Asian Journal of Research in Agriculture and Forestry

3(2): 1-8, 2019; Article no.AJRAF.48800
ISSN: 2581-7418

Effect of Transplanting Method and Gypsum Rate on Yield and Yield Contributing Characters of Boro Rice in Saline Zone of Bangladesh

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJRAF/2019/v3i230035
Editor(s):
(1) Dr. Nebi Bilir, Professor, Forestry Faculty, Isparta University of Applied Sciences, 32260 Isparta, Turkey.
Reviewers:
(1) Primitiva Andrea Mboyerwa, Sokoine University of Agriculture, Tanzania.
(2) Florin Sala, Banat University of Agricultural Sciences and Veterinary Medicine, Romania.
Complete Peer review History: http://www.sdiarticle3.com/review-history/48800

Original Research Article

Received 31 January 2019
Accepted 30 April 2019
Published 07 May 2019

ABSTRACT

Salinity intrusion causes problems in the coastal areas of Bangladesh. Climate change creates hazards like cyclone, sea level rise, and storm surge have been increasing the salinity problem in many folds. The coastal region covers about 20% of the country; from where cultivable land more than 30%. Agricultural land uses in these areas are very poor, because of high content of salinity in Rabi season. Already, 830,000 million hectares of land already identified as affected by soil salinity. A field experiment was carried out at saline prone area at Binerpota, Satkhira under natural salinity condition during Rabi season 2017-2018. The experiment was carried out with rice variety Binadhan-10.This variety was evaluated under four transplanting methods i.e., M_0: Control (No Slope/flat land), M_1: Ridge and furrow (each furrow 30 cm wide accommodating 3 lines transplanting), M_2: Ridge and furrow (each furrow 60 cm wide accommodating 5 lines transplanting) and four levels of gypsum with control G_0: control, G_1: 75 kg ha^{-1}, G_2: 150 kg ha^{-1} as basal and G_3: 150 kg ha^{-1}(75 kg ha^{-1} as basal +75 kg ha^{-1} 42 DAT). The experiment was laid out in a split plot design with three replications. The unit plot size was 3 m x 4 m. The recommended fertilizer doses applied for the experiment were 80 kg N ha^{-1}, 15 kg P ha^{-1}, 50 kg K ha^{-1}. Nitrogen, phosphorus,

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potassium, sulphur and zinc were supplied from urea, TSP, MoP, gypsum and zinc sulphate monohydrate respectively while urea was applied in three equal splits. Application of gypsum had significant effect on plant height, number of effective tiller m^{-2}, length of panicle, total number of spikelets $panicle^{-1}$, thousand grain weight, number of filled spikelets $panicle^{-1}$, grain yield straw yield. It seems that the crop responded to the application of gypsum. Overall results suggest that an application of gypsum The highest grain yield (7.7 t ha-1) was produced in ridge and furrow method where gypsum rate was 150 kg ha^{-1} (75 kg ha^{-1} as basal + 75kg ha^{-1} at weeks after transplanting followed by (7.4 t ha^{-1}) basal application of 150 kg ha^{-1} gypsum along with N, P, K, Zn and Boron might be necessary to ensure satisfactory yield of rice in saline prone area under natural salinity condition.

Keywords: Salinity intrusion; zinc sulphate monohydrate.

