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Common Organic Amendment (Rice Straw) Can Reduce Salinity Effects on Bean (*Phaseolus vulgaris*) Growth with or without Photoperiod Manipulation

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Abstract

Soil salinity is a major limiting factor for crop production in coastal areas of Bangladesh. Cheap and sustainable management of soil salinity is hence most sought out topics in agricultural research. Conceptualizing that idea in mind, a pot experiment was conducted in the Department of Soil, Water & Environment, University of Dhaka in order to analyze if common organic amendments (rice straw, saw dust) coupled with reduce photoperiod can mitigate salinity effect on the growth of bean (*Phaseolus vulgaris*). The experiment was set up following completely randomized design (CRD) with nine treatments and three replications containing Tc (Control), T1 (Ambient photoperiod + 110 mM Salinity treatment + Rice straw), T2 (Reduced photoperiod + 110 mM Salinity treatment + Rice straw), T3 (Ambient photoperiod + 220 mM Salinity treatment + Rice straw), T4 (Reduced photoperiod + 220 mM Salinity treatment + Rice straw), T5 (Ambient photoperiod + 110 mM Salinity treatment + Saw dust), T6 (Reduced photoperiod + 110 mM Salinity treatment + Saw dust), T7 (Ambient photoperiod + 220 mM Salinity treatment + Saw dust) and T8 (Reduced photoperiod + 220 mM Salinity treatment + Saw dust). Organic amendments were used separately at the rate of 12 ton/ha. The highest plant height (98.67 cm), root length (12.5 cm), pod number (10.33), leaf area (13.99 cm^2), fresh weight (680 kg/ha), dry weight (316.67 kg/ha) were recorded with the treatment T1 while the second-best treatment was treatment T2 (with highest harvest index 0.040) and these results were statistically significant ($p < 0.001$). In post-harvest soil, pH, EC, OC, OM; available N, P, K, S; total Ca, Mg, Zn, Mn were increased significantly in treatment T1. The overall results illustrated that the best growth and yield performances were achieved in the treatment T1 and T2.

Keywords

Phaseolus vulgaris, Rice Straw, Saw Dust, Salinity Treatment, Photoperiod

1. Introduction

Salt-affected soils cover an area of around 1060.1 Mha in the world and has been gradually increasing due to increase in sea level intrusion and rise in day time temperature, decrease in precipitation etc. climate change events as well as factors like environmental degradation, poor irrigation practices, poorly regulated fertilizer use, and industrial pollution also contribute to this [1]. Being a deltaic plain with a very flat, low topography, soil and water salinity are the major limitations for agricultural production in the coastal areas of Bangladesh [2]. Salinity affected land in coastal belt was recorded 102 Mha, which were increased to 105.6 Mha in 2009 [3]. Over the last 35 years, salinity has increased by around 26% in the coastal region of Bangladesh [4]. There are several methods to reclaim a salt-affected soil, including salt leaching, soil ripping, salt scrapping, addition of amendments, and revegetation using halophytes. Salt leaching is the most important method among the aforementioned strategies. However, its efficacy depends on soil physico-chemical conditions and climatic conditions of the site. Leaching may result in imbalanced ion content of the soil and thus negatively affect soil conditions [5] [6]. All these mentioned methods for reclamation of saline soil is both expensive and time-consuming, therefore, comparatively available and cheaper method is most desirable to solve this problem. That is why organic amendments such as rice straw, saw dust, wood shavings, etc. can be a better option for amelioration of soil salinity and improvement of soil physical and chemical characteristics.

Rice straw is an organic crop residue available in greater quantities for farmers. Rice straw contains numerous elements essential for plant growth, including nitrogen, phosphorus, and potassium [7] and saw dust is a substance containing high carbon and nitrogen content which helps potentially to act as a carbon source for increasing soil organic matter. Addition of rice straw is expected to mitigate the harmful effects of salinity on crop growth by improving nitrogen cycling and others nutrient availability in soil [8]. It has also been reported to increase soil fertility through accumulation of organic carbon under saline condition [9]. Besides, different mechanism of rice straw application in soil provides different results in soil physical and biochemical properties. Rice straw incorporation in soil macro and micro aggregate with different water regimes provided differential effect on soil properties like decreasing enzyme activity with high water content but increasing aggregation [10]. Application in the form of biochar decreases sorption capacity of phosphorus as well as reclaim acid soil [11]. Rice straw biochar has been reported to remediate certain heavy metal (like cadmium and led) toxicity in soil but method of biochar production highly influenced the process [12] [13]. Long-term application of rice straw compost in combination with gypsum [14] and rice straw biochar alone has been reported [15] to alleviate soil salinity in some extent but application of rice straw only after drying (which is less expensive and less time consuming than compost or biochar) to reclaim salinity has not been reported.

Responses to the relative duration of day and night length, known as photoperiod. Photoperiodic responses in plants are reflected in a diverse set of traits, including vegetative growth period extension, bud set, switch to development of flowers, fruit set and seed production, tuberization, changes in chemical composition and in enzyme activity. Photoperiod regulation has been most effective in onset of flowering and seed setting which in term affects yield and taste in different legumes like bambara groundnut, soybean, fava bean, lentil and common bean [16] [17]. The amount of solar radiation is higher in summer than in winter and so the evaporation rate is also higher which results in soil salinity. So, we can use the salt affected soil for crop yield in winter in combination with addition of organic amendments.

