0.27	0.41	0.85	2.53	0.96	2.18	3.68	6.9	240	248	312	220
	8 EC	0.25	0.41	0.84	2.39	0.78	2.05	3.57	5.75	281	292	292	232
	12 EC	0.23	0.39	0.83	2.19	0.68	1.89	3.19	5.49	262	278	286	224
	16 EC	0.23	0.37	0.78	2.15	0.62	1.5	2.9	5.3	232	250	256	198
C2 SHARBATI SONORA (Mod. Salt-tolerant)	Control	0.95	1.45	3.96	6.67	1.75	4.33	6.87	8.73	282	296	320	232
	4 EC	0.76	1.36	3.26	6.43	1.45	4.31	6.3	8.66	262	276	282	198
	8 EC	0.51	1.02	2.9	6.12	1.43	4.26	6.04	8.32	242	242	256	195
	12 EC	0.08	0.61	1.98	3.68	0.69	3.11	5.75	7.28	198	213	232	122
	16 EC	0.06	0.61	1.74	2.85	0.55	2.88	3.41	5.79	120	140	146	127
C3 IWP-72 (Salt-sensitive)	Control	0.38	1.05	2.86	5.42	1	2.65	4.66	8.14	240	290	320	356
	4 EC	0.3	0.94	2.2	4.62	0.71	2.5	4.45	6.3	202	218	230	290
	8 EC	0.2	0.36	1.12	2.12	0.41	1.65	2.54	3.4	188	226	240	272
	12 EC	0.12	0.16	0.2	0.28	0.1	0.25	0.65	1.42	122	134	218	218
	16 EC	0.1	0.12	0.12	0.16	0.04	0.12	0.22	0.58	90	120	204	218
SEm		±0.053				±0.065				±9.332			

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Table 4 Effect of different levels of salt stress (NaCl) exposure on shoot length, root length and IAA oxidase enzyme activity in three wheat cultivars (Data expressed as percent over control)

Variety	Treatment NaCl Conc. (EC dsm-1)	Shoot Length (cm)				Root Length (cm)				IAA oxidase activity(µg IAA destroyed/g fresh wt/hr)			
		Duration (hours)				Duration (hours)				Duration (hours)			
		48hrs	72hrs	96hrs	120hrs	48hrs	72hrs	96hrs	120hrs	48hrs	72hrs	96hrs	120hrs
C1	Control	0.27	0.49	0.95	2.56	1.14	2.3	3.7	7.36	224	262	262	248
HD-2160	4 EC	0.27	0.41	0.85	2.53	0.96	2.18	3.68	6.9	240	248	312	220
(Salt-tolerant)	8 EC	0.25	0.41	0.84	2.39	0.78	2.05	3.57	5.75	281	292	292	232
	12 EC	0.23	0.39	0.83	2.19	0.68	1.89	3.19	5.49	262	278	286	224
	16 EC	0.23	0.37	0.78	2.15	0.62	1.5	2.9	5.3	232	250	256	198
C2 SHARBATI SONORA	Control	0.95	1.45	3.96	6.67	1.75	4.33	6.87	8.73	282	296	320	232
(Mod. Salt-tolerant)	4 EC	0.76	1.36	3.26	6.43	1.45	4.31	6.3	8.66	262	276	282	198
	8 EC	0.51	1.02	2.9	6.12	1.43	4.26	6.04	8.32	242	242	256	195
	12 EC	0.08	0.61	1.98	3.68	0.69	3.11	5.75	7.28	198	213	232	122
	16 EC	0.06	0.61	1.74	2.85	0.55	2.88	3.41	5.79	120	140	146	127
C3	Control	0.38	1.05	2.86	5.42	1	2.65	4.66	8.14	240	290	320	356
IWP-72	4 EC	0.3	0.94	2.2	4.62	0.71	2.5	4.45	6.3	202	218	230	290
(Salt-sensitive)	8 EC	0.2	0.36	1.12	2.12	0.41	1.65	2.54	3.4	188	226	240	272
	12 EC	0.12	0.16	0.2	0.28	0.1	0.25	0.65	1.42	122	134	218	218
	16 EC	0.1	0.12	0.12	0.16	0.04	0.12	0.22	0.58	90	120	204	218
SEm		±0.053				±0.065				±9.332			