1. INTRODUCTION

Bangladesh is a deltaic country with 14.4 million ha area [1]. About 80% of the country's area consists of alluvial sediments deposited by the rivers Ganga, Brahmaputra, Tista, Jamuna, Meghna and their tributaries [2]. However, a part of the cultivable area in coastal districts is affected with varying degree of soil salinity due to the intrusion of saline water during high tides. Soil salinity is also believed to be responsible for low cropping intensity in these districts [3]. The salinity affected area increased from about 0.83 million ha in 1973 to 1.02 million ha in 2000, and 1.05 million ha in 2009 [4]. Salinity is one of the major causes hindering agricultural productivity in the world. Globally nearly 7% of the world is afflicted by soil salinity. Salinity caused by anthropogenic factors (secondary salinization) is often related to large-scale development of irrigated agriculture without adequate drainage and clearing of natural deep rooted vegetation. Problems associated with the presence of excess salts in the soil have for long constrained agricultural productivity. More than 80 per cent of the total area of the Khulna, Bagerhat and Satkhira districts are already affected by different magnitudes of soil salinity of which about 35 per cent is in the grip of strong salinity [5]. Soil degradation, which can be caused by salinity, is considered as an environmental impairment with severe adverse effects on agricultural productivity, particularly in arid and semiarid regions [6]. Effects of high level of soluble salts in soil mainly because an increase in osmotic pressure that hindered to uptake water from soil. Soil salinity is considered the most critical environmental stress which can negatively affect rice growth and the metabolism process [7]. Several procedures and strategies that can be used to improve salt affected area. The chemical remediation is one of these reclamation strategies [8]. The application of Ca^{2+} amendments can improve different properties of soil and act as soil modifiers that can prevent development of sodicity which is directly related to plant growth, crop productivity and crop yields [9,10]. Specific chemical amendments gypsum ($CaSO_4 \cdot 2H_2O$) can be used as direct source for Ca^{2+} cation; however gypsum is normally available. Gypsum plays a significant role in the reclamation of saline soils by providing a Ca^{2+} cation to replace the exchangeable Na^+ from the colloid's cation exchange positions and leaching it out from the root zone into groundwater [8]. Fageria and Knupp reported that gypsum and lime application significantly improved growth and yield of rice [11]. There is some agronomic management practices (ridge and furrow method) through which salinity level of a soil can be lowered and the stress effects can be mitigate. Application of gypsum and organic amendments and irrigation recast. Introduction of salinity tolerant rice varieties in combination with agronomic management practices (ridge and furrow method) for the amelioration of salinity stress effect is the key for improving crop productivity in coastal ecosystem of Bangladesh.

2. MATERIALS AND METHODS

2.1 Experimental Site and Weather

The experiment was conducted at the field of BINA substation, Satkhira (22°45'09.1"N 89°06'22.0"E) under natural salinity condition during 2017-2018. The climatic parameters during the growing period of boro rice are presented in Table 1. It was observed that the cropping season through January to May. During the growing period of boro rice, maximum and minimum temperature varied from 19.5 to 37.2°C and 5.6 to 29.8°C, respectively. The average relative humidity varied from 71 to 79%. The average sunshine (minute) varied from 570.25 to 817.16.

Table 1. Climatic parameters during the growing days of boro rice (from seeding preparation to harvest)

Growing period (month)	Days after sowing (DAS)	Days after transplanting (DAT)	Maximum temperature (°C) Range	Minimum temperature (°C) Range	Average temperature (°C)	Maximum relative humidity (%) range	Minimum relative humidity (%) range	Average relative humidity (%)	Average sunshine (minute)
January	0-30		19.5-27.8	5.6-15.1	16.86	77-100	24-61	78	709.16
February	31-58	0-26	19.5-33.6	5.6-20.4	22.86	77-100	19-54	72	570.25
March	59-89	27-57	30-35.6	15-25.5	27.5	77-100	20-97	71	660.94
April	90-119	58-87	28.4-37.2	19.4-29.8	28.94	78-98	37-73	73	817.16
May	120-127	88-95	31.8-36.2	21.4-28.6	29.8	75-96	45-93	79	738.25

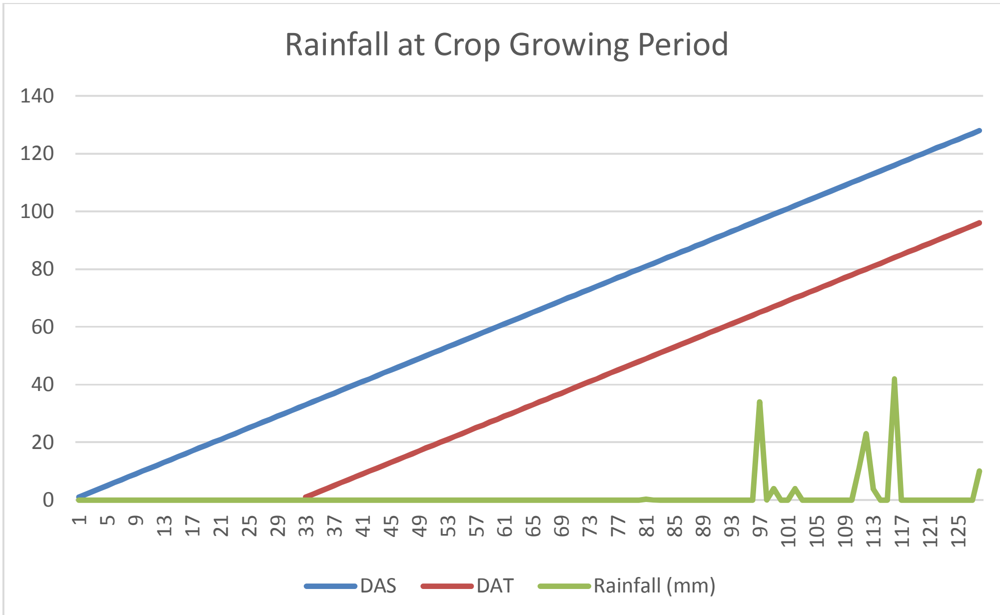

Fig. 1. Rainfall distribution during crop growing period

Rainfall distribution during crop growing period given in the Fig. 1.

