Bangladesh J. Bot. **46**(1): 381-388, 2017 (March) Supplementary

EFFECTS OF SOIL AMENDMENT AND NITROGEN LEVELS ON GROWTH, YIELD AND NITROGEN UPTAKE BY RICE PLANT UNDER SALINE CONDITION IN NOAKHALI DISTRICT, BANGLADESH

ANA HAQUE, ME HOSSAIN, ME HAQUE, MM HASAN, MY RAFII*, LEE HENG[1] AND SM SHAMSUZZAMAN[2]

Soil Science Division, Bangladesh Institute of Nuclear Agriculture, Mymensingh-2202, Bangladesh.

Keywords: Soil amendment, Nitrogen level, Saline condition, BINA dhan10

Abstract

A field experiment was conducted to evaluate the effect of different soil amendments and nitrogen levels on growth, yield and N uptake by rice (cv. BINA dhan10) under saline soil condition. Treatments consisted of three FYM and gypsum combinations in main plot *viz.* M_1: gypsum @ 210 kg/ha, M_2: FYM 3 t/ha + gypsum 140 kg/ha and M_3: FYM 6 t/ha. Three nitrogen treatments assigned in sub-plots *viz.* N_1: 75 kg N/ha, N_2: 100 kg N/ha and N_3: 125 kg N/ha. The study revealed that the combination of FYM and gypsum with and N levels produced the maximum grain yield of rice (6.07 t/ha) under the treatment combinations of M_1N_3, i.e. gypsum @ 210 kg/ha along with 125 kg N/ha.

Introduction

Bangladesh is one of the sea side countries of world and, due to this condition it faces many adverse effects of salt intrusion. The coastal areas of Bangladesh consist of 19 districts, which cover 32% of the country and accommodate more than 35 million people (Huq and Rabbani 2011). Increasing of salinity is a climacteric issue to the people of the coastal area of Bangladesh. In 1973, Bangladesh had 83.3 million hectares of land, which was affected by salinity that increased up to 102 million hectares in 2000 and the value raised to 105.6 million hectares in 2009 and it is continuing to increase (SRDI 2010). Concerning the rising salinity in the water and soil, the public of coastal region suffering from scarcity of drinking water, agriculture and other uses. It has been observed that the coastal cultivable lands are not being used for crop cultivation, mostly due to the soil salinity; rising soil salinity retards crop growth and reduce the ultimate production (Mahmuduzzaman *et al*. 2014). Mainly there are two factors that cause the development of soil salinity, one is tidal flooding during the wet season (June to October) and another is lateral movement of ground water during the dry season (November to May) (Rasel *et al*. 2013).

Two salt tolerant rice varieties have been tested and released by BINA. The varieties are BINA dhan8 and BINA dhan10 which can tolerate soil salinity level up to 8 - 10 dS/m, but EC value of soil in many areas are much higher (Sinha *et al*. 2014). Rice is affected mostly during the dry season as the salt concentration becomes higher but during wet season the effect of salinity is insignificant because the salt is diluted by the monsoon rain water (Sinha *et al*. 2014). Salt toxicity and poor soil properties are the main reasons for low productivity of crops grown in saline soil (Gao *et al*. 2008).

---

*Author for correspondence: <mrafii@upm.edu.my>. [1]Soil and Water Management & Crop Nutrition Section, Division of Nuclear Techniques in Food and Agriculture, IAEA Laboratories Seibersdorf, Vienna, Austria. [2]Soil Resource Development Institute, Krishi Khamar Sarak, Dhaka-1215, Bangladesh.

Proper management strategies and techniques with suitable crop variety consisting of higher yield potential could contribute to the development of crop production in the salt stressed areas. One of the approaches for the economic utilization of moderately salt affected land is to grow salt tolerant crop varieties along with the suitable management of cultural practices (Khattak *et al*. 2007). The best means of maintaining soil fertility, productivity and salt tolerance could be through adding of soil amendments such as farmyard manure, compost and gypsum etc. (Hasan *et al*. 2014). Gypsum is widely used amendment for saline soil reclamation, due to the application of the gypsum in saline-sodic soil removes the greatest amount of sodium ion from the soil particle and reduces the soil electrical conductivity (Abdel-Fattah 2012). Keeping in view the ameliorating effect of farmyard manure and gypsum on saline soils, Binadhan-10 (salt tolerant rice variety) was selected to monitor its response to various levels of combination of farmyard manure and gypsum under saline conditions along with N uptake under different N levels.

