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ROLE OF SOIL APPLICATION OF CHITOSAN POWDER ON GROWTH AND DEVELOPMENT OF *Basella alba* (BARI PUISAK-1)

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ABSTRACT

Chitