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Effects of salinity on canopy structure, yield and yield attributes in wheat

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Abstract

A pot culture experiment was carried out in Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, during the period from November 2001 to March 2002 to investigate the effect of salinity stresses on canopy structure, yield and yield attributes of three varieties of wheat e.g. shotabdi, kanchan and gourob. The plants were subjected to grow under five salinity levels, 0.6 (control), 2.6, 5.2, 8.2 and 11.0 dSm^{-1} imposed by crude sodium chloride salt. Increasing salinity levels significantly decreased plant height, number of total tiller per hill, number of effective tiller per hill, length of spike, number of grain per spike, grain weight, straw yield, grain yield and harvest index compared to control. Salt tolerant capability varied among varieties and shotabdi was the best for canopy growth, yield and yield attributes over the rest. The per cent decrease of grain yield and harvest index were the highest in gourob, medium in kanchon and the lowest in shotabdi. Thus shotabdi was found salt tolerant variety than others.

Keywords: Salinity, Vegetative growth, Yield attributes, Wheat

Introduction

Wheat (*Triticum aestivum* L.) is the second staple food crop in Bangladesh. Total production of wheat in Bangladesh is 1.67 million metric tons (mt) from 1.9 millions hectares of lands with an average yield of 1.16 mt ha^{-1} (BBS, 2003). The average yield of wheat in Bangladesh is much lower than that of other wheat producing countries like India, Pakistan and USA, where yield was 2.77, 2.2 and 2.37 mt ha^{-1} respectively (FAO, 2002). To meet increasing demand, Bangladesh has been importing wheat grain every year. Increasing population pressure decreasing the cultivation area as well as total grain production and thus enhancing food shortage and land scarcity. Different attempts were made to improve the crop production but genetic potentiality has almost been attained in saturation in grain crops and therefore further genetically breakthrough is very difficult and expensive. Horizontal expansion of croplands is almost impossible, as it will hamper other crop production. Extension of cultivation area by utilizing saline-affected land is one of the prospects for Bangladesh. There are 2.85 million hectares of coastal and offshore areas in Bangladesh of which 0.833 millions are arable land (Karim *et al.*, 1990). This area is affected by varying degree of soil salinity and decreased agricultural land use seriously. As reclamation of saline soils is almost impossible, development or selection of salt tolerant crop species is one of the possible means for extension of cropping area.

Wheat is largely grown in winter season and comparatively more tolerant to salinity than rice. In selecting variety, wheat could be grown satisfactorily in the wide range of salinity up to 16 dSm^{-1} and thus 1.08 millions hectares of saline areas may be utilized in Bangladesh (Karim *et al.*, 1990). As a winter crop, wheat might be fitted in saline prone area and will enhance food grain production as well as cropping intensity in Bangladesh. To achieve the goal, selection of salt tolerant variety is a primary task and therefore, the present experiment was planned to estimate the salinity tolerant capability of some wheat varieties by evaluating their canopy growth, yield and yield attributes.

Materials and Methods

A pot culture experiment was carried out in Bangladesh Institute of Nuclear Agriculture (BINA) during winter season from November 2001 to March 2002. Each pot contained 8.0 kg of dried soil, belongs to the Sonatala series of the Agro-ecological zone Old Brahmaputra Flood plain (AEZ-9). The pH value, cation exchange capacity (CEC) and electrical conductivity (EC) of the soil were 6.44, 6.78 meq/100 g soil and 0.6 dSm^{-1} respectively. Wheat variety kanchan, shotabdi and gourob were used in the present study.