Table 5 Effect of Different Levels of Salt Stress (NaCl) Exposure on Shoot Length, Root Length and IAA Oxidase Enzyme Activity in Three Wheat Cultivars (TREATMENT

Treatment NaCl (EC dsm^{-1})	Shoot length (cm)	Root length (cm)	IAA oxidase activity (µg IAA destroyed/g fresh wt/hr)
Control	2.251	4.386	277.667
4 EC	1.994	4.033	248.167
8 EC	1.52	3.35	246.528
12 EC	0.896	2.542	208.917
16 EC	0.774	1.992	175.111
SEM	±0.015	±0.019	±2.694

SD, standard deviation; BMI, body mass index; WC, waist circumference; AC, abdominal circumference; HC, hip circumference; RER, respiratory exchange ratio; HR, hear rate

Table 6 Effect of different levels of salt stress (NaCl) exposure on shoot length, root length and IAA oxidase enzyme activity in three wheat cultivars (DURATION)

Duration (hours)	Shoot length (cm)	Root length (cm)	IAA oxidase activity (µg IAA destroyed/g fresh wt/hr)
48 hrs	0.314	0.821	212.333
72 hrs	0.65	2.399	232.333
96 hrs	1.639	3.862	257.067
120 hrs	3.345	5.961	223.378
SEM	±0.014	±0.017	±2.409

Discussion

One of the most common effects of salinity is stunting of growth often without any other sign of damage. This and other modifications of growth habit have suggested that growth hormones may be involved in the responses of plants to salinity.[30] Germinating seeds have been found to be rich sources of hormones such as IAA, GA, Kinins and some inhibitors also.[31–35] It has been observed that the salinity inhibits seedling growth and that the inhibition is directly correlated to the increase in salinity. To further understand this growth inhibition the pattern of hormonal regulation has been studied as IAA and GA contents along with the enzymes which regulate these systems.[5,8,7,36,37] Chen[3] suggested that these endogenous levels of plant hormones play a predominant role in growth regulation which depends upon the balance between the growth promoters [e.g., GA, Kinins etc.,] and the inhibitors [e.g., ABA or in some instances IAA]. It had been observed that with increasing salinity IAA oxidase activity increased in the tolerant cultivar, while it decreased in the sensitive cultivar. Also IAA oxidase activity increased with seedling age and reached a peak at 96 hours and later it declined, in the three cultivars. Verga et al.,[36] have also reported similar behavior of IAA oxidase activity during early seedling growth. Pilet et al.,[38] have observed that one of the mechanisms controlling growth *via* endogenous auxins is through enzymatic oxidations. IAA oxidase is regarded to oxidize the IAA, thereby controlling the endogenous level in the seedlings. Interestingly it was observed in the tolerant cultivar while the auxin-like promoters were highest at 24 hours the IAA oxidase activity was lowest (Table 6). On the other hand, the sensitive cultivar showed peak auxin levels at 48 hours it also exhibited a higher level of IAA oxidase. Therefore, it is likely that the reduction in auxin-like promoters observed in the present investigation as a result of salt stress is mediated through the enzyme IAA oxidase. Goyal et al.,[26] reported that IAA oxidase enzyme activity of the different cultivars of the same species is regulated by the specific gene in each cultivar, therefore, a genetic diversity was found in the growth behavior of the three cultivars differing in salt tolerance as well as in IAA oxidase enzyme activity. From our laboratory workers[7–22] have shown genotypic variation among the same species of crop plants in relation to salt stress as shown in the present work.

Conclusion

From the results presented, it appears that the growth under salt stress condition is mediated by endogenous IAA level at different state regulated by IAA oxidase enzyme system indirectly affecting metabolism. Thus, resulting in differential growth response of the three wheat cultivars *viz*., *salt-tolerant* (HD-2160), *moderately salt-tolerant* (Sharbati sonora) and *salt-sensitive* (IWP-72) in relation to salt stress and that the tolerance of a cultivar depends mainly on the endogenous IAA at the effective level.

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Conflict of interest

The author declares no conflict of interest.

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