Material and Methods

The experiment was conducted at farmer's field in Khashirhat village under the Subornochar Upazila of Noakhali district during the Boro season of 2015 (January to May, 2015). The land belongs to Agro-ecological Zone 18 (Young Meghna Estuary Floodplain). The soil was silty loam in texture, having pH 6.85, total N 0.11%, organic carbon 1.16%, available P 6.40 ppm, available K 65.24 ppm and available S 10.30 ppm. The salinity level of initial soil was 4.25 dS/m; that considered as very slight saline to slight saline soil (Sinha *et al*. 2014). EC value (d/Sm) ranged between 4.25 and 8.50.

The experiment was laid out in a RCBD split-plot design with three replications, where three FYM and gypsum combination treatments were assigned in main plots *viz.* M_1: gypsum @ 210 kg/ha, M_2: FYM 3 t/ha +140 gypsum kg/ha, M_3: FYM 6 t/ha and nitrogen levels were assigned in sub-plots viz. N_1: 75 kg N/ha, N_2: 100 kg N/ha and N_3: 125 kg N/ha. The test rice variety was BINA dhan10 which can tolerate 10 to 12 dS/m of EC value (Sinha *et al*. 2014). Total amounts of TSP, MoP and gypsum were added as broadcast during final land preparation (FRG 2012). Urea was applied in three equal splits at 10 days after transplanting (DAT), 25 DAT (maximum tillering stage) and 40 DAT (panicle initiation stage). The crop characters *viz.* plant height, panicle length, number of tiller/hill, grain and straw yield t/ha were recorded at maturity. The grain and straw samples were dried in an oven at 65^0C for about 48 hrs and then ground by a grinding machine to pass through a 20-mesh sieve. The N contents of grain and straw were measured following the Kjeldahl method (Bremmer and Mulvaney 1982). The analysis of variance for every crop characters, yield and N data was done following the principle of F-statistics using MSTAT-C software and the mean results in case of significant F-value were adjudged by DMRT at 5% level of significance.

Results and Discussion

Among the yield contributing characters numbers of tiller per hill and grain yield were affected significantly by different soil amendment combinations, while plant height, panicle length and straw yield were not affected significantly (Table 1). The highest number of tillers produced when gypsum applied @ 210 kg/ha (M_1) and minimum numbers of tillers produced by the treatment M_3 (FYM 6 t/ha) which is statistically similar to M_2 (FYM 3 t/ha with gypsum 140 kg/ha). According to Hossain *et al*. (2016) addition of extra gypsum @190 kg/ha with recommended fertilizer dose, significantly increases tillering of rice in saline soil. Maximum grain yield (5.43 t/ha) produced by the treatment M_2 (FYM 3 t/ha with gypsum 140 kg/ha) which is statistically identical to M_1 (Gypsum @ 210 kg/ha) and minimum (4.94 t/ha) produced when FYM applied @ 6 t/ha (M_3). In saline soil, gypsum and farmyard manure could be used as competent soil amendment in rice cultivation, which may reduce toxic level of salt present in soil and enhance physiological growth and increase the grain yield of rice (Suriyan *et al.* 2011).

Table 1. Mean effect of soil amendments on growth and yield of rice in saline area.

Treatments	Plant height (cm)	Panicle length (cm)	Tillers/hill (no.)	Grain yield (t/ha)	Straw yield (t/ha)
M_1	97.56	23.46	14.58a	5.28a	6.56
M_2	96.83	23.35	13.63b	5.43a	6.44
M_3	96.11	23.05	13.48b	4.94b	6.15
LS	NS	NS	*	**	NS
CV (%)	9.54	5.92	10.57	6.17	7.96

In a column, figures having similar letter(s) of without letter(s) do not differ significantly as per DMRT. LS = Level of significance, CV (%) = Coefficient of variation. M_1: Gypsum @ 210kg/ha, M_2: FYM 3 t/ha +140 gypsum kg/ha, M_3: FYM 6 t/ha. NS = Non significant, * = Significant at 5% level, ** = Significant at 1% level.