Preparation of Pots

Earthen pots of 24.5 cm diameter at the top, 14 cm at the bottom and 30 cm depth were used. Each pot was filled with 6 kg of sun dried and weeds free soil. A polythene lining was provided inside the pots and the plants were protected from rain by keeping polythene cover on the netting of the pot yard. The cowdung, N, P, K and S fertilizers were applied in each pot at the rate of 10 t/ha, 220 kg/ha, 180 kg/ha 150 kg/ha and 120 kg/ha respectively. The N, P, K and S fertilizers were applied in the form of urea, triple super phosphate, muriate of potash and gypsum respectively. One third of urea and the whole amount of manure and fertilizers were added to soil at final pot preparation and rest of nitrogen was applied in two equal splits at 30 days after sowing and at panicle initiation stage.

Salinity treatments and cultivation

There were 5 salinity levels including a control were used by adding crude salt (NaCl of 0 g (control), 7.7 g, 15.5 g, 23.3 g and 31.1 g by dissolving in 200 ml of tap water following the formula of Michael (1978) and Ponnamperuma and Bandyopadhya, (1980). Salinity treatments were given at 40 days after sowing (DAS). The salinity levels of pot soil were made at 0.6 dSm^{-1} (control), 2.6 dSm^{-1}, 5.2 dSm^{-1}, 8.2 dSm^{-1} and 11.0 dSm^{-1}, the average values of measurement at 60, 80 and 105 DAS. The soil sampling was done at above mentioned days and electrical conductivity (EC), pH and cation exchange capacity (CEC) were measured. EC was measured by the electrical Conductivity Bridge at room temperature and calculated to the standard temperature of 25^0C. The pH and CEC of soil were analyses following the methods of Jackson (1982) and (Black 1965) respectively. The experiment was laid out in a Randomized Complete Block Design (RCBD) with 5 replications.

Seed sowing and intercultural operation

Five healthy seeds of each variety were sown in each pot and after germination 3 plants were allowed to grow. All pots were kept free from weed and after salt treatment 3 irrigation were applied to maintain moisture level uniformly. No insect and disease were infested in pot plants.

Data collection and analysis

Data on growth and yield attributes were collected at 60, 70, 80 DAS and at maturity (105 DAS). Harvest index was calculated by the formula of Donald and Humblin (1976). Data were analyzed using the MSTAT-C package programe (Russel, 1986). The differences between pairs of means were compared by Duncuns Multiple Range Test (Gomez and Gomez, 1984) at 5 % level of significance.

Results and Discussions

Effects on plant height

The plant height was significantly decreased with increasing salinity levels. After 60 days of sowing, the plant heights were 69.9, 68.6, 67.1, 64.7 and 61.7 for 0.6 (control), 2.6, 5.2, 8.2 and 11.0 dSm^{-1} of salinity levels respectively (Table 1). Similar trend in plant height was found in subsequent growing periods. After 105 DAS, the highest plant height was in control which gradually decreased and become the lowest at the highest salinity level of 11.01 dSm^{-1}. Similar result was reported by Majumder *et al.* (2000) and by Ashraf *et al.* (2002) in different varieties and cultivars of wheat.

Table 1. Effects of salinity levels on canopy structure of wheat

Salinity levels (dSm^{-1})	Plant height (cm) at days after sowing				Number of total tillers per hill at days after sowing			
	60	70	80	105	60	70	80	105
0.6 (Control)	69.94a	80.07a	89.09a	96.67a	6.01a	6.61a	7.05a	6.76a
2.6	68.68b	77.55a	86.07b	92.67b	5.50ab	6.02ab	6.45a	6.13ab
5.2	67.19c	74.91b	82.82c	88.15c	4.96bc	5.36bc	5.78b	5.45bc
8.2	64.76d	72.01c	79.12d	83.40d	4.38c	4.73cd	5.13b	4.80cd
11.0	61.71e	67.91d	74.52e	78.15e	3.75d	4.04d	4.33c	4.10d

Values with different letters within a column differ significantly at 5% level of significance by DMRT

There were significant variations in plant height of different varieties under study. At 60 DAS, variety shotabdi had the highest plant height over kanchan and gourob (Table 2). At 80 DAS, kanchon and shotabdi showed the highest plant height over gourob. Similar trend in plant height was also found at harvest. The result indicated that salt tolerance varied significantly among varieties. It might be due to the differences in genetic potentiality of the varieties. The interaction effects between salinity stresses and varieties on the plant height presented in Table 3 indicates that at control all varieties were similar for the plant height but tolerance capability to salinity varied significantly. Reduction of the plant height with increasing salinity was comparatively lower in shotabdi over other two varieties. Variety gourob was the lowest tolerant to salinity in respect to the plant height all along the growth periods.

