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CYTOLOGY AND YIELDS ANALYSIS OF ONIONS (*ALLIUM CEPA* L.) UNDER COMPOST APPLICATION IN COASTAL SALINE SOIL

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Abstract

Onion (*Allium cepa* L.) is a valuable crop in Bangladesh for its diversified usage and availability of enriched germplasms including local and exotic ones. However, the cultivation of onions in the coastal regions of Bangladesh has become a major challenge because of salinity and soil fertility. Therefore, a pot experiment of coastal saline soil amendment with compost was carried out with mostly cultivated varieties i.e. Taherpuri and King. The treatments T_1 (2.5 t/ha) and T_2 (5.0 t/ha) significantly improved the plant height for the Taherpuri variety and revealed an escalation to the no. of the leaflet, root length and bulb diameter for the King variety. Compost application on saline soil didn't increase the mitotic index (MI%) for all the treatments for both of the experimented varieties but increased the mitotic inhibition index (MII%) for the treatments T_3 (7.5 t/ha) and T_4 (10.0 t/ha) treatment for the Taherpuri and King varieties respectively. The correlation coefficient between the treatment and different yields of onion was found better for the Taherpuri than the King variety.

Keywords: Saline soil**,** Compost, Coastal, Cytology, Yields, *Allium cepa*

Introduction

Onion (*Allium cepa* L.) is a species from the family Amaryllidaceae and is widely cultivated in almost every country of the world though its center of origin is middle Asiatic countries (Peters, 1990). The species is highly demandable because of its medicinal, culinary and personal care potentiality. Onion is a rich source of different nutrients and metabolites. These nutrient and metabolic profiles may vary for different factors like maturity stage, storage duration, species cultivated and locality of cultivation (Kumar *et al*., 2010). In addition, Onion (2n=16) is a model species for cytological

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studies because of having healthy root tip, quick sensitivity to stress, clear mitotic phases, stable chromosome number (2n=16) and diversity in the chromosome morphology (Firbas and Amon, 2014). Bangladesh is one of the top most onion (*Allium cepa*) yielding countries of the world (FAO, 2016), where different exotic and local cultivars are available (Pinky *et al*., 2017). These cultivars could be differentiated by bulb size and color of scale leaves. It is ranked first among the spices crops concerning production amount and second regarding acreage cultivated in Bangladesh (BBS, 2015). Madaripur, Faridpur, Rajbari, Kushtia, Pabna, Rangpur, Rajshahi, Manikganj, Magura and Jhenaidah are the major commercial onion-producing districts in Bangladesh that cover 79% of total production (BBS, 2018). Despite the increasing production, the yield rate per unit area of onion isn't capable of meeting the country's total demand. So there is an acute shortage of onion in Bangladesh. The best solution to meet the demand is to bring arable land as well as coastal saline land under onion cultivation.

Plant growth and yields result from the coordinated interaction of cell cycle and cell expansion. Soil salinity hampers the crops in different ways like affecting crop quality, growth, yield and cytology (Dong *et al*., 2008). Additionally, salinity stress has adverse effects on cell cycle and overall growth of plants by altering cell proliferation (Teerarak *et al*., 2009) and affecting the root zone of crops (Qi and Zhang, 2020) respectively. On the contrary, soaring salinity in the coastal areas of Bangladesh decreases the availability of suitable arable lands day by day. In this situation, soil amendments with various organic substances such as farmyard manure, poultry manure and compost can be the best practices to bring the coastal soil under cultivation (Zaki, 2011). The amendment of compost in soil releases essential nutrients like Nitrogen (N), Potassium (K) and Phosphorus (P). These three nutrients have an immense effects on growth and development of onions. For example, N is required for cell division, plant growth, boost leaf rate and bulb diameter extension (Garcia, 1980); P promotes early root formation, cell enlargement and growth (Diriba-Shiferaw *et al.*, 2015); K is an essential nutrient for improving onion yields and efficiency (Sharma *et al*., 2003). Several studies have been carried out by different researchers in the coastal region of Bangladesh (Hossen *et al.,* 2021) including Cox's Bazar Sadar Upazila (Hoque and Hossain, 2018) on suitable land identification for onion cultivation. There was hardly any evidence of a comprehensive study that can correlate the cytology and yield of onion for compost amendment in coastal saline soil. Therefore, the present study aims to analyze the changes in the mitotic proportion and yields. Cytological indices for root tips cell division and yield attributes of onions are used to analyze the effects compost application in coastal saline soil of Bangladesh.