Nitrogen fertilizer increases tillering and vegetative growth, increases plant height, grain and straw yield and number of heads usually are proportionally to the amount of nitrogen added (Mahtalat *et al*. 2005). Different levels of N affected the yield and yield contributing characters significantly (Table 2). However, all the yield and yield contributing characters gave good results when N applied @ 125 kg/ha. Among the various levels of N, the tallest plant (101.90 cm) produced in the treatment N_3 (125 kg N/ha) and the shortest plant was observed under the plot where N applied @ 75 kg/ha. The increase in plant height with increased N application might be

Table 2. Mean effect of nitrogen level on growth and yield of rice in saline area.

Treatments	Plant height (cm)	Panicle length (cm)	Tillers/ hill (no.)	Grain yield (t/ha)	Straw yield (t/ha)
N_1	91.79c	18.93c	11.55c	4.55c	5.67c
N_2	96.80b	24.21b	14.23b	5.28b	6.58b
N_3	101.90a	26.72a	15.92a	5.82a	6.90a
LS	*	*	**	**	**
%CV =	9.54	5.92	10.57	6.17	7.96

In a column, figures having similar letter(s) of without letter(s) do not differ significantly as per DMRT. LS = Level of significance, CV (%) = Coefficient of variation. M_1: Gypsum @210 kg/ha, M_2: FYM 3 t/ha +140 gypsum kg/ha, M_3: FYM 6 t/ha. NS = Non significant, * = Significant at 5% level, ** = Significant at 1% level.

primarily due enhanced vegetative growth with more nitrogen supply to plant (Manzoor *et al*. 2005). Due to the application of different levels of N the panicle length of rice was also varied significantly and the maximum panicle length (26.72 cm) obtained in N_3 treatment (125 kg N/ha) and the minimum panicle length (18.93cm) observed by the treatment N_1 (75 kg N/ha). The elongation of panicle increased with increasing level of nitrogen (Kaushal *et al*. 2010). Regarding the number of tillers/hill in rice, a marked influence was noticed by the application of different levels of nitrogen. The highest number of tillers/hill (15.92) was observed in N_3 where nitrogen was applied as 125 kg/ha and the lowest (11.55) number was found in N_1 (75 kg N/ha) treatment.

According to Mirza *et al*. (2010), more number of tillers per square meter might be due to more availability of nitrogen, which plays a vital role in cell division. Results also showed that there was a remarkable influence on grain yield by the application of different doses of nitrogen. The highest grain yield (5.82 t/ha) was observed in N_3 (125 kgN/ha) and the lowest grain yield (4.55 t/ha) was obtained in N_1. From the study, it was revealed that yield contributing characters, i.e., panicle length, number of effective tiller/hill, number of grains/panicle increased with the higher rate of nitrogen application which may lead to higher grain yield (Vennila *et al*. 2007). Grain yield of rice increases with the increase of N rate up to a certain level and similar result was also reported by Salahuddin *et al*. (2009).

Considering the straw yield, maximum straw (6.90 t/ha) produced by N_3 and minimum (5.67 t/ha) by N_1. Gypsum and FYM applications to paddy saline soil is an effective remediation procedure in terms of the physical, chemical and biological properties of the soil (Tejada *et al*. 2006; Wong *et al*. 2009) which can be used to enhance the growth and development of rice crops prior to grain harvesting (Zaka *et al*. 2003, Sharma and Minhas 2005). Interaction effect of soil amendments and N levels on the yield and yield contributing characters also showed significant effects on BINA dhan10 (Table 3). However, statistically similar results that could consider as better or best were obtained from various combinations. Among the different treatment combinations, the tallest rice plant of 102.90 cm was found under the treatment combination of M_1N_3, where nitrogen fertilizer was applied (125 kg N/ha) along with the gypsum (210 kg/ha), which is statistically similar to M_2N_3 (FYM 3 t/ha + 140 gypsum kg/ha with 125 kg N/ha) and M_3N_3 (FYM 6 t/ha + 125 kg N/ha). The shortest plant of 91.33 cm was observed under the treatment combination of M_1N_3. Regarding the panicle length of rice, the interaction effect of different FYM and gypsum combination and nitrogen levels also showed significant result and the

Table 3. Interaction effect of soil amendments and nitrogen level on growth and yield of rice in saline area.