Number of total tillers per hill

The number of total tillers per hill was significantly varied due to effects of salinity stresses. At 60 DAS, the number of tillers per hill was the highest in control, similar to that of for 2.6 dSm^{-1} and than decreased significantly with increasing salinity levels (Table 1). Similar trend of-total tillers per hill was observed in subsequent growth periods. The number of tiller per hill was increased up to 80 DAS and than decreased due to senescence of some infective tillers. The present result agrees with the report of Faiz *et al.* (1981), Halim *et al.* (1988) and Francoise *et al.* (1994). They stated that the number of tiller per hill decreased with increasing salinity levels in wheat. Performance of varieties for the production of tiller under salinity stresses varied significantly (Table 2). In all growth stages, the highest number of total tiller per hill were in shotabdi compared to other varieties. It might be due to the higher tiller production potentiality of the shotabdi under salinity stresses. The interaction effect between salinity stresses and varieties was insignificant at early and final growth stage (60 and 105 DAS) but significant at 70 and 80 DAS (Table 3). At 70 DAS, all varieties produced the highest number of tiller per hill, which gradually decreased with increasing salinity levels. This reduction of tiller number was the lowest in the shotabdi and the highest in gourob among varieties. Similar trend in tiller number was observed at 80 DAS.

Table 2. Performance of wheat varieties on canopy structure under salinity stress

Name of varieties	Plant height (cm) at days after sowing				Number of total tillers per hill at days after sowing			
	60	70	80	105	60	70	80	105
Kanchan	65.90b	75.63a	82.81a	88.14a	4.71b	5.16b	5.64b	5.32b
Shotabdi	67.82a	74.58ab	82.88a	88.71a	5.57a	6.03a	6.40a	6.06a
Gourob	65.65b	73.27b	81.29b	86.58b	4.48b	4.87b	5.27b	4.94b

Values with different letters within a column differ significantly at 5% level of significance by DMRT

Table 3. Interaction effects between salinity levels and varieties for canopy structure of wheat

Name of varieties	Salinity levels (dsm^{-1})	Plant height (cm) at days after sowing				Number of total tillers per hill at days after sowing			
		60	70	80	105	60	70	80	105
Kanchan	0.6 (Control	68.83ab	80.63a	89.45a	96.46a	5.90a	6.45ab	6.98ab	6.68a
	2.6	67.75b-d	78.50ab	86.27bc	92.67b	5.33a	5.81a-d	6.31a-d	6.00a
	5.2	66.62cd	76.54a-c	83.50de	88.50de	4.73a	5.18b-f	5.66c-f	5.34a
	8.2	64.57ef	73.33c-e	79.67fg	83.96ef	4.12a	4.53d-g	4.99e-g	4.66a
	11.0	61.75g	69.15ef	75.15h	79.13g	3.45a	3.83fg	4.27gh	3.93a
Shotabdi	0.6 (Control	70.50a	79.50ab	88.67ab	95.23ab	6.37a	7.13a	7.51a	7.18a
	2.6	69.65ab	77.23a-c	85.83cd	92.20bc	6.00a	6.65ab	7.03ab	6.70a
	5.2	68.61a-c	75.00b-d	83.30de	89.09cd	5.62a	5.98a-d	6.35a-d	6.01a
	8.2	66.47de	72.53c-e	80.16f	85.87de	5.19a	5.47b-e	5.83b-f	5.49a
	11.0	63.86f	68.62ef	76.32h	81.15fg	4.67	4.92c-f	5.27d-g	4.93a
Gourob	0.6 (Control	70.50a	80.07a	89.15a	98.33a	5.75a	6.25a-c	6.67a-c	6.35a
	2.6	68.65a-c	76.93a-c	86.00cd	93.15b	5.16a	5.61b-e	6.02b-e	5.69a
	5.2	66.34de	73.20c-e	81.67ef	86.87de	4.52a	4.92c-f	5.32d-g	4.99a
	8.2	63.25fg	70.17d-f	77.52gh	80.37ge	3.83a	4.18efg	4.57f-h	4.24a
	11.0	59.50h	65.96f	72.10i	72.16h	3.12a	3.38g	3.76h	3.43a