Under this condition, legume can be the best option as legumes have long been recognized and valued as "soil building crop". Besides this, legumes have root-nodules which contain nitrogen fixing rhizobia acting as an additional nitrogen source for plant and soil also. Considering all the constraints induced due to salinity level in the coastal areas and the problems related to the reclamation of saline soils, the main objectives of this research work are: i) To assess the interactive effects of solar radiation, organic amendments and salinity treatment on growth of leguminous crop (bean); ii) To evaluate cost effective organic amendments to reduce harmful effect of salinity on plant growth; iii) To assess the nutrient status of salt-affected soil; iv) To assess the growth and yield parameters of plant under salinity stress after using organic amendments.

2. Materials and Method

2.1. Selection of Soil Sampling Site

The soil sample was collected from Village Joypura, Dhamraiupazilla of Dhaka district.

Dhamrai Upazila (dhaka district) area of 303.36 sq km, located in between 23˚49' and 24˚03' north latitudes and in between 90˚01' and 90˚15' east longitudes. The sampling soil belongs to the Young Brahmaputra and Jamuna floodplain. The texture of top soil of the locality is basically silty loam. The soil is a heterogeneous assortment of dry, moist and clay material. The structure of soil is medium angular to sub-angular, blocky and granular.

2.2. Preparation and Processing of the Soil Sample

After collection the soil sample, the soil sample was air-dried for 3 days by spreading in a thin layer and then hammered to make the clods smaller. Visible roots and debris were discarded from the soil sample. After that, larger and massive aggregates were broken down into smaller aggregates by gently crushing them using a wooden hammer. The ground samples were screened through a 2mm stainless steel sieve. The sieved sample was then stored into plastic containers in a cool dry place in the laboratory for background analysis and pot experiment.

2.3. Collection and Preparation of Organic Amendments

Two different types of organic amendments were collected for use. Rice straw was collected from Sonakanda, Daudkandi in the district of Comilla and saw dust was collected from saw mills at the Sonirakhra, Dhaka. After collection, the materials were packed in polythene bags and the bags were tied with strings to prevent any air-exchange between atmosphere and the sample itself. The bags were labeled with markings of date, time, name of collection site etc. Rice straw and saw dust were prepared for applying in the soil by drying and grinding. First the rice straw was dried in the oven at 70˚C for two days. When the sample was fully dried, the sample was cut into small pieces for suitable form of application. Finally the sample was preserved in the jar and labeled. The saw dust was spread into a sheet and dried exposed to the sun. The air-dried saw dust was also preserved in the jar for applying into the soil. The background chemical analysis was done for each type of amendments following standard method, listed in Table 1.

2.4. Experimental Design and Treatment Combination

In order to study the combined effects of salinity treatment (two levels of salt solution), photoperiodic response (two level of light exposure), and organic amendments e.g. Rice straw and saw dust, nine different treatments were applied in this experiment, namely, Control (TC), Ambient photoperiod with 110 mM salt solution with rice straw (T1), Reduced photoperiod with 110 mM salt solution with rice straw (T2), Ambient photoperiod with 220 mM salt solution with

Table 1. Chemical composition of different organic amendments.

Nutrient (%)	Rice straw	Saw dust
Total Nitrogen	1.851	0.220
Total Phosphorous	0.074	0.190
Total Potassium	0.879	1.185
Total Sulfur	0.230	0.119
Total Calcium	0.289	0.219
Total Magnesium	0.261	0.036
Total Sodium	0.151	0.327
Total Zinc	0.006	0.004
Total Manganese	0.008	0.002
Total Iron	0.006	0.005

rice straw (T3), Reduced photoperiod with 220 mM salt solution with rice straw (T4), Ambient photoperiod with 110 mM salt solution with saw dust (T5), Reduced photoperiod with 110 mM salt solution with saw dust (T6), Ambient photoperiod with 220 mM salt solution with saw dust (T7), Reduced photoperiod with 220 mM salt solution with saw dust (T8). A total of 27 pots with three replications were used to set up the experiment in the net-house of the department of Soil, water and Environment at the University of Dhaka following a complete randomized design.

2.5. Pot Preparation and Crop Variety Selection

Four kilogram (4 kg) of composite soil samples were taken in each five kilogram (5 kg) plastic pot for the culture of bean seeds and growth of bean plants. Each pot was marked in accordance with the treatments using a black color marking pen for the purpose of further crop analysis. A winter crop locally known as "Shim", *Phaseolus vulgaris* was selected for this purpose.

2.6. Rate of Organic Amendments Application

Two types of organic amendments (rice straw and saw dust) were applied in the soil at the rate of 12 ton/hectare. Approximately 21.41 g amendment was mixed in each pot of 4 kg soil according to the treatment combination.

2.7. Preparation of Salinity Treatment

Sea water was artificially simulated with the help of NaCl and MgCl. The artificial saline water having salt concentrations 110 mM and 220 mM was prepared in the laboratory as these concentrations represented moderate and high salinity condition found in the coastal region of the country 110 mM salt solution was prepared by dissolving 5.457 g NaCl and 1 g MgCl in 1000 ml water and 220 mM solution was prepared by dissolving 11 g NaCl and 1.914 g MgCl in 1000 ml water. In this experiment, plants were exposed to saline condition of soil by the addition of artificial salt solution.

2.8. Crop Management

Registered seeds of *Phaseolus vulgaris* were collected from local seed market Siddique Bazar, Dhaka. To complete the seed pretreatment, the seeds were mixed in water with malathion and were kept overnight. Seven seeds per pot were sown. After the germination of seeds, two plants were kept in each pot. During this period, the pots were irrigated with water and thereafter the pots were kept exposed to constant levels of salinity stress. Weeds were controlled by uprooting. Insecticide (malathion) was sprayed twice (after 30^{th} and 40^{th} days respectively) during the growing period to control pest.