2.2 Treatments and Cultural Practices

The experiment was carried out with Binadhan-10. It's a high yielding variety. It can tolerate soil salinity level up to EC 8-10 dSm-1 [1]. Kibria et.al reported that among salt-tolerant varieties BRRI dhan 47, BINA dhan 8 and BINA dhan 10; BINA dhan 10 showed higher salt tolerance in all measured physiological parameters [12].

Binadhan-10 was evaluated under four transplanting methods i.e., M_0: Control (No Slope/flat land), M_1: Ridge and furrow (each furrow 30 cm wide accommodating 3 lines transplanting), M_2: Ridge and furrow (each furrow 60 cm wide accommodating 5 lines transplanting). Four levels of gypsum with control G_0: control, G_1: 75 kg ha^{-1}, G_2: 150 kg ha^{-1} as basal and G_3: 150 kg ha^{-1}(75 kg ha^{-1} as basal +75 kg ha^{-1} 42 DAT). The experiment was laid out in a split plot design with three replications.

2.3 Seedlings Raising

Seedlings were raised in well prepared wet seed bed at the sub-station Satkhira farms. Before sowing, seeds were immersed in water for 24 hours and then they were taken out and kept in jute sacks in dark condition for 48 hours. Seedling nurseries for each variety were prepared by pudding the soil. The sprouted seeds were sown on a well prepared wet nursery bed in 1 January, 2018. No manuring and fertilization was done but water and pest management practices were followed in order to raise healthy seedlings.

2.4 Land Preparation

The land preparation was started one month prior to transplant of the seedlings. The land was thoroughly prepared with the help of a power tiller. Subsequently the land was sufficiently irrigated and ploughed and cross ploughed three times with country plough followed by laddering to have a good tilth. All kinds of stubble and residues of previous crop were removed from the field. After uniform leveling, the experimental plots were laid out according to the requirement of the treatment.

2.5 Fertilization and Manuring

The plots of Boro rice were fertilized with N, P, K, Zn and Boron respectively according to the recommendation of BARC (2012). The whole amount at triple super phosphate, muriatic of potash, and zinc sulphate were applied to the soil at the time of final land preparation. Urea was applied in three equal splits. One split of urea was applied with other fertilizers as basal dose and the other two splits were applied 21 and 45

DAT. The seed bed was wet by application of water both in the morning and evening on the previous day before uprooting the seedling. Thirty days old seedlings were uprooted carefully from the seedling nursery for transplanting in the experimental plots. Only selected healthy seedlings were translated in the experimental plots in 1 February 2018 in 20 cm apart line maintaining a distance of 15 cm from hill to hill with three seedlings hill^{-1} proper care was taken during the growing period of the crop.

2.6 Intercultural Operation

Intercultural operating were done in order to ensure and to maintain the normal growth of the plant as and when needed. After one week of transplanting dead seedling were replaced carefully by transplanting fresh seedlings from the same source. The experiment plots were infested with some common weeds which were removed twice by hand weeding. After transplanting six irrigation were needed to maintain 5-6 cm standing water in each plot. Finally the field was drained out 7 days before harvest. Observations were regularly made and the field looked nice with normal green plants.

2.7 Harvesting and Data Collection

The maturity of crops was determined when some 70% of the seeds became attain their characters color. Grain and straw yields plot were recorded after threshing by a pedal thresher winnowing and drying in the sun properly including the grains and straws of the sample plants. The weight of grains was adjusted to 12% moisture content. Grain and straw yield were them converted to t ha^{-1}. From the 10 randomly harvested hills, the following data were recorded, plant height, number of total tillers hill^{-1}, number of effective tillers hill^{-1}, number of non-effective tillers hill^{-1}, number of grain panicle^{-1}, number of unfilled spikelet's panicle^{-1},1000 grain weight, Grain yield (tha^{-1}), Straw yield (t ha^{-1}).