Values with different letters within a column differ significantly at 5% level of significance by DMRT

Number of effective tillers per hill

The number of effective tillers per hill was the highest at control and was similar at 2.6 dSm^{-1} salinity level (Table 4). With the increasing salinity levels, number of effective tillers decreased. Similar effect of salinity on number of effective tillers per hill was reported by Halim *et al.* (1988) and Francoise *et al.* (1994). Among varieties, sotabdi produced the maximum number of effective tillers per hill (Table 5). Gourob and kanchan were similar in producing effective tiller. Thus shotabdi showed more tolerance than other varieties. The interaction between salinity stresses and effective tiller number per hill presented in Table 6, showing that shotabdi interacted the best and produced the highest number of effective tiller per hill compared to other two varieties under increasing salinity stresses.

Table 4. Effects of salinity levels on the yield and yield contributing characters of wheat

Salinity levels (dsm^{-1})	Number of effective tillers per hill	Length of the spike (cm)	Number of spikelets per spike	1000 grain weight (g)	Number of grains per spike	Grain yield per plant (g)	Decreased grain yield over control (%)	Straw yield per plant (g)	Harvest index (%)	Decreased harvest index over control (%)
0.6 (Control)	6.11a	10.19a	20.18a	37.42a	45.75a	10.44a	--	14.50a	41.84a	--
2.6	5.74a	9.64b	19.43ab	34.22b	44.97ab	8.33b	20.81	12.46b	40.02b	4.35
5.2	4.87b	9.07c	18.64bc	30.78c	41.12b	6.30c	39.66	10.16c	38.15c	8.82
8.2	4.25bc	8.47d	17.78cd	27.20d	43.21c	4.61d	55.84	8.04d	36.20b	13.48
11.0	3.85c	7.85e	16.85d	23.50e	43.34d	3.22e	69.16	6.29e	34.20e	18.26

Values with different letters within a column differ significantly at 5% level of significance by DMRT

Table 5. Performance of wheat varieties on the yield and yield contributing characters under salinity stress

Name of varieties	Number of effective tillers per hill	Length of the spike (cm)	Number of spikelets per spike	1000 grain weight (g)	Number of grains per spike	Grain yield per plant (g)	Straw yield per plant (g)	Harvest index (%)
Kanchan	4.89b	8.92b	17.75b	44.41b	29.08b	6.12b	9.63b	37.87b
Shotabdi	5.54a	9.30a	19.06a	45.74a	32.39a	8.06a	12.23a	46.16a
Gourob	4.47b	8.90b	18.94a	42.09	30.40b	5.56c	9.01b	37.21b

Values with different letters within a column differ significantly at 5% level of significance by DMRT

Length of spike

The increasing salinity stress significantly decreased the length of spikes (Table 4). The highest length of spike (10.19 cm) was obtained in control which gradually decreased with increasing salinity and attained to the lowest (7.85 cm) at 11.o5 salinity. Similar result was reported by Pillal *et al.* (1982) and Shazia *et al.* (2001) in wheat. The length of spike was different among varieties under salinity stress. The highest length of spikes was in variety shotabdi over gourob and kanchan (Table 5). This variation might be due to genetic character of varieties.