Treatments	Plant height (cm)	Panicle length (cm)	Tillers/hill (no.)	Grain yield (t/ha)	Straw yield (t/ha)
M_1N_1	92.13c	18.30c	11.47d	4.53de	5.87d
M_1N_2	97.60b	24.20b	15.07ab	5.25bc	6.80a
M_1N_3	102.90a	27.87a	17.20a	6.07a	6.99a
M_2N_1	91.90c	19.22c	12.20cd	4.99cd	5.86cd
M_2N_2	96.87b	24.10b	13.03bcd	5.52abc	6.60ab
M_2N_3	101.7a	26.73ab	15.67ab	5.79ab	6.86a
M_3N_1	91.33c	19.27c	10.98d	4.13e	5.28e
M_3N_2	95.93b	24.33b	14.59abc	5.07cd	6.32bc
M_3N_3	101.10a	25.55ab	14.88abc	5.61abc	6.86a
LS	*	**	*	**	**
%CV	9.54	5.92	10.57	6.17	7.96

In a column, figures having similar letter(s) of without letter(s) do not differ significantly as per DMRT. LS = Level of significance, CV (%) = Coefficient of variation. M_1: gypsum @ 210 kg/ha, M_2: FYM 3 t/ha +140 gypsum kg/ha, M_3: FYM 6 t/ha. NS = Non significant, * = Significant at 5% level, ** = Significant at 1% level.

maximum length of rice panicle (27.87 cm) was found under the treatment combination of M_1N_3 i.e. gypsum @ 210 kg/ha with 125 kg N/ha which is followed by M_2N_3 and M_3N_3 treatment. Hence, the minimum length of rice panicle (18.30 cm) was recorded from the treatment M_1N_1. The panicle length of rice also significantly affected by cumulative application of gypsum and it increases with the higher rates of gypsum (Khan *et al.* 2006). Maximum number of effective tiller/hill produced by M_1N_3 (17.20), which is statistically similar to M_1N_2, M_2N_3, M_3N_2 and M_3N_3 with values 15.07, 15.67, 14.59 and 14.88, respectively and minimum effective tiller/hill (10.98) produced by M_3N_1. Fatema and Khan (2013) observed that the higher dose of gypsum increased the vegetative growth like plant height of rice under saline condition. Like other parameters, the grain yield of Binadhan-10 rice significantly influenced by the interaction of both FYM and gypsum combinations and different levels of nitrogen (Table 3). The maximum grain yield of 6.07 t/ha was obtained from M_1N_3 (Gypsum @ 210 kg/ha with 125 kg N/ha) which was also statistically identical to the treatments M_2N_2 (5.52 t/ha), M_2N_3 (5.79 t/ha) and M_3N_3 (5.61 t/ha); the minimum (4.13 t/ha) was found in M_3N_1 (FYM 6 t/ha with 75 kg N/ha) which is statistically similar to treatment M_1N_1 (4.53 t/ha).

According to Haque *et al*. (2015), due to the interaction effect of both FYM and gypsum combinations and N levels, the maximum grain yield of rice was found where plot received FYM @ 5 t/ha with gypsum 210 kg/ha combined with 125 kgN/ha. Application of gypsum and farmyard manure helped in improvement of soil properties and leaching of excessive ions to the deeper layer thus, concentration of salts was decreased in the upper layers which favored the growth of plant and ultimately a significant increase in rice grain was observed (Ghafoor *et al*. 2008). Similarly, the highest and lowest straw yield of rice was noticed as 6.99 and 5.28 t/ha from the treatment combination of M_1N_3 and M_3N_1, respectively (Table 3).