2.8 Collection and Preparation of Soil Samples

The initial soil samples were collected from the plough depth level (0-15) cm. The samples were taken by means of an auger from different spots of the field and mixed thoroughly to make a composite sample. The composite sample was air dried ground and sieved through a 10-mesh (2 mm) sieve and stored in a plastic bag for physical and chemical analysis. The initial soil sample was analyzed for physical and chemical properties in the Soil Science laboratory of BINA.

2.9 Chemical Analysis of Soil Sample

Soil samples were analyzed for both physical and chemical characteristics. The soil samples were analyzed following the standard methods as follows.

Table 2. Chemical properties of the soil at the experimental field

Chemical properties	
$pH_{1:5}$	7.2
$EC_{1:5}$ (dS m^{-1})	8.1
Na^{+} (meq L^{-1}	59
K^{+} (meq L^{-1})	0.29
Ca^{2+} (meq L^{-1})	6.0
Mg^{2+} (meq L^{-1})	10.3
HCO_3^{-} (meq L^{-1})	7.1
Cl^{-} (meq L^{-1})	47.0
SO_4^{2-} (meq L^{-1})	24.8
SAR	18.5
ESP (%)	31.2

2.10 Data Processing and Analysis

Data recorded for different parameters were subjected to analysis of variance (ANOVA) and the treatment means were compared using the least significant different test. The statistical analysis was done by using Statistix10.

3. RESULTS AND DISCUSSION

Transplanting method had significant effect on most of the plant parameters. The highest grain yield (6.6 t ha^{-1}) was produced in ridge and furrow (each furrow 30 cm wide accommodating 3 lines transplanting) and lowest yield (5.8 t ha^{-1}) in control (flat land) method. In case of gypsum rates, 150 kg ha^{-1} (75 kg ha^{-1} as basal + 75kg ha^{-1} at 7 WAT (G_3)) gypsum produced the highest grain yield (7.3 t ha^{-1}) followed by 150 kg ha^{-1} gypsum application as basal (7.0 t ha^{-1}). The plant height, number of total tillers hill^{-1}, panicle length, number of filled grains panicle^{-1} and thousand grain weight were higher in the 150 kg ha^{-1} (75kg ha^{-1} as basal +75kg ha^{-1} at 7WAT (G_3)) application of gypsum than basal 150 kg ha^{-1} application of gypsum. Interaction between transplanting method and gypsum application showed that the highest grain yield in ridge & furrow (each furrow 30 cm wide accommodating 3 lines transplanting) method with 150 kg ha^{-1} gypsum (75kg ha^{-1} as basal +75kg ha^{-1} at 7WAT)

Table 3. Effect of transplanting method, rates of gypsum on yield and yield contributing characters of rice

Treatments	Plant height (cm)	Total tillers hill^{-1} (no)	Effective tillers hill^{-1} (no)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains Panicle^{-1} (no.)	1000 Seed wt. (g.)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
Transplanting method									
Control (Flat land) (M_1)	102.3	12.8	12.0	26.0	132.8	5.3	24.2	5.8	9.3
Ridge & Furrow 30cm (M_2)	100.9	13.0	12.0	26.8	137.6	4.9	24.2	6.6	9.8
Ridge & Furrow 60cm (M_3)	101.3	12.6	11.9	25.9	134.9	6.1	24.4	6.4	9.1
$LSD_{0.05}$	NS	NS	NS	1.8	17.0	NS	1.4	0.4	0.9
Level of Gypsum									
0 kg ha^{-1} (G_0)	102.4	13.3	12.5	26.2	132.2	6.0	24.4	5.4	8.5
75kg ha^{-1} (G_1)	102.1	12.7	12.0	26.3	136.7	5.1	23.8	6.2	9.2
150 kg ha^{-1} (G_2)	100.7	12.4	11.4	26.2	138.8	5.3	24.5	7.0	9.8
150 kg ha^{-1} (G_3)	100.8	12.8	11.9	26.3	132.7	5.3	24.4	7.3	10.2
$LSD_{0.05}$	NS	NS	1.0	0.9	19.5	NS	1.5	0.7	1.0
Transplanting Method × Rates of Gypsum									
M_1G_0	104.2	12.5	11.8	25.8	145.2	3.7	25.2	5.3	8.0
M_1G_1	102.2	11.9	11.4	25.9	132.1	5.4	24.9	6.3	9.1
M_1G_2	99.5	12.8	11.9	25.9	129.2	4.3	24.9	6.7	9.1
M_1G_3	103.5	13.9	13.0	26.6	124.8	7.9	24.9	6.8	10.8
M_2G_0	100.6	14.1	13.2	26.9	117.9	6.7	24.4	5.3	8.3
M_2G_1	102.1	12.2	11.3	27.8	138.1	3.9	24.3	6.0	9.3
M_2G_2	101.2	13.2	11.8	26.3	146.4	4.4	24.3	7.2	10.8
M_2G_3	99.8	12.5	11.6	26.1	148.1	4.4	24.2	7.7	10.7
M_3G_0	102.4	13.4	12.6	25.8	133.7	7.7	23.8	5.7	9.0
M_3G_1	102.0	13.9	13.2	25.4	139.9	5.9	23.6	6.3	9.1
M_3G_2	101.6	11.0	10.5	26.4	140.7	7.3	23.3	6.9	9.3
M_3G_3	99.0	12.0	11.2	26.1	125.1	3.5	23.3	7.4	9.0
$LSD_{0.05}$	NS	1.8	NS	1.5	33.7	NS	2.5	1.2	1.7
CV%	7.2	8.0	8.7	6.4	14.6	11.5	6.1	10.6	10.8

