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Research Communication

Effect of organic amendments on soil salinity and the growth of maize (*Zea mays* L.)

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Abstract

Soil salinity is a major concern in southwestern part of Bangladesh because almost 30% cultivable lands are currently lying under risk of salinity where 30-50% yields loss is happening. Organic amendments have found to be effective in the amelioration of saline soil by improving soil physical and chemical properties as well as crop selection is another criteria for sustaining viability of crops in saline soil. For ensuring sustainable saline soil management, a comparative pot study was carried out during kharif 1 season in 2015 to observe the effect of organic amendments (solid waste, vermicompost and cow dung) on soil salinity and its influence on the growth of maize. Composite soil was collected at a depth of 0-15 cm from Gozalmari village of Jalma Union in Batiaghata Upazila under Khulna district, Bangladesh that was saline (10.6 dS/m) in nature and the irrigation water sample was collected from beside Kazibacha river (4.28 dS/m) that was also moderately saline. The maize cultivar "Shuvra" was used for cultivation in the study. The experiment comprised of four treatments viz. T0: Control (No organic manure); T1: Solid waste (36g); T2: Vermicompost (72g); T3: Cow dung (33g). Five seeds were sown in each pot. Seeds were treated with Agrosan GN to protect them from seed and soil borne pathogens. Chemical fertilizers were not used in the experiment. Irrigation was done two times before harvesting: at 20 days after sowing (DAS) and at 40 DAS with river water and rain water was irrigated naturally during the season. Findings were that the organic amendments significantly influence the physico-chemical properties of the saline soil. All organic treated soils significantly reduce the soil EC (from 10.6 dS/m to 3.4 dS/m) and pH (from 7.63 to 7.38) compared to control soil ($p < 0.05$). In case of survival parameters (e.g. %germination, rate of survival at 50 DAS) of maize, the treatments were found insignificant ($p > 0.05$). But in terms of growth parameter (plant height and root length), significant differences were found between control and organic amendments treated soil ($p < 0.05$). It may be concluded that organic amendments treated soils showed better results than that of control soil. If proper management can be implemented, this positive results will bring hope to the local poor farmers at least can introduce a new crop in fallow agricultural land during the kharif 1 season.

Keywords: EC; maize; organic amendments; river water irrigation; soil salinity

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Introduction

Soil salinity is a major concern to agriculture because it affects almost all plant functions (1). Usually 30-50% yield losses occur depending on the level of soil salinity. Over 30% of the cultivable area of Bangladesh lies in the coastal and offshore zones. Out of 2.86 million hectares of coastal and offshore lands, about 1.056 million hectares are affected by varying degrees of salinity (2). Batiaghata Upazila is situated in the eastern side of Khulna District in the Division of Khulna, Bangladesh. The areas of the Upazila are seasonally flooded with saline water of the Kazibacha river which causes various degrees of soil salinity. In this area farmers grow mostly low-yielding, traditional rice varieties during the wet season. Most of the lands remain fallow in the Kharif-1 season (January–May) because of increasing soil salinity and the lack of good-quality irrigation water (3,4). Both organic and inorganic amendments are found to be effective in the amelioration of saline soils. Organic matter decomposition and plant root action also help dissolve the calcium compounds found in most soils, thus promoting reclamation of saline soil (5). Various organic amendments such as farmyard manure, compost, poultry manure and mulch can be used for the amelioration of saline soils. Organic amendments improve physical, chemical and biological properties of soils under saline conditions (6). Leithy et al. (2010) (7) conducted an experiment on study the effect of saline water addition to bio and organic fertilization treatment on geranium plant growth, mineral and chemical constituents. Salinity affected most of the morphological parameters and decreased the growth performance. The use of peanut compost increased plant height, number of branches and Fresh and dry weights. Maize (*Zea mays*) is the third most important cereal crop after rice and wheat in Bangladesh and is grown under a wide spectrum of soil and climatic conditions. It is an important C4 plant from the Poaceae family and is moderately sensitive to salt stress (8). Well drained fertile

sandy loam or loamy soil is the best for maize. However, it can be grown in clay soil with adequate drainage facilities (9). It can therefore be grown throughout the year in the sub-tropical climate of Bangladesh. If proper amendments can be introduced, the farmers can be benefited by introducing a new crop in fallow agricultural field during the Kharif 1 season. Due to this reason, a scientific study was undertaken to determine the effect of solid waste, vermicompost and cow dung as organic amendments on the saline soil and its influence on the growth of maize.