The nitrogen uptake by grain and straw of Binadhan-10 did not affect by different soil amendment (Table 4). The N uptake by grain ranged from 41.07 to 42.81 kg/ha and in case of straw it's varied between 30.82 and 34.94 kg/ha. Regarding the different N levels, N uptake by grain and straw affected significantly (Table 5). The maximum N uptake (52.31 kg/ha) by grain observed in the treatment N_3 (125 kg/ha) and the lowest (37.00 kg/ha) N uptake observed by the

Table 4. Mean effect of soil amendment and nitrogen level on N uptake by rice in saline area.

Treatments	Grain N uptake (kg/ha)	Straw N uptake (kg/ha)
Soil amendment		
M_1	41.07	33.57
M_2	43.00	34.94
M_3	42.81	30.82
LS	NS	NS
CV (%)	10.31	12.85
Nitrogen levels		
N_1	37.00c	32.08b
N_2	44.50b	33.17b
N_3	52.31a	37.89a
LS	**	*
CV (%)	10.31	12.85

In a column, figures having similar letter(s) of without letter(s) do not differ significantly as per DMRT. LS = Level of significance, CV (%) = Coefficient of variation. M_1: Gypsum @210kg/ha, M_2: FYM 3 t/ha +140 gypsum kg/ha, M_3: FYM 6 t/ha. NS = Non significant, * = Significant at 5% level, ** = Significant at 1% level.

treatment N_1 (75 kg/ha). In case of straw highest N uptake (37.89 kg/ha) was also found from the treatment N_3 and lowest (32.08 kg/ha) by N_1which is statistically similar to N_2 (100 kgN/ha). This finding was supported by Sarmin *et al*. (2015) who mentioned that N uptake by rice grain and straw increased significantly with the application of nitrogenous fertilizer. Considering the interaction effect of soil amendment and N levels (Fig. 1) maximum N uptake (56.93 kg/ha) was observed by the treatment M_1N_3 (Gypsum @ 210 kg/ha with 125 kgN/ha) which is statistically identical to M_3N_3 (FYM 6 t/ha + 125 kgN/ha) with value 52.32 kg/ha.

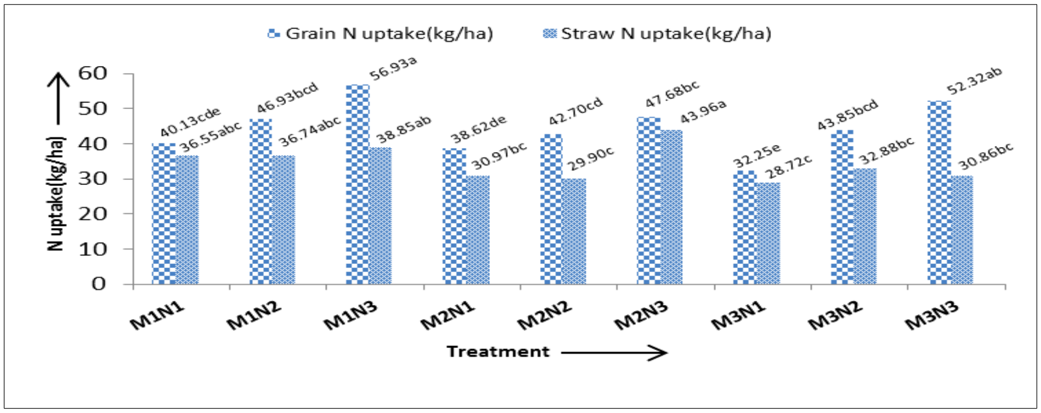

Fig 2. Interaction effect of different soil amendment and N rates on N uptake (kg/ha) by grain and straw of BINA dhan10.