Materials and Methods

Coastal saline soil collection and preparation: For this experiment, the coastal soil was collected from the Satkhira district under the Khulna division. The soil was air dried for 4-5 days by spreading on a clean piece of paper. All sorts of debris including plant roots and plastics were discarded from the soil samples. The soil samples were exposed to sunlight to hasten the drying process. For further processing, a portion of the larger and more massive aggregates were broken by crushing them gently with a wooden hammer after drying. Ground samples were passed through 2mm stainless steel sieve. Finally, the different amount of composed fertilizer was mixed separately with this soil. This ready soil was kept for seven days to plant the seedlings.

Physico-chemical properties of soil and compost: Different established protocols were applied to estimate the physico-chemical properties of soil and compost. For the measurement of pH, electrical conductivity (EC) and salinity, a multimeter analyzer was used. Different nutrient profiles were determined by following earlier reports viz Nitrogen and organic carbon (Huq and Alam, 2005), Phosphorus according to Olsen and Sommer (1982) with slight modification, Sulfur by the calcium di-hydrogen phosphate extraction method, Potassium, Calcium and Magnesium were measured by the N-NH_4OAc method (Warncke and Brown 1998) Zinc & Iron by DTPA extraction method described by Lindsay and Norvell (1978).

Germplasm collection and plantation: The seedlings of two different varieties of onion namely King and Taherpuri were collected from the local market of Faridpur. Those seedlings were planted and maintained in the net house of the University of Barishal. The seedlings of onions were cultivated in different pots containing different dosages of compost viz. T_0 (control), T_1 (2.5 t/ha), T_2 (5.0 t/ha), T_3 (7.5 t/ha) and T_4 (10.0 t/ha) with three replications. Other intercultural operations like gap filling & thinning, soil loosening, weeding, irrigation and required plant protection were meticulously performed.

Cytological study: For the cytogenetical study, healthy roots were collected from two varieties of each treatment followed by pre-treatment with 8-hydroxyquinoline (0.02 M) for 1.5 hrs. Then the roots were fixed in 45% acetic acid at 4ºC followed by hydrolyzation in a mixture of 1 N HCl and 45% acetic acid (2:1) at 60ºC for 30 sec. The young healthy roots were cut 0.5 cm away from the tip by a clean blade. Then the root tips were stained and squashed in 1% aceto-orcein. The slides were observed in the electric microscope and photographs were taken by using the Euromex camera. Then the mitotic index and mitotic inhibition index were calculated by the following formula:

$$\text{Mitotic index (MI) \%} = \frac{\text{Number of dividing cell}}{\text{Total number of cell}} \times 100$$

$$\text{Mitotic inhibition index (MII) \%} = \frac{\text{MI in control - MI in treatment}}{\text{MI in control}} \times 100$$

Yield attributes collection and analysis: Yielding attributes like individual plant height, number of leaflets per plant and root length were recorded at 30 days after transplant (DAT) and bulb diameter was measured at 50 DAT. The plant height and root length were recorded by using measuring tape at centimeter scale and bulb diameter was measured by using vernier calipers at millimeter scale. The mean for all the treatments was calculated and statistical analysis was performed with Microsoft Excel 2010 and Statistics 10.

Results and Discussion

Physico-chemical properties of soil and compost: The physico-chemical properties of soil are prime indicators of soil quality and productivity. The comparative physical and chemical qualities of soil samples are presented in Table 1. Soil pH is the sign of soil microbial activity, plant growth, biochemical breakdown, solubility and absorption of nutrients (Brady and Weil, 2004). According to the Bangladesh Agricultural Research Council (BARC, 2018), the optimum pH range for sufficient nutrient availability in most of the soil is 6.0-7.5. The pH of the experimental soil and compost was found 7.2 and 7.9 respectively (Table 1) and which indicated that, this soil was slightly saline according to BARC (2018). The pH of the experimental soil sample is consistent with the result of Bhadha *et al.* (2010). Another attribute, Electrical conductivity (EC) measures the extent of salts in the soil. In saturated soil extracts the range of salinity for most of the vegetable crops is 1.0-2.5 dS/m (Haque, 2021). In the experiment, the EC of soil and compost was found 5.34 dS/m and 4.08 dS/m subsequently (Table 1). The EC of the experimental coastal soil sample is alike the soil of Kalapara upazila of Patuakhali district (Khanam *et al*., 2020).