2.9. Harvesting

Plants were harvested after 95 days of sowing after the development of pod and fruit. All the plant samples were washed twice carefully first with water and then with distilled water to remove the dust. Then the fresh weight and fresh plant height and root length of all the samples were measured using meter scale and noted down.

2.10. Plant Samples Preparation

The collected plant samples were separated into two parts-root and shoot for further analysis. Then the samples were air-dried as well as oven dried at 70˚C for two days in the microwave oven and the dried samples were grinded with mortar and pestle. The dry weights were recorded with the help of electric balance. Then the samples were passed through 0.25 mm sieve and stored in plastic containers for further chemical analysis.

2.11. Study of Growth and Yield Parameters

Different growth parameters such as pod number, node number, plant height, root length, shoot-root ratio, and leaf area were measured. The leaf area has been calculated using the linear equation LA (Leaf area) = 11.98 + (0.06*L*W) where L = length of leaf and W = width of leaf [18]. Different yield parameters such as fresh weight, dry weight, harvest index also was recorded. Harvest had been calculated using the formula: Harvest index = weight of grain/(dry weight of plant+ weight of grain).

2.12. Chemical Analysis of Plant Samples

The total nitrogen of plant sample was determined by Kjeldahl's method following concentrated Sulfuric acid digestion. The total phosphorous content was determined colorimetrically using spectrophotometer at 490 nm wavelength. The concentration of total potassium and sodium was determined from the digest directly by a flame photometer. Total Sulfur concentration was estimated by Turbidimetric method using a spectrophotometer at 420 nm wavelength. The total calcium and magnesium content of the soil samples were determined by Atomic Absorption Spectroscopy [19]. Heavy metals like Fe and Mn contents of the soil were determined by Atomic Absorption Spectrophotometer (AAS) [19].

2.13. Computation of Nutrient Uptake

After chemical analysis of root, shoot and bean seeds samples, the nutrient uptake was calculated. The nutrient uptake was calculated using the following formula:

$$\text{Nutrient Uptake (kg/ha)} = \frac{\text{Nutrient content}(\%) \times \text{Dryweight}(\text{kg/ha})}{100}$$

2.14. Analysis of Organic Amendments and Background Soil Sample

Different physical, chemical properties of the amendments (**Table 1**) and soil sample were analyzed using standard method as mentioned earlier. Determination of pH was done taking amendment and water in the ration 1:2.5 and the nutrient contents were measured using the same method as mentioned earlier in plant sample analysis. Moisture content of air-dried soil was determined by oven drying at 105˚C for 24 hours until constant weight was obtained and the moisture percentage was calculated from the loss of moisture from the samples. Particle size analysis of the soil sample was done by Hydrometer method. Textural classification was determined by Marshall's Triangular Co-ordinates. The electrical conductivity of collected soils was measured at a ratio of 1:5 by an EC Meter [20]. Organic carbon of the soil samples was determined by wet oxidation method of Walkley and Black [21]. Organic matter content was determined by multiplying the percent value of organic carbon with the conventional Van-Bemmelen's factor of 1.724. Total nitrogen of the soil samples was determined by Kjeldahl's digestion and available nitrogen was extracted by 1 N KCl and was determined by Distillation using 40% NaOH and Devarda's alloy, and collected over 4% Boric acid mixed indicator solution, followed by a titration against 0.02 N H_2SO_4. Available phosphorous of soil was extracted using Olsen method following the blue color method using Ascorbic Acid [19]. The available potassium was determined by flame analyzer after extracting the samples with 1N ammonium acetate at pH 7. The available sulfur content was determined by suspended Barium sulfate using Tween-80 as stabilizer extracting with Calcium di-hydrogen phosphate $Ca(H_2PO_4)_2$ solution and the turbidity was measured by spectrophotometer, at 420 nm wavelength. Total Ca, Mg, Fe, Na and Zn in the soil was measured as mentioned for the plant sample.

2.15. Data Analysis

All the data in the present experiment were statistically analyzed using Microsoft Excel (2010) and SPSS (version 20). The results of the experiment were statistically evaluated in the form one-way analysis variance (ANOVA).

3. Results

3.1. Effects of Different Treatments on Growth Stages and Parameters

The potentiality of organic amendments in reclaiming soil provided with saline treatment and effects of solar radiation on growth of bean are the major consideration of the present research study. The growth of plants is an irreversible, quantitative and qualitative increase of size and mass and/or volume of a plant or its parts and nutrient concentration on its root, shoot and fruit. The growth stages of *Phaseolus vulgaris* under different photoperiodic condition and salinity level was recorded in **Table 2**. It can be illustrated that to reach on every stage of vegetative and reproductive growth of bean plant, it took longer time period under reduced day length than under the ambient condition. It can be assumed that the plant's physiological and morphological metabolism might be hindered due to reduction of day length and higher salinity treatment application. But

Table 2. Growth stages at DAS (days after sowing) of *P. vulgaris* under different salinity treatment and photoperiodic condition.

Growth stages	Code	Days after sowing (DAS)				
		S0 (control)	S1 (low salinity)		S2 (High salinity)	
			A.P	R.P	A.P	R.P
Germination	V0	0 - 6	0 - 8	0 - 12	0 - 14	0 - 16
Emergence	V1	6	8	12	14	16
Primary leaves	V2	9	14	17	21	22
First trifoliate leaf	V3	16	20	20	26	30
Third trifoliate leaf	V4	24	26	30	33	36
Pre-flowering	R5	36	41	43	45	44
Flowering	R6	43	44	47	48	50
Pod formation	R7	47	49	48	52	53
Pod filling	R8	55	57	60	68	72
Maturity	R9	85	87	89	94	96

A.P = Ambient photoperiod; R. P = Reduced photoperiod.

ambient photoperiod condition might help the plant to complete its vegetative and reproductive growth timely and to give better yield.