Materials and Methods

Site description and sample collection

The soil sample was collected from Gozalmari village of Jalma Union in Batiaghata Upazila under Khulna district, Bangladesh with the geographic location 22° 46' 125" N 89° 31' 773" E. The soil was clay, slightly alkaline in reaction (pH, 7.63), saline (EC, 10.6 dS/m), noncalcareous in nature, high in soil fertility containing medium organic matter (1.05%). Composite soil samples were collected at a depth of 0-15 cm and the water sample was collected from nearby Kazibacha River. The maize cultivar "Shuvra" was used for cultivation in the study.

Table 1: Methods of analysis

Parameters	Methods of analysis
Soil Texture	Hydrometer method
EC (dS/m)	electrochemically at 1:5 soil: water ratio as suggested by USDA
pH	electrochemically at 1:2.5 soil: water ratio as suggested by Jackson
Organic Matter	Walkley & Black's wet oxidation method
Available Na	NH ₄ OAc (pH 7) extract in FES 589 nm
Available Ca	NH ₄ OAc (pH 7) extract by complexometric titration method, involving ethylene diamine tetra-acetic acid (EDTA)

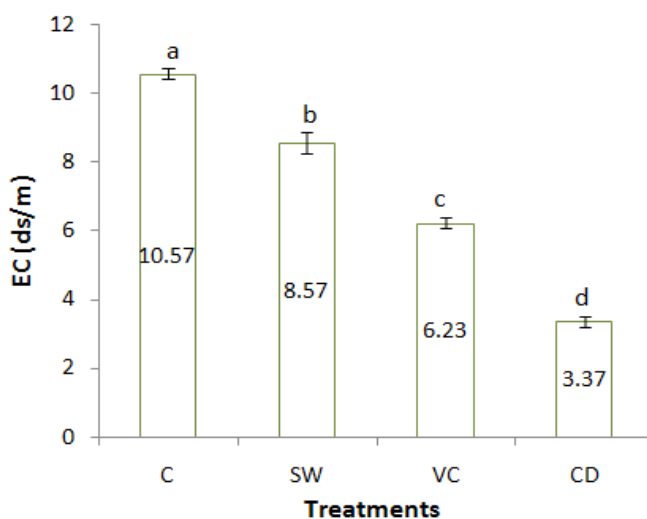


Fig. 1: Effect of organic amendments treated soil on soil EC

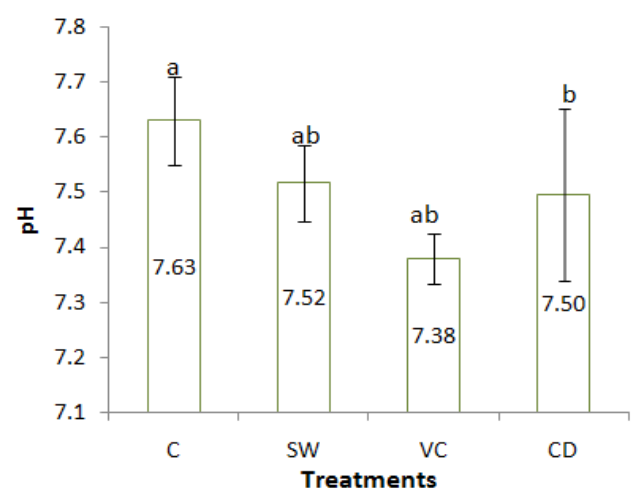


Fig. 2: Effect of organic amendments treated soil on soil pH

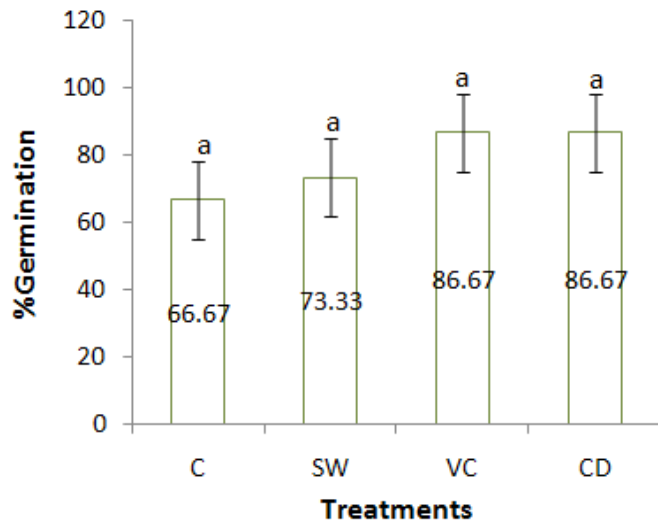


Fig. 3: Effect of organic amendments mixed soil on germination rate of maize

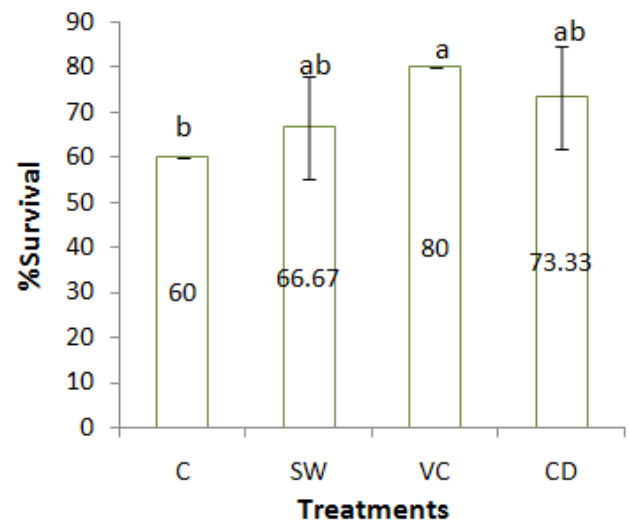


Fig. 4: Effect of organic amendments mixed soil on survival rate of maize

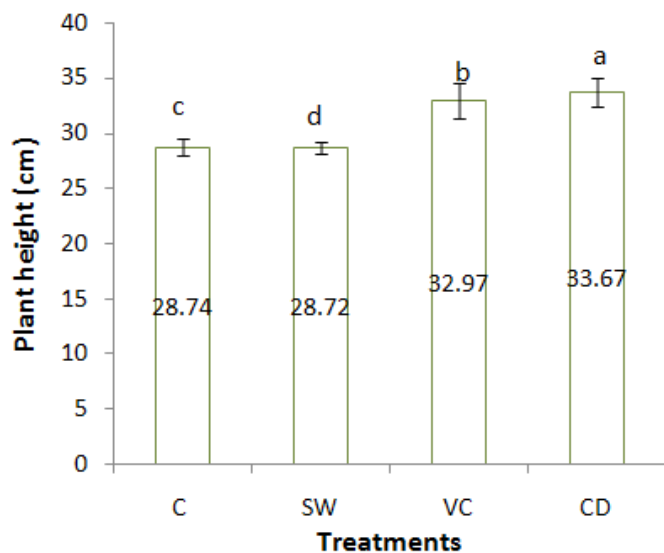


Fig. 5: Effect of organic amendments mixed soil on plant height (cm) of maize

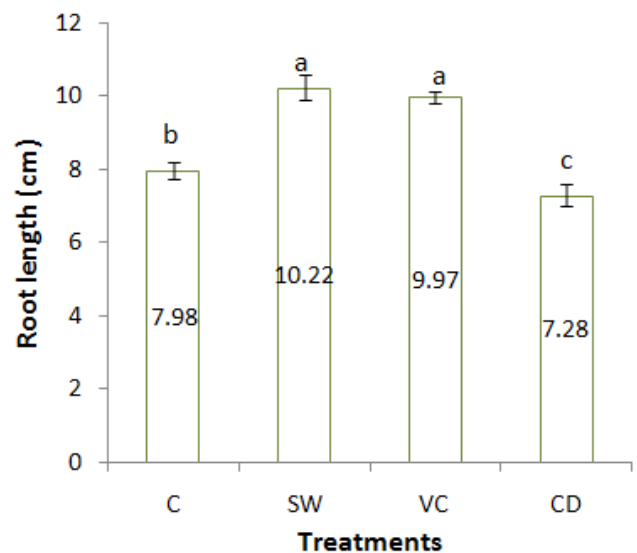


Fig. 6: Effect of organic amendments mixed soil on root length (cm) of maize

Sample analysis

Standard methods for the determination of samples physico-chemical properties were followed that were presented in Table 1. General properties of soil, water and organic amendments were measured and presented in Table 2. Table 3 presented the coding of experiment.