The most importantly soil organic matter (SOM) is known to play a significant role in the biological profile, soil fertility and productivity. The SOM (%) of experimental coastal soil and compost were 2.02 and 2.47 accordingly (Table 1). The SOM (%) of the experimental soil sample is higher than that of the Kalapra upzilla of Patuakhali (Hossin *et al*., 2022). Moreover, N, P, K, Ca, Mg and S are known as essential nutrient elements since all plants require these nutrient elements (Samuel and Ebenezer, 2014) for their growth and development.

Table 1. Physico-chemical properties of soil and compost.

Physico-chemical parameters	Soil	Compost	BARC (2018) soil category
pH	7.2	7.9	Neutral (6.6-7.3)
EC (ds/m)	5.34	4.08	Slight saline (4.1-8.0)
Soil organic matter (SOM %)	2.02	2.47	Medium (1.8-3.4)
Available N (%)	0.100	0.124	Low (<0.180%)
P (µg/g)	70.0	45.5	Very high (>37.5)
K (meq/100g)	1.28	0.47	Very high (>0.45)
Fe (µg/g)	3.80	7.83	Low (3.1-6.0)
Ca (meq/100g)	4.11	5.38	Medium (3.1-4.5)
Mg (meq/100g)	2.05	2.56	Very high (>1.875)
Zn (µg/g)	0.43	0.66	Very low (<0.45)
S (µg/g)	11.3	8.0	Low (7.51-15.0)

The available N (%) contents of the soil and compost were 0.10 and 0.124 respectively (Table 1) which is close to the low categories of BARC (2018) and supportive of that of Rahman *et al.,* (2014). N availability of soil is influenced by several environmental factors such as soil profile, salinity, temperature, water tables and logging frequency (Bai *et al*., 2012). P is essential for plant growth and health. The application of fertilizers for agricultural practices determines the availability and solubility of P (Hossain *et al*., 2015). The P content was 70µg/g and 45.5µg/g for experimental soil and compost respectively and according to BARC (2018) the study area is very high category (Table 1).

K is another important nutrient for early growth of plants, the efficiency of water and resistance to diseases and pests (Hasanuzzaman *et al*., 2018). The K content was found 1.28 (meq/100 g) in soil and 0.47 (meq/100 g) in compost (Table 1). The Fe content of the experimental soil and compost was 3.80 and 7.83 µg/g, respectively. According to Lindsay, 1974 Fe activity is inversely proportional to soil pH. Moreover, the Ca and Mg content of the experimental coastal soil and compost were 4.11 meq/100 g and 2.05

meq/100 g, respectively (Table 1). This result categorizes the both type of soil as medium (Ca) and very high category (Mg) in comparison with BARC (2018) The Zn and S content of soil were 0.43 and 11.3 µg/g, respectively and according to BARC (2018) the soil is in very low and low categories on the basis of Zn and S availability, respectively (Table 1).

Cytology of compost amendment in saline soil: Cell division rate, mitotic phase rate, mitotic index (MI%) and mitotic inhibition index (MII%) are the major indices of cytology any plant. Firbas and Amon (2014) found different aberrations in response of salt stress in onion. In this study mitotic index (MI%) result was not consistent for both Taherpuri and King varieties. The MI% was reduced abruptly for T_2 and T_3 treatments with respect to T_0 and T_1 treatments and increased suddenly at T_4 treatment in contrast to T_3 treatment for the Taherpuri variety. In the King variety the MI% was reduced suddenly at T_1 with respect to control, but gradual reduction of MI% was found at all the treatments except T_3 treatment (Fig. 1). The mitotic inhibition index (MII%) showed abrupt increased tendency for all the treatments in contrast to control (T_0) in the Taherpuri variety while fluctuate tendency was found for all the treatments in compare to control (T_0) in the King variety (Fig. 2). Kiełkowska (2017) studied the effect of artificial salt stress on mitotic index by applying NaCl and KCl and found reduction in root growth along with reduction in mitotic activity of onion root tip cells.