Different treatments were found to affect different growth parameters such as plant height, root length, leaf area significantly, as significant differences ($p < 0.001$) were observed with each treatment (**Table 3**). Plant heights were significantly increased over T_C (Control) for the treatments T1, T2, T5, T6. The maximum plant height (98.67 cm) was recorded in T1 treatment which is 24.90% higher over TC (Control). Plant height was consistently lowest from germination to maturity for the treatment T3, T4, T7 and T8. There is no significant difference between TC (Control) and these four treatments T3, T4, T7 and T8. From the Duncan's Multiple Range Test (**Figure 1**), it was observed that T1 and T2 treatments are significantly varied from other treatments at 5% level. Plant heights were found to be increased significantly with the application of rice straw at ambient photoperiodic condition and lower salinity level. In case of root length treatments T1 and T2 were found to be increased over TC (Control). There is no significant difference between TC (Control) and other treatments, although all treatment were significantly varied at 5% ($p < 0.01$). In case of leaf area, the effects of treatment T1 was found to be most effective in obtaining highest root length (13.99 cm^2) which is 3.17% higher than TC (Control). The lowest leaf area (12.49 cm^2) was recorded in the T3 which decreased 7.89% over TC. Surprisingly; there is no significant difference among the treatments TC, T2, T5, and T6. From the DMRT test it (**Figure 2**) was found that T1 is the only treatment varying significantly from other treatments ($p < 0.001$). The shoot-root ratio was observed highest for T1 and lowest for T4. But all the treatments showed no significant difference at LSD 5% level. Pods which help to encapsulating the developing seeds from pest and pathogens were affected significantly by various treatments. The maximum pod number was recorded in T1 which

Table 3. Growth performances of *P. vulgaris* in response to different treatments.

Treatment	Plant height (cm)	Root length (cm)	Leaf Area (cm^2)	Pod number per plant	Shoot-root ratio (length basis)	Node number per plant	Harvest Index
T0	79	10.4	13.56	7.33	7.50	9	0.028
T1	98.67	12.5	13.99	10.33	7.89	16	0.038
T2	90.67	11.57	13.58	9.33	7.83	14	0.040
T3	64.67	8.93	12.49	5.33	7.24	6.33	-
T4	70.67	9.83	12.64	5.67	7.19	8	-
T5	83.33	11	13.60	8.67	7.58	12	0.035
T6	85.33	11.20	13.61	9.67	7.62	13	0.033
T7	71.33	9.60	12.58	6.33	7.42	10	-
T8	70.67	9.77	12.72	7	7.21	7	-
LSD at 5%	5.20	0.89	0.37	1.10	NS	1.84	0.004

Tc = Control, T1 = Ambient Photoperiod + 110 mM Salinity treatment + Rice straw, T2 = Reduced Photoperiod + 110 mM Salinity treatment + Rice straw, T3 = Ambient Photoperiod + 2200 mM Salinity treatment + Rice straw, T4 = Reduced Photoperiod + 220 mM Salinity treatment + Rice straw, T5 = Ambient Photoperiod + 110 mM Salinity treatment + Saw dust, T6 = Reduced Photoperiod + 110 mM Salinity treatment + Saw dust, T7 = Ambient Photoperiod + 220 mM Salinity treatment + Saw dust, T8 = Reduced Photoperiod + 220 mM Salinity treatment + Saw dust.

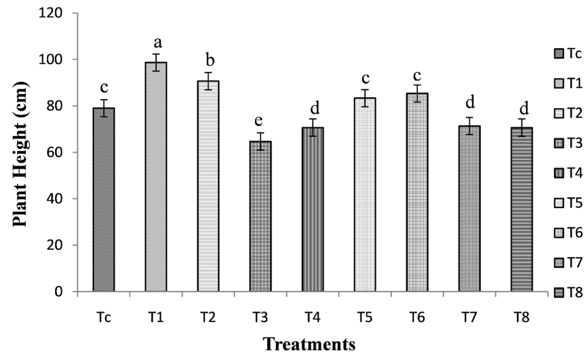

Figure 1. Plant height in response to different treatments (The notations followed by the different letter in Duncan's Multiple Range Test are significantly different at 5% level and LSD = 5.20).

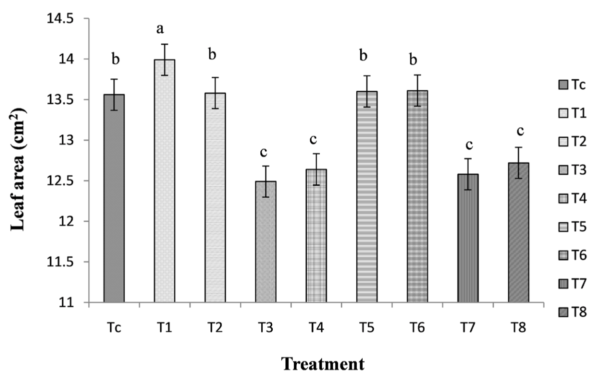

Figure 2. Lear area (cm^2) in responses to different treatments (The notations followed by the different letter in Duncan's Multiple Range Test are significantly different at 5% level and LSD = 0.37).

increases 40.93% over control. The lowest pod number was found in T3 which was not varied significantly at LSD 5% level with control.