Number of spikelets per spike

Salinity significantly affected the number of spikelet per spike. The highest number of spikelet per spike was in control, which was statistically similar to salinity level of 2.6 dSm^{-1} and thereafter decreased significantly with increasing salinity levels (Table 4). The lowest number of spikelet per spike was 16.85 at 11.0 dSm^{-1} salinity. Francoise *et al.* (1994) reported similar results. Among varieties, shotabdi and kanchan were produced the highest and the lowest number of spikelets respectively (Table 5). The interaction effects between salinity levels and varieties, presented in Table 6, shows that shotabdi was more tolerant followed by gourob and kanchan variety in producing number of spikelets per spike.

Number of grains per spike

The highest number of grain per spike was produced in plants under control, followed by 2.6 dSm^{-1} salinity and gradually decreased significantly with increasing salinity (Table 4). The present result supports the report of Halim *et al.* (1988) and Parasher and Varma (1992). The number of grain per spike was varied among varieties (Table 5). Variety shotabdi was more tolerant to salinity stresses in producing grain per spike, followed by gourob and kanchan (Table 6).

Table 6. Interaction effects of salinity levels to varieties on the yield and yield contributing characters of wheat

Name of varieties	Salinity levels (dsm^{-1})	Number of effective tillers per hill	Length of the spike (cm)	Number of spikelets per spike	Number of grains per spike	1000 grain weight (g)	Grain yield per plant (g)	Decreased grain yield over control (%)	Straw yield per plant (g)	Harvest index (%)	Decreased harvest index over control (%)
Kanchan	0.6 (Control)	6.10a	9.97a	19.32a-d	35.49ab	46.18ab	9.97b	--	13.84bc	41.87a	--
	2.6	6.09ab	9.47a	18.57a-e	32.39bc	45.33a-c	7.75c	8.73	11.67d	39.90a-c	4.71
	5.2	4.78cd	8.95a	17.79b-e	29.19c-e	44.48c-e	5.88de	17.75	9.62ef	37.93b-e	9.41
	8.2	4.10de	8.40a	16.97c-e	25.87ef	43.53d-e	4.20gh	27.11	7.51gh	35.88ef	14.31
	11.0	3.38e	7.81a	16.10e	22.48fg	42.51fg	2.81ij	36.66	5.51i	33.77fg	19.35
Shotabdi	0.6 (Control)	6.65a	10.15a	20.18ab	37.61a	46.92a	11.71a	--	16.07a	42.15a	--
	2.6	6.14ab	9.74a	19.68a-c	35.11ab	46.31ab	9.88b	6.65	14.40ab	40.70ab	3.44
	5.2	5.49a-c	9.32a	19.14a-d	32.49bc	45.70a-c	7.81c	13.61	12.11cd	39.21a-d	6.98
	8.2	4.98b-d	8.87a	18.50a-e	29.78c-e	45.06b-d	6.19d	20.82	10.24d-f	37.67b-e	10.63
	11.0	4.42c-e	8.43a	17.81b-c	26.96de	44.73b-e	4.71fg	28.32	8.34fg	36.09d-f	14.38
Gourob	0.6 (Control)	5.59a-c	10.45a	21.05a	39.15a	44.15c-e	9.65b	--	13.60bc	41.50a	--
	2.6	4.98b-d	9.70a	20.04ab	35.16ab	43.28ef	7.37c	10.19	11.31de	39.45a-c	4.94
	5.2	4.34c-e	8.93a	18.98a-d	30.67cd	42.19fg	5.20ef	21.66	8.74fg	37.30c-e	10.12
	8.2	3.67de	8.13a	17.88b-e	25.96ef	41.03gh	3.43hi	33.69	6.36hi	35.05e-g	15.54
	11.0	3.75de	7.30a	16.75de	21.06g	39.78h	2.15j	46.21	5.03i	32.75g	21.08