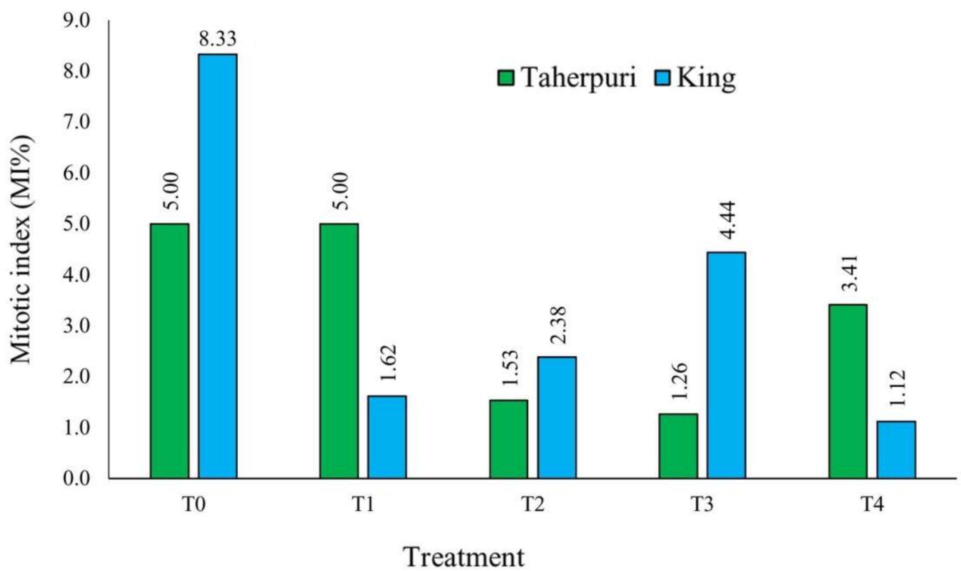

Fig. 1. Mitotic index (MI%) for different doses of treatment.

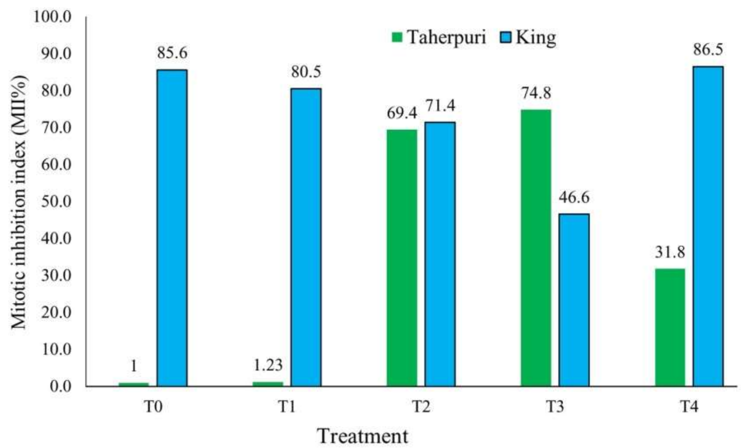

Fig. 2. Mitotic inhibition index (MII%) of different doses of treatment.

Table 2. Effects of compost on yields of experimental varieties of onion.