3.2. Effects of Different Treatments on Yield Responses

To quantify the plant responses to environmental condition and the applied treatments, relative yield responses such as fresh weight (kg/ha), dry weight (kg/ha), harvest index etc. of *Phaseolus vulgaris* were recorded and shown in (**Figure 3**, **Figure 4**). The maximum fresh weight and dry weight were observed in T1 followed by T2, T6, and T5 respectively (**Figure 3**). The lowest fresh and dry weight was observed in T3 which is decreased 45.03% and 49.25% over Control respectively. All the treatments for the fresh and dry weight were found significant statistically ($p < 0.001$). The analysis of the data of fresh and dry weight revealed that the application of rice straw at ambient photoperiod condition was the most effective treatment for yield response of *P. vulgaris.* The DMRT test of fresh weight indicated that there is no significant difference between TC, T2, T5 and T6. In case of harvest index, T3, T4, T7 and T8 showed no results due to fruitlet drop related with higher salinity level (**Table 3**). The highest harvest index was recorded in T2 which is 42.86% higher over control. Here, TC (Control) were found to be significantly different at 5% level ($p < 0.001$). But other treatments containing same notation letter (**Figure 4**) were not found to be significantly different.

3.3. Effects of Different Treatments on Nutrient Uptake (kg/ha)

The nutrient uptake refers to the process of nutrient movement from an external environment into a plant. Nutrients that are mobile in plants include basic

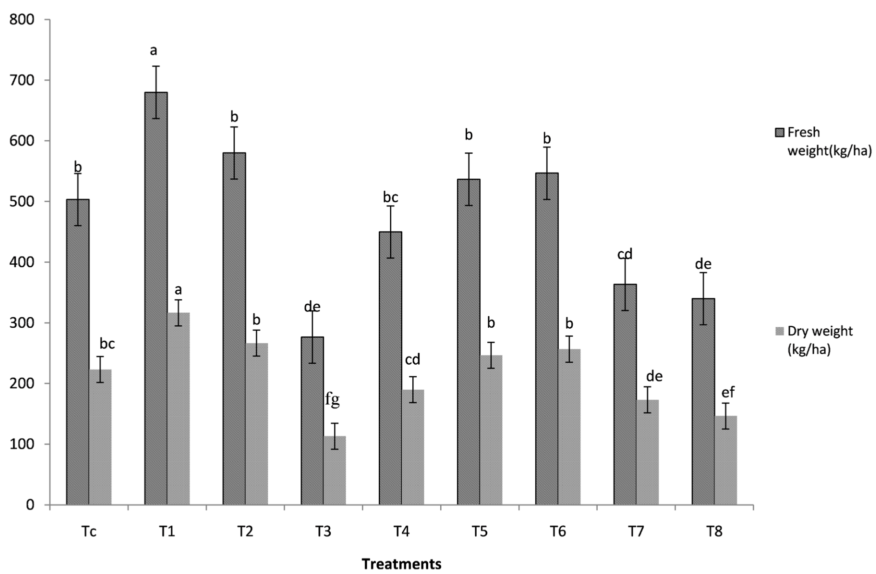

Figure 3. Fresh weight and dry weight (kg/ha) of *P. vulgaris* in response to different treatment where T1 treatment appeared to be significantly different from all other treatment for both fresh weight and dry weight ($p < 0.001$).

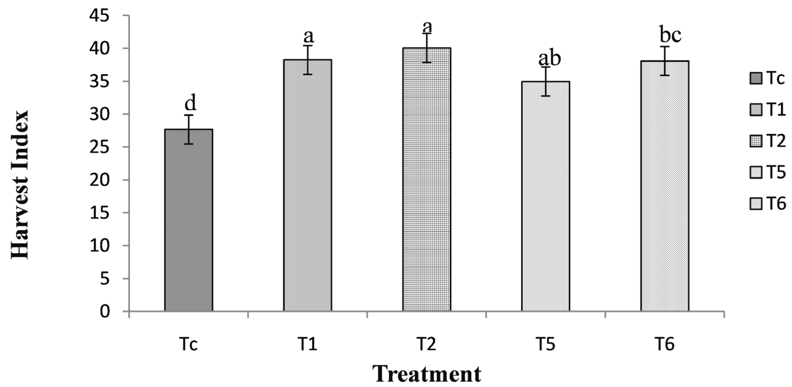

Figure 4. Harvest Index in response to various treatments (The notations followed by the same letter in Duncan's Multiple Range Test are not significantly different at 5% level).

N-P-K-S primary macronutrients; nutrients that are immobile in plants include the secondary macronutrients Ca and Mg and most of the micronutrients. The results of this experiment showed that the uptake of macronutrient and micronutrient by *P. vulgaris* was affected by different treatment presented in Table 4. The macronutrient (N-P-K-S-Ca-Mg) uptake was recorded highest for T1 treatment followed by the treatment T2. The results showed significant difference between all the treatments statistically at LSD 5% level. The lowest macronutrient uptake was found in T3 perhaps due to higher salinity level. In case of micronutrient uptake, the maximum uptake value was accounted for Zn, Mn and Fe in the T1 treatment followed by T2, T6 and T5 respectively. The highest Sodium uptake was observed in T4 treatment which is increased 172.84% over Control.

Table 4. Nutrient uptake (Kg/ha) by *P. vulgaris* in response to various treatments.