Table 2. Properties of soil, water and organic amendments

Samples	EC (dS/m)	pH	% Ca (Available)	% Na (Available)
Soil	10.6	7.63	-	0.29
River water	4.28	8.17	-	-
Solid waste	6.56	7.78	0.16	0.43
Vermicompost	1.85	6.65	0.8	0.34
Cow dung	4.67	6.84	1.76	0.31

Experimental design:

An experiment was conducted during kharif 1 season in 2015 within earthen pots in Khulna University campus. The experiment was carried out in a completely randomized design (CRD) with 3 replications. The total number of pots used in the study was 12. Each pot was 15 cm deep with 17 cm diameter at the top and was filled with 5kg of air dried soil. The EC level of the soil was measured 10.6 dS/m. Solid waste (SW), Vermicompost (VC), and Cow dung (CD) were incorporated with the pot soils and incubated for 15 days before seed sowing. Table 3 presented the coding of experiment. The amount of organic manures was calculated according to the available Ca amount that can replace available Na of the pot's soil. The experiment comprised of four treatments viz. T0: Control (No organic manure); T1: Solid waste (36g); T2: Vermicompost (72g); T3: Cow dung (33g). Five seeds were sown in each pot. Seeds were treated with Agrosan GN to protect them from seed and soil borne pathogens. Chemical fertilizers were not

used in this experiment. Irrigation was done two times before harvesting: at 20 days after sowing (DAS) and at 40 DAS with river water and rain water was irrigated naturally during the season.

Table 3: Coding of Experiment

Code	Experiment
C	Control soil (No organic amendments)
SW	Solid Waste treated soil
VC	Vermicompost treated soil
CD	Cow dung treated soil

Data recording

At Matured stage (50 DAS), plants height and roots length were recorded by using measuring tape as well as soil sampling was also done from each pot for determination of soil EC and pH.

Statistical analysis

The collected data were analyzed by following analysis of variance (ANOVA) technique by using statistical software SPSS 16.0 (10) and the mean difference as well as standard deviation was calculated by using Microsoft Excel.

Results

The soil EC values for different treatments varied from 3.37-10.6 dS/m (Fig. 1). The highest EC value (10.6 dS/m) was observed in initial control (C) soil whereas the lowest EC value (3.37 dS/m) was observed in Cow dung (CD) treated soil at matured stage. Result showed that application of organic amendments significantly reduced soil EC rather than control soil statistically (Fig. 1, $p \leq 0.05$). The pH values for different treatments vary from 7.38-7.63 (Fig. 2). The highest pH value (7.63) was observed in initial control soil whereas the lowest pH value (7.38) was observed in Vermicompost (VC) treated soil at matured stage. pH results revealed that application of SD and VC were statistically insignificant with other treatments but CD showed the significant difference with control (Fig. 2, $p \leq 0.05$). The rate of germination was varied from 66.67% to 86.67% (Fig. 3). The highest seed germination percentage (86.67%) was observed in Vermicompost (VC) treated soil and Cow dung (CD) treated soil whereas the lowest seed germination percentage (66.67%) was observed in control soil (Fig. 3). Though the average seed germination rate was higher in organic amendment treated soil but statistically they were insignificant among the treatments (Fig. 3, $p \leq 0.05$). The rate of plant survival percentage was varied from 60% to 80%. The highest plant survival rate (80%) was observed in Vermicompost (VC) treated soil whereas the lowest plant survival rate (60%) was observed in control soil (Fig. 4). The mean length of plant

height varied from 28.72 cm to 33.67 cm. The highest plant height (33.67cm) was observed in Cow dung (CD) treated soil whereas the shortest plant height (28.72 cm) was observed in Solid waste (SD) treated soil (Fig. 5). The plant height was significantly higher in VC treated soil but treatments were statistically significant (Fig. 5, $p \leq 0.05$). Result revealed that VC, CD treated soil increased plant height rather than control soil. The mean length of plant root length varied from 7.28 cm to 10.22 cm. The highest plant root length (10.22 cm) was observed in solid waste (SD) treated soil whereas the shortest plant root length (7.28 cm) was observed in cow dung (CD) treated soil. Treatment SW and VC were insignificant with each other but there was a significant difference between organic amendments treated soils and control soil (Fig. 6, $p \leq 0.05$).