Treatment	Variety	Yields			
		Plant height (cm)	No. of leaflet	Root length (cm)	Bulb diameter (mm)
		30 DAT			50 DAT
T_0	Taherpuri	31.67**abc**	4.33**a**	5.50**bc**	5.73**bcd**
	King	23.33**d**	3.00**cd**	6.00**abc**	7.00**ab**
T_1	Taherpuri	35.00**a**	3.67**abc**	5.50**bc**	5.16**d**
	King	26.16**cd**	2.67**d**	6.37**abc**	7.33**a**
T_2	Taherpuri	33.67**ab**	3.67**abc**	6.33**abc**	6.83**ab**
	King	24.33**d**	4.00**ab**	7.00**a**	6.17**abcd**
	Taherpuri	27.00**cd**	3.00**cd**	5.33**c**	5.33**cd**
T_3	King	26.00**cd**	3.33**bcd**	6.67**ab**	6.87**ab**
	Taherpuri	27.33**bcd**	3.33**bcd**	5.67**bc**	5.67**bcd**
T_4	King	29.33**abcd**	4.00**ab**	6.00**abc**	6.70**abc**
Mean	Taherpuri	30.93	6.0	5.66	5.74
	King	25.83	3.4	6.40	6.81
SEM	Taherpuri	2.3369	0.3073	0.5028	0.3656
	King	0.4441	13.69	0.3469	0.3607
CV (%)	Taherpuri	13.09	14.79	15.37	11.02
	King	2.98	13.69	9.38	9.17
LSD	Taherpuri	7.2611	1.0022	1.6396	1.1923
	King	1.4483	0.8764	1.1313	1.1763
Level of significance	Taherpuri	0.1332	0.1176	0.6706	0.773
	King	0.0001	0.0268	0.2736	0.33112

Similar letters in a column are not significantly different at the 5% level by DMRT. DAT- Day after transplantation

Yield response and correlation to compost application: The treatments T_1 and T_3 showed the highest and lowest response i.e. 35.0 and 27.0 cm, respectively in term of plant height for Taherpuri variety onion at 30 DAT while the T_4 and T_2 performed the highest and lowest effects by resulting 29.33 and 24.33 cm plant height, respectively in King variety at 30 DAT (Table 2). The result regarding no. of leaflets for all the treatments was more or less similar to control (T_0) for both Taherpuri and King varieties at 30 DAT. The treatment T_3 showed the highest result i.e. 6.33 and 7.0 cm for root length of both Taherpuri and King varieties respectively at 30 DAT (Table 2). The treatments T_1 and T_2 showed the largest bulb diameter i.e. 7.33 and 6.83 mm for King and Taherpuri varieties, respectively (Table 2) at 50 DAT.

Table 3. Correlation coefficient (r) matrix of among treatment, plant yield and cytology.

		Treatment	Plant height	No. of leaflet	Root length	Bulb diameter	MI	MII
Treatment	Taherpuri	1						
	King	1						
Plant height	Taherpuri	-0.724	1					
	King	0.819	1					
No. of leaflet	Taherpuri	-0.855	0.60*	1				
	King	0.706*	0.35*	1				
Root length	Taherpuri	0.069*	0.40*	0.14*	1			
	King	0.109*	-0.319	0.27*	1			
Bulb diameter	Taherpuri	0.012*	0.26*	0.22*	0.943	1		
	King	-0.392	0.07*	-0.893	-0.559	1		
MI	Taherpuri	-0.605*	0.41*	0.68*	-0.374	-0.446	1	
	King	-0.623	-0.713	-0.389	-0.263	0.193*	1	
MII	Taherpuri	0.600*	-0.411	-0.679	0.373*	0.445*	-0.999	1
	King	-0.307	-0.106	-0.037	-0.654	0.147*	-0.046	1

* Significant at 5% probability level.

Furthermore, treatment revealed a significant positive correlation for the Taherpuri variety for root length, bulb diameter and MII% while it was for no. of leaflet and root length for the King variety at 5% probability level (Table 3). The MI% exhibited a significant positive correlation for Taherpuri variety for plant height and no. of leaflet yield of the Taherpuri variety while it was for the bulb diameter of the King variety at 5% probability level (Table 3). The MII% manifested a significant positive correlation for root length and bulb diameter yields of the Taherpuri variety while it was only for bulb diameter of the King variety (Table 3).

Conclusion

Soil salinization decreases soil fertility. Soil fertility is inseparably interconnected with plant growth and productivity. In addition, plant growth and yields also depend on cytology. But soil salinity impedes the cytology of plants. Amendment of saline soil with compost application is one of the major methods. The present study revealed that compost amendment has a positive contribution to onion (*Allium cepa*) yield increment. The comprehensive analysis of treatments, cytology and yield unveiled that the application of compost in saline soil has a reduction tendency for mitotic index and mitotic inhibition index, but increasing tendency for some yields at different doses of treatments. So further extensive study is needed to confirm exact dose of compost for saline soil amendment to bring under onion cultivation in Bangladesh.

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