Treatments	Macronutrients						Micronutrients			
	N uptake (kg/ha)	P uptake (kg/ha)	K uptake (kg/ha)	S uptake (kg/ha)	Ca uptake (kg/ha)	Mg uptake (kg/ha)	Zn uptake (kg/ha)	Mn uptake (kg/ha)	Fe uptake (kg/ha)	Na uptake (kg/ha)
T0	9.94	0.75	5.42	1.26	9.29	1.68	0.025	0.019	0.053	0.81
T1	22.73	2.57	14.86	3.1	20.44	2.83	0.039	0.054	0.111	1.52
T2	18.06	1.94	11.04	2.31	15.7	2.15	0.030	0.039	0.088	2.01
T3	1.51	0.033	0.65	0.16	1.36	0.51	0.004	0.004	0.002	1.26
T4	2.84	0.048	1.80	0.40	2.57	1.17	0.011	0.007	0.025	2.21
T5	16.2	1.51	9.31	1.61	11.55	2.14	0.027	0.031	0.062	1.50
T6	16.31	1.66	8.24	1.90	13.14	1.97	0.029	0.035	0.068	1.97
T7	2.94	0.09	2.21	0.44	2.64	0.85	0.010	0.007	0.009	1.90
T8	2.02	0.05	1.56	0.26	2.54	0.70	0.009	0.006	0.005	1.55
LSD at 5%	0.30	0.18	0.29	0.06	0.37	0.07	0.0009	0.0013	0.0033	0.4419

Tc = Control, T1 = Ambient Photoperiod + 110 mM Salinity treatment + Rice straw, T2 = Reduced Photoperiod +110 mM Salinity treatment + Rice straw, T3 = Ambient Photoperiod + 2200 mM Salinity treatment + Rice straw, T4 = Reduced Photoperiod + 220 mM Salinity treatment + Rice straw, T5 = Ambient Photoperiod + 110 mM Salinity treatment + Saw dust, T6 = Reduced Photoperiod + 110 mM Salinity treatment + Saw dust, T7 = Ambient Photoperiod + 220 mM Salinity treatment + Saw dust, T8 = Reduced Photoperiod + 220 mM Salinity treatment + Saw dust.

3.4. Effects of Different Treatments on the Physiochemical and Chemical Properties of Post-Harvest Soil

Post-harvest soil samples were analyzed in comparison with the initial soil characteristics to see the changes occurs in different physiochemical properties pH, EC, Organic Carbon, Organic Matter, available N, P, K, S and other micronutrients as well presented in Table 5 & Table 6.

Table 5. Changes in pH, EC, OC and OM in initial and post-harvest soil samples in response to various treatments.

Treatment	pH	EC (mS/m) from 0 to 120 days of plant growth						Organic carbon %	Organic matter %
		0 - 20	20 - 40	40 - 60	60 - 80	80 - 100	100 - 120		
Initial soil	7.19			0.68				0.34	0.59
T0S0	7.19	0.46	0.58	0.67	0.62	0.54	0.44	0.93	1.46
T1S1	7.52	1.02	1.30	2.16	1.68	1.12	0.86	1.54	2.66
T2S1	7.47	0.70	0.92	1.51	2.13	1.83	1.12	1.35	2.33
T3S2	7.69	1.60	2.28	6.44	3.84	2.54	1.90	0.64	1.11
T4S2	7.75	1.37	2.22	4.72	2.92	2.14	1.96	1.03	1.77
T5S1	7.52	0.86	1.08	1.44	2.52	1.42	0.75	1.12	1.93
T6S1	7.50	0.62	0.93	1.62	1.53	1.23	1.02	1.20	2.06
T7S2	7.62	1.83	2.11	3.97	5.33	2.74	2.0	0.89	1.39
T8S2	7.92	1.50	2.92	6.32	4.17	2.67	2.14	0.77	1.33
LSD at 5%	0.03	0.04	0.04	0.05	0.22	0.03	0.03	0.06	0.15

Tc = Control, T1 = Ambient Photoperiod + 110 mM Salinity treatment + Rice straw, T2 = Reduced Photoperiod + 110 mM Salinity treatment + Rice straw, T3 = Ambient Photoperiod + 2200 mM Salinity treatment + Rice straw, T4 = Reduced Photoperiod + 220 mM Salinity treatment + Rice straw, T5 = Ambient Photoperiod + 110 mM Salinity treatment + Saw dust, T6 = Reduced Photoperiod + 110 mM Salinity treatment + Saw dust, T7 = Ambient Photoperiod + 220 mM Salinity treatment + Saw dust, T8 = Reduced Photoperiod + 220 mM Salinity treatment + Saw dust.

Table 6. Available nutrient status in post-harvest soil samples (all the results are in mg/kg unit).

Treatment	N	P	K	S	Ca	Mg	Na	Mn	Zn
Initial soil	1153.7	69.4	165.0	191.8	698.9	73.8	395	584.8	88.3
T0	1302.3	57.7	256.7	186.3	1366.9	418.9	428.3	478.3	87.1
T1	3013.3	213.3	456.7	228.9	1874.2	423.8	482.3	736.3	91.7
T2	2770.3	193.3	430.0	200.0	1797.2	360.5	390.0	689.8	88.6
T3	784.0	20.0	146.7	151.0	992.1	595.7	1860.0	454.6	71.8
T4	1392.7	36.7	193.3	175.4	1178.7	644.0	2151.7	459.9	78.3
T5	2534.7	173.3	403.3	216.5	1625.7	328.8	376.7	620.1	87.9
T6	2584.7	150.0	368.3	209.9	1523.7	290.5	356.7	699.3	88.4
T7	1455.7	65.3	186.7	168.2	1430.4	885.7	1446.7	416.3	71.9
T8	865.0	49.3	91.7	112.7	965.2	1012.2	1680.0	447.9	64.2
$LSD_{(0.05)}$	26.6	1.8	17.2	3.5	12.6	24.0	19.7	22.5	2.0