Lowest N uptake by grain (32.25 kg/ha) was observed in the treatment M_3N_1 (FYM @ 6 t/ha+ 75 kgN/ha) which is statistically similar to M_1N_1 with value 40.13 kg/ha. Regarding N uptake by straw, the highest value (43.96 kg/ha) found from the treatment M_2N_3 (FYM 3 t/ha + 140 gypsum kg/ha with 125 kgN/ha) which is statistically similar to M_1N_3, M_2N_2 and M_1N_1 with value 38.85, 36.74 and 36.55 kg/ha, respectively. The minimum N uptake by straw (28.72 kg/ha) was observed in the treatment M_3N_1 which show the same lettering in the treatment M_2N_2 with value 29.90 kg/ha. The interaction result revealed that with higher nitrogen dose and combination of farmyard manure with gypsum showed higher nitrogen uptake. The combined application of gypsum and farm manure improves their effectiveness for increasing soil properties (Ullah and Bhatti 2007) that may cause improved nitrogen use efficiency under salt stressed soil. Azza *et al*. (2011) mentioned that, S promotes the use efficiency of other essential plant nutrients, particularly N and P.

BINA dhan10 is a salt tolerant rice variety. In saline condition, additional yield of BINA dhan10 can be obtained by the application of gypsum @ 210 kg/ha with 125 kgN/ha. Nitrogen uptake by rice increased by the application of gypsum and farm yard manure in saline soil.

Acknowledgement

Authors are grateful to International Atomic Energy Agency (IAEA), Vienna, Austria for financial support to carry out this research work.

References

Abdel-Fattah MK 2012. Role of gypsum and compost in reclaiming saline-sodic soils. J. Agric. and Vet. Sci. **1**: 30-38

Azza AMM, Mahgoub HM and Abd El-Aziz NG 2011. Response of *Schefflera arboricola* L. to gypsum and sulphur application irrigated with different levels of saline water. Austr. J. Basic Appl. Sci. **5**: 121-129.

Bremmer JM and Mulvaney CS 1982. Nitrogen: Total. *In:* Methods of Soil Analysis, Part 2 (2nd Edition). Page AL, Miller R. and Keeney DR (eds.). Amer. Soc. Agron., Inc. and Soil Sci. Soc. Amer., Inc., Madison, Wisconsin. USA. pp. 595-622.

Fatema Kaniz and Khan MHR 2013. Reclamation of saline soil using gypsum, rice hull and saw dust in relation to rice production. J. Adv. Sci. Res. **4**: 01-05.

FRG (Fertilizer Recommendation Guide-2012) 2012. Banlgadesh Agricultural Research Council, Farmgate, New Air port road, Dhaka-1215. pp. 80-256.

Gao S, Ouyang C, Wang S, Xu Y, Tang L and Chen F 2008. Effects of salt stress on growth, antioxidant enzyme and phenylalanine ammonia-lyase activities in *Jatropha curcas* L. seedlings. Plant, Soil and Env. **54**: 374-381.

Ghafoor A, Murtaza G, Ahmad B and Boers TM 2008. Evaluation of amelioration treatments and economic aspects of using saline-sodic water for rice and wheat production on salt affected soils under arid land conditions. Irrigation and Drainage **57**: 424-434.

Hasan MS, Raihan MZ, Moslehuddin AZM, Tarafder MA and Haque ANA. 2014. Effects of organic and inorganic amendments on boro rice cv. binadhan-8 in saline soil. Bangladesh J. Crop Sci. **25:** 97-101

Haque ANA, Haque ME, Hossain ME, Khan MK and Razzaque AHM 2015. Effect of farm yard manure, gypsum and nitrogen on growth and yield of rice in saline soil of Satkhira district, Bangladesh. J. Bios. and Agril. Res. **3**: 65-72.

Hossain ME, Haque ANA, Haque ME and Heng L 2016. Performance and productivity of boro rice varieties cultivated in saline area of Satkhira. J. Biosci. Agric. Res. **08:**726-733.

Huq S and Rabbani G 2011. Adaptation Technologies in Agriculture; The Economics of rice farming technology in climate – vulnerable areas of Bangladesh. *In:* Chrisitansen L, Olhoff A and Traerup S (ed.). Technologies for Adaptation: Perspectives and practical experiences. UNEP, Roskilde.