Values with different letters within a column differ significantly at 5% level of significance by DMRT

Grain weight

Grain weight was inhibited significantly with increasing salinity stress. Grain weight decreased significantly with increasing salinity levels (Table 4). Seed size decrease with higher salinity is reported by Shazia *et al.* (2001). The highest grain weight was noticed in shotabdi followed by kanchan, and lowest was for gourob. Interaction effects between salinity levels and varieties shows that shotabdi was dominant in producing grain weight under salinity stresses, followed by kanchan and gourob was highly susceptible (Table 6).

Grain yield

Effect of salinity stress on grain yield per plant was significant. The highest grain yield per plant was in control, followed by yield at 2.6 dSm^{-1} salinity. The lowest yield was in 11.0 dSm^{-1} of salinity (Table 4). Chopra *et al.* (1997) and Maliwal (1997) also reported similar result in wheat. Among varieties, shotabdi produced significantly higher grain yield, followed by kanchan and lowest yield was in gourob (Table 5). The interaction effect between salinity stresses and varieties on grain yield per plant was also significant (Table 6). The highest grain yield per plant was in shotabdi under salinity stresses, followed by kanchan and gourob. The per cent decrease in grain yield over control was gradually increased with increasing salinity levels. Among varieties, per cent decrease grain yield was the highest in gourob than that of kanchan and shotabdi. The decrease in grain yield at all salinity levels were minimum in shotabdi, medium in kanchan and the highest in gourob (Table 6). Thus shotabdi was more resistant to salinity stress over other varieties.

Straw yield

Straw yield production was significantly decreased with increasing salinity stresses. The highest straw yield per plant was in control, followed by 2.6 dSm^{-1} salinity and the lowest was for 11.0 dSm^{-1} salinity (Table 4). Majumdar *et al.* (2000) also reported similar result in wheat. Shotabdi produced higher straw yield, followed by kanchan and gourob (Table 5). Similar result was revealed due to interaction effects between salinity levels and varieties. Shotabdi was the highest in producing straw yield under salinity stresses over kanchan and gourob (Table 6).

Harvest Index

The harvest index (HI) indicates the proportion of grain yield and biological yields and shows translocation ability from vegetative organ to reproductive organ. The highest HI (41.8%) was in control, followed by 2.6 dSm^{-1} salinity and gradually decreased with increasing salinity. Among varieties, shotabdi had significantly higher HI over other varieties (Table 5). Similar result was found due to interaction effects between salinity levels and varieties. Shotabdi was more resistant to salinity stresses followed by kanchan and the lowest resistant variety was gourab. Thus grain yield reduction trend was higher in gourab over other varieties.

Growth in a higher plant is a complex phenomenon, which is affected by numerous external and internal factors. Salinity stress in one of the stress factors which affect growth and development of plants. The nature and content of soluble salts, salt dynamic and water regimes during the growing season influence crop growth. Salts have two types of effect on the growing crops, specific effect due to particular ions exerting harmful action to the plants and or the osmotic potential of the solution around the roots regime of the crops may be unaccepted. Thus over absorption of particular ion(s) or lacking of absorption of required element may inhibit / imbalance protoplasmic activities concern to cell division, cell elongation and finally cell division. Furthermore, the prolonged transpiration brings about large amount of salt into the plants especially in the old leaves that causes their early senescence. Increasing salinity levels in the present experiment inhibited canopy growth, yield attributes and yield. Any one or all above mention mechanisms might involve in inhibiting growth process. The yield contributing characters like plant height, tiller numbers per hill, number of effective tiller per hill, length of spike, number of grain per spike etc. were affected by salinity stress, and finally decreased grain and straw yield in wheat.