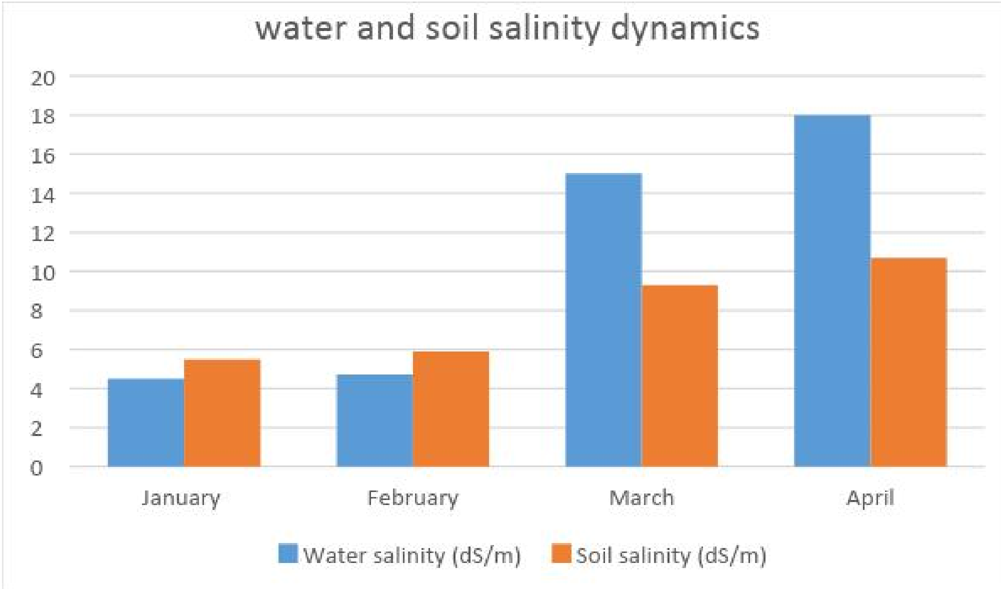

Fig. 2. Water and Soil salinity status of experimental site

(7.7 t ha^{-1}) followed by ridge & furrow (each furrow 60 cm wide accommodating 5 lines transplanting) 150 kg ha^{-1} gypsum application as basal (7.4 t ha^{-1}) (Table 3).

3.1 Water and Soil Salinity Dynamics

Salinity causes unfavorable environment and hydrological situation that hinders the normal crop growth and development. The factors which contribute significantly to the development of saline soil are, tidal flooding during wet season (June to October), direct inundation by saline water, and lateral movement of saline ground water during dry season (November to May). The severity of salinity problem in Bangladesh increases with the desiccation of the soil. It affects crops depending on degree of salinity at the critical stages of growth, which reduces yield and in severe cases total yield is lost. Maximum salinity was observed during (March and April) at maximum tillering stage to flowering stage. Maximum salinity was also found at ridge and minimum in furrow.

4. CONCLUSIONS

Binadhan-10 was evaluated among three transplanting methods and three levels of gypsum at saline prone area. The highest grain yield (7.7 t ha-1) was produced in ridge and furrow method where gypsum rate was 150 kg ha^{-1} (75 kg ha^{-1} as basal + 75kg ha^{-1} at 6 weeks after transplanting followed by (7.3 t ha^{-1}) basal application of 150 kg ha^{-1} gypsum along with N, P, K, Zn and Boron might be necessary to ensure satisfactory yield of rice in saline prone area under natural salinity condition.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle3.com/review-history/48800