Kaushal AK, Rana NS, Singh A, Neeray S and Strivastav A 2010. Response of levels and split application of nitrogen is green manured wetland rice (*Oryza sativa* L.). Asian J. Agric. Sci. **2**: 42-46.

Khan R, Gurmani AR, Khan MS and Gurmani AH 2006. Effect of gypsum application on rice yield under wheat rice system. Int. J. Agric. Bio. **8**: 23-36.

Khattak SG, Haq I, Malik A, Khattak MJ and Naveedullah 2007. Effect of various levels of gypsum application on the reclamation of salt affected soil grown under rice followed by wheat crop. Sarhad J. Agric. **23:** 13-21

Mahmuduzzaman M, Ahmed ZU, Nuruzzaman AKM, Rabbi F and Ahmed S 2014. Causes of salinity intrusion in coastal belt of Bangladesh. Int. J. Plant Res. **4**: 8-13.

Mahtalat A, Islam MM and Paul SK 2005. Effect of nitrogen on yield and other plant characters of local T. aman rice, Var. Jatai. Res. J. Agric. and Biol. Sci. **1:** 158-161.

Manzoor Z, Awan TH, Zahid MA and Faiz FA. 2005. Response of rice crop (super basmati) to different nitrogen levels. J. Anim. Plant Sci. **16**: 1-2.

Mirza Hasanuzzaman KU, Ahamed NM, Rahmatullah N, Akhter KN and Rahman ML 2010. Plant growth characters and productivity of wetland rice (*Oryza sativa* L.) as affected by application of different manures, Emir. J. Food Agric. **22:** 46-58.

Rasel HM, Hasan MR, Ahmed B and Miah MSU. 2013. Investigation of soil and water salinity, its effect on crop production and adaptation strategy. Int. J. of Water Resources and Env. Engineering **5:** 475-481.

Salahuddin KM, Chowdhury SH, Munira S, Islam MM and Parvin S 2009. Response of nitrogen and plant spacing transplanted aman rice. Bangladesh J. Agril. Res. **34(2)**: 279-285.

Sarmin Sultana, Hashem MA, Haque TS, Baki MZI and Haque MM 2015. Optimization of nitrogen dose for yield maximization of brri dhan49. Amer. J. Bio. Life Sci. **3**: 58-64.

Sharma BR and Minhas PS 2005. Strategies for managing saline/alkali waters for sustainable agricultural production in South Asia. Agric Water Manage. **78**:136-151

Sinha DD, Singh AN and Singh US 2014. Site suitability analysis for dissemination of salt-tolerant rice varieties in southern Bangladesh. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences XL-8, pp. 961-966.

Soil Resources Development Institute (SRDI) 2010. Saline Soils of Bangladesh; SRDI, Ministry of Agriculture: Dhaka, Bangladesh.

Suriyan C, Yuthasak P and Chalermpol K 2011. Remediation of salt-affected soil by gypsum and farmyard manure - Importance for the production of Jasmine rice. Aust. J. Crop. Sci. **5:** 458-465.

Tejada M, Garcia C, Gonzalez JL and Hernandez MT 2006. Use of organic amendment as a strategy for saline soil remediation: Influence on the physical, chemical and biological properties of soil. Soil Biol. Biochem. **38**:1413-1421

Ullah W and Bhatti A 2007: Physico-chemical properties of soils of Kohat and Bannu districts NWFP Pakistan. J. Chem. Soc. Pak. **29**: 20-25.

Vennila C, Jayanthi C and Nalini K 2007. Nitrogen management in wet seeded rice. Agric, Rev. **28**: 270-276.

Wong VNL, Dalal RC and Greene RSB 2009. Carbon dynamics of sodic and saline soil following gypsum and organic material additions: A laboratory incubation. Appl. Soil. Ecol. **41**: 29-40

Zaka MA, Mujeeb F, Sarwar G, Hassan NM and Hassan G 2003. Agromelioration of saline sodic soil. Online J. Biol. Sci. **3:** 329-334.

(Manuscript received on 30 November, 2016; revised on 22 December, 2016)