Table 4: Status of treatments in matured stage (% increase or decrease in compare with control, * $p \leq 0.05$ and ns= non significant)

Parameters	Status (increase or decrease)	Value (%) Mean \pm SD
EC	Decrease	42.69 \pm 0.67*
pH	Decrease	2.17 \pm 0.31 ^{ns}
Germination rate	Increase	24.07 \pm 8.49 ^{ns}
Survival rate	Increase	22.22 \pm 0.01*
Plant height	Increase	10.67 \pm 3.16*
Root length	Increase	14.89 \pm 5.20*

Table 4 stated that organic manure treated soil significantly decreased EC (42.69%, $p \leq 0.05$) which is a good sign in reducing soil salinity. Thought germination rate was not significantly affected (Table 4, $p \geq 0.05$) but plants height, roots length and plant survival rates were significantly increased in application of organic manures (Table 4, $p \leq 0.05$).

Discussion

Organic amendments significantly improve the growth of maize under saline condition. This may be due to application of organic amendments can improve the concentration of Ca^{2+} in soil solution thus can replace Na^+ and reduce salinity. Abou El-Magd et al. (2008) (11) conducted two pot experiments on sweet fennel variety "Dulce" with the combination of two levels of organic manure (with, without) and six saline irrigation water treatments, i.e. well water (Control), 1000, 2000, 3000, 4000 and 5000 ppm Results indicated that organic manure treatment increased all the vegetative growth parameters expressed as plant height, leaf number, fresh and dry weight of the total plant and its organs, green yield, nutrient contents of the leaves and bulbs (N, P and K). Also, K/Na ratio, calcium and proline content of bulbs

were increased by organic manuring. Same result was also found by Liang et al. (2005) (12) where he applied organic fertilizers to reclaim saline soil and found positive results. Prapagar et al. (2012) (13) found that organic amendments were effective in reducing saline soil pH. Mostafa et al. (2012) (14) reported that soil salinity has strong effects on maize seed germination rate. This may due to organic fertilizers increase soil fertility and promote more plant growth than that of control soils. Ozdemir, 2005 (15) reported that organic fertilizer definitely increased nodulation, plant growth in low fertile soil (Marginal land). Ibrahim Zidan et al, 1990 (16) reported that salt did not inhibit maize root growth by reducing the capacity of epidermal cells to acidify their walls. Banaras et al. (2002) (17) reported that saline soil productivity can be improved by applying organic amendments in different crops. Survival rate was significantly higher in vermicompost treated soil. Vermicomposts, which are stabilized organic materials produced by earthworms and microorganisms, have been reported to improve plant germination growth and yields in greenhouse crops (18). Vermicompost has large particulate surface areas that provide many micro sites for microbial activity, strong retention of nutrients, high nutrients content and rich microbial populations (19). Plant height was significantly higher in cow dung treated soil. Abubakar et al. (2018) (20) conducted a research to screen the effect of organic manure (poultry manure & cow dung) on the vegetative growth of maize and observed that plant height increased by increasing the application of both manure and that was better than that of inorganic fertilizer application.

Conclusion

The organic amendments significantly influence the physico-chemical properties of the saline soil. Cow dung significantly reduce the soil EC compared to other treatments and vermicompost were found effective in reducing the soil EC (from 10.6 dS/m to 3.64 dS/m) significantly. In case of growth parameters (plant height, root length) of maize the treatments were found significant better in organic amendment treated soil rather than control. The positive result of the research especially in case of reducing EC of the saline soil will bring hope to the local farmers. They can produce at least one more crop in fallow period. In the studied area, organic amendments can be used for mitigating salinity problem and maize can be a good option for cultivation in Kharif-1 cropping season.

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Authors Contribution

MK initiated the work and experimental design, ARS helped in field work, HR helped in laboratory work and TBS contributed in manuscript writing and corrections.

Competing Interest

The authors declare that they have no competing interest.

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