Tc = Control, T1 = Ambient Photoperiod + 110 mM Salinity treatment + Rice straw, T2 = Reduced Photoperiod + 110 mM Salinity treatment + Rice straw, T3 = Ambient Photoperiod + 2200 mM Salinity treatment + Rice straw, T4 = Reduced Photoperiod + 220 mM Salinity treatment + Rice straw, T5 = Ambient Photoperiod + 110 mM Salinity treatment + Saw dust, T6 = Reduced Photoperiod + 110 mM Salinity treatment + Saw dust, T7 = Ambient Photoperiod + 220 mM Salinity treatment + Saw dust, T8 = Reduced = Photoperiod + 220 mM Salinity treatment + Saw dust.

Different treatment application caused changes in both initial soil and post-harvest soil. The maximum pH value was found in T_8 treatment with application of saw dust under higher salinity level. The results showed that the pH of the soil samples increased with the higher salinity treatment. All results were found statistically significant at 5% level.

EC, an important indicator of soil health, was measured during cultivation time at 20 days interval (Table 5). The highest EC, 6.44 mS/cm was recorded in T3 during 40 - 60 days of cultivation. But the EC was decreased as a result of decomposition of rice straw and production of organic acid to a level of 1.9 mS/cm after 15 days of harvesting. The lowest EC, 0.75 mS/cm was recorded in T5 in post-harvest soil samples. From the graph (Figure 5), it might be assumed that the EC level was gradually increased from the initial level to a highest peak point and after almost 2 months of decomposition of organic amendments the EC was decreased sequentially to a balanced level in all treatments. All the results were found to be statistically significant ($p < 0.001$).

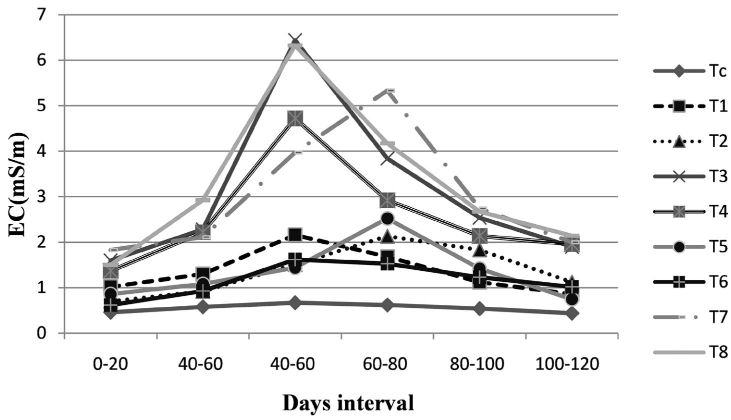

Figure 5. Changes of EC (mS/m) at 20 days interval during experiment.

Soil organic carbon and organic matter makes up just 2% - 10% of most soil's mass and has an important role in the physical, chemical and biological function of agricultural soils. Soil organic carbon in the experimental soil samples was changed greatly due to application of different treatments. Soil organic carbon and organic matter were increased significantly among all the treatments ($p < 0.001$) while the highest OC and OM % were found 1.54 and 2.66 discretely which were observed in T1 and the lowest OC and OM% were 0.64 and 1.11% in T3.

Addition of organic amendments under two type of salinity level affected the nutrient concentration in post-harvest soils greatly (Table 6). In case of nitrogen, the most limiting factor for crop growth, the maximum available nitrogen percentage (0.30%) was observed in T1 which showed significant difference with control and other treatments ($p < 0.001$). The available P content increased for all the treatments from initial soil except control. The highest P was found in T1 followed by T2 and the lowest P content was observed in T3 which is 65.38%

lower than control. Exchangeable potassium is readily available potassium, which plants can easily absorb. The highest K content was observed in T1 which is increased 77.91% over control. Available S content of post-harvest soil samples was increased significantly over control for all treatments except T3, T4, T7 and T8. The maximum S content was recorded in T1 which is 22.93% higher over control while the lowest S content was observed in T8. The highest available Ca was recorded in T1. The minimum Ca content was recorded in T8which was drastically reduced from the control and initial soil sample. The exchangeable Mg is increased significantly as it was provided in the form of salt solution treatments. The highest Mg was recorded in T8, while the lowest Mg content was observed in T6. Like other nutrient, the micro nutrient such as Zn, Mn were also increased for all treatments over control except T3, T4, T7 and T8. All the results showed significant difference between all the treatments ($p < 0.001$). The maximum Na content which was observed in T4. The application of organic amendment reduces salinity and sodium toxicity in other treatments. The application of organic amendments to soils caused an increase in exchangeable cation comparing with un-amended control and increased adsorption of Ca^{2+}, Mg^{2+}, and K^+ at the expense of Na^+.