References

Ashraf, M., Fakhra, K. and Rasul, E. 2002. Interactive effects of gibberellic acid (GA_3) and salt stress on growth, ion accumulation and photosynthetic capacity of two spring wheat (*Triticum aestivum* L.) cultivars differing in salt tolerance. Plant-Growth-Regulation. 36(1): 49-59.

BBS, 2003. Statistical Yearbook of Bangladesh. Bangladesh Bureau of Statistics, Statistics Division, Ministry of Planning. Govt. of the People's Republic of Bangladesh. P. 141.

Black, C. A. 1965. Methods of Soil Analysis part I and II. American Society of Agronomy, U. S. A.

Chopra, N. K., Chopra, N. S. and Chopra N. 1997. Effect of saline water on performance of wheat (*Triticum* ***aestivum*** L.) varieties in western Rajsthan. Indian J. Agron. 42(3): 468- 470.

Donald, C.N. and Humblin, J. 1976. The biological yield and harvest index of cereals as agronomic and plant breeding criteria. Adv. Agron. 28: 361-405.

Faiz, S.M.A.; Karim, Z.; Salahuddin, A.B.M. and Haque, A. 1981. Gardening of Brackish water management for Irrigation and its influence on the change of soil properties associated with crop management. First Annual Report. Coordinated Irrigation and Water Management Studies, BARC.

FAO (Food and Agriculture Organization). 2002. Production year book, Rome. 55: 74-75.

Francoise, L.E.; Grieve, C.M.; Maas, E.V. and Lesch, S.M. 1994. Time of salt stress affects growth and yield components of irrigated wheat. USA J. Agron. 86(1): 100-107.

Gomez, K.A. and Gomez, A.A. 1984. Statistical procedure for agricultural research. Second Edn. John Willey and Sons. New York. 97-411.

Halim, A.; Salih, R.K.; Ahmed, H.M. and Rahim, A.A. 1988. Growth and development of Maxipak wheat as affected by soil salinity and moisture levels. Plant Soil. 112(2): 255-259.

Jackson, M.L. 1982. Soil chemical Analysis. Prentice Hall. India Pvt. Ltd. p. 498.

Karim, Z.; Hussain, S.G. and Ahmed, M. 1990. Salinity problems and crop intensification in the coastal regions of Bangladesh, BARC, soil publication No. 33: 63.

Majumdar, S.P. and Belal, C.M. 2000. Effect of sodic water irrigation and potassium application on yield, mineral uptake and soil properties in wheat crop grown on Typic-Ustipsamment. Indian. J. Biol. Sci. 70(1): 81-94.

Maliwal, G. L. 1997. Response of wheat varieties to chloride and sulphate dominant sality. Indian J. Plant Physiol. 2(3): 225-228.

Michael, A. M. 1978. Irrigation theory and practice. Vikas Pub. House Pvt. Ltd., New Delhi, p. 690.

Parasher, A. and Varma , S. K. 1992. Effect of different levels of soil salinity on germination, growth and yield of wheat (*Triticum aestivum* L.). Indian J. Agric. Res. 26(2): 100 – 106.

Pillal, V. A., Stark, C. and Unger, J. 1982. Growth, organogenesis and yield formation in wheat under NaCl stress in green house trials. 1982. Beitrage Zur Tropichan Land wirt schaft and victerinar medizin. 20(4): 359 – 363.

Ponnamperuma, F. N. and Bandyopadhya, A. K. 1980. Soil salinity as constraints on food production in the humid tropics. Proc. Priorities for alleviating soil related constrains to food production in the tropics IRRI, Los Banos, Philippines.

Russell, D.F. 1986. MSTAT-C package programme. Crop and Soil Science Department, Michigan State University, USA.

Shazia, N.; Rasu, E. and Muhammad, A. 2001. Effect of foliar application of Indole-3-Acetic Acid on growth and yield attributes of spring wheat (*Triticum aestivum* L.) under salt stress. Int. J. Agric. And Biol. 3(1): 139-142.