4. Discussion

The above analyzed pot experiment on bean variety (*Phaseolus vulgaris)* had been carried out to appraise the consequences related to salinity hazard, the effects of day length, organic amendments and salinity treatments on the growth of Bean (*Phaseolus vulgaris*), the beneficent side of cultivating legume in problem soil. The distinctive parameter which were studied in this research task are plant height, root length, node number per plant, leaf area, pod number per plant, fresh weight, dry weight, harvest index, nutrient uptake (kg/ha) by plant, physical and chemical characteristics of initial and post-harvest soil samples. The results of the experiment showed that all the growth and yield parameters were significantly increased for application of organic amendments at lower salinity level in comparison to control and treatment of higher salinity level. The maximum plant height (98.67 cm), root length (12.5 cm), node number per plant (16), leaf area (13.99 cm^2), pod number per plant (10.33), fresh weight (680 kg/ha), dry weight (316.67 kg/ha) were recorded in T1 (Ambient photoperiod with 110 mM salt solution with rice straw)which were significantly increased over control. The maximum harvest index (0.04) was recorded in T2 (Reduced photoperiod with 110 mM salt solution with rice straw.

Results of a different study revealed that application of rice straw biochar in addition to low nitrogen fertilizer had significantly ($p \leq 0.05$) increased the growth of *B. nivea* in terms of biomass, height of plant, diameter of stem and number of leaves. Another study showed that that chlorophyll content and gas exchange parameters in leaves were significantly higher at with 10% rice straw biochar application than in control [22].

The highest macro and micro nutrient uptake were found for the T1 treatment followed by T2. In comparison with sawdust amendments application, the application of rice straw has showed better result in macro and micro nutrient uptake of plant. Correlation indicates the growth parameters and the nutrient uptake showed highly positive correlation with each-other. Plant height showed very highly significant correlation with root length, leaf area, pod number, dry weight, harvest index (R = 0.99, R = 0.94, R = 0.96, R = 0.97, R = 0.91) sequentially. All of the growth attributes are significant at 1% level according to Pearson 2-tailed test. Plant height was observed to be closely influenced by the uptake of N, P, K, S where the coefficient values were R = 0.98, R = 0.98, R = 0.99, R = 0.99 respectively. Yield attributes specifically dry weight (kg/ha) and harvest index exhibited highly positive correlation with macronutrient uptake. From the discussion, it may be assumed that with the increasing supply of macronutrient content specifically N and S the growth attributes and yield performances may be increased. Among the major nutrient, nitrogen uptake showed highly positive correlation with all the growth attributes like plant height, root length, leaf area, pod number, dry weight and harvest index where coefficient value were 0.98, 0.97, 0.96, 0.95, 0.96 and 0.96 respectively. P uptake showed highly positive correlation with the uptake of Nitrogen where R = 0.994 and then secondly positive relation with K uptake (R = 0.991) and in both cases the values were significant at 1% level. Plant height and S uptake showed positive relation also where R = 0.99 and it indicated that under saline condition plant height largely depend on S uptake apart from N.A study showed that organic amendments are important for retaining nutrients and making them available to plants [23]. Other researchers speculated that improved N availability upon rice straw application was due to reduced nitrification-denitrification losses [24].

It was observed that the application of organic amendments in combination with photoperiodic condition helped to reduce EC, increase organic carbon and organic matter and availability of essential nutrients for plant growth and ameliorate harmful effects of salinity on plant growth. A research showed that rice straw incorporation increases soil organic matter [25]. Rice straw incorporation also markedly increased SOC, by an average of 22% [26]. The results indicated that the addition of rice straw in combination with ambient photoperiodic condition helped to lower salinity stress and improve plant growth better than saw dust. Barzegar *et al.*, (1997) found that the application of organic matter to saline soils can accelerate Na^+ leaching, increase the percentage of water-stable aggregates, and decrease the ESP, EC, and soil salinity [27]. Another study showed that the EC values reduced 2.87 dS/m to 1.95 dS/m is a naturally saline soil due to application of rice straw [22]. Similarly, Iqbal *et al.*, (2016) found that addition of rice straw reduced the salinity within Bangladeshi saline paddy soil [28].

The maximum nutrient availability was found for T1 treatment followed by T2 treatment which indicated that application of rice straw at any photoperiodic condition might help to restore nutrient availability in post-harvest soil rather than addition of saw dust. A study showed that the total soil N concentration increased by 10.4% due to incorporation rice straw in a paddy soil [29]. A study speculated that the incorporation of rice straw within saline soil increase the activity of phosphatase [30]. A 30-years field trial conducted by Liao *et al*., 2013 indicated that straw management could increase exchangeable K by 26.4%) [31]. It has also been reported from a study that the iron, manganese, copper, boron and zinc concentration is increased in post-harvest soil due to application of rice straw as an amendment [32]. The availability of sodium was highest for the treatment T4 due to higher level of salt solution addition. The application of rice straw and ambient photoperiodic condition was appeared to be more effective in ameliorating harmful effects of salinity treatment and increasing growth and yield response of bean.

5. Conclusions

From the study, it was cleared that the best results for growth and yield parameter of plants as well as physical and chemical properties of post-harvest soil were observed in the treatment of combination of ambient photoperiodic condition with addition of 110 mM salt solution and rice straw (T1) which indicates moderate level of salinity can be mitigated with rice straw application without photoperiod manipulation.

The second-best results were showed by the combination of reduced photoperiodic condition with addition of 110 mM salt solution and rice straw in context to harvest index. Although application of saw dust under 110 mM salinity level showed also good results, results obtained by the application of rice straw at two photoperiodic condition appeared better than it. It might be indicated that the compilation of rice straw at any photoperiodic condition appeared to be the better treatment in reducing salinity stress on plant growth. Bangladesh is a deltaic country and has many coastal fallow lands where cultivation is not possible due to salinity stress. For this reason, use of relatively inexpensive organic amendment and photoperiodic manipulation and legume cultivation may be an effective way to reclaim salt-affected soil. For better recommendation, further broad scale experiment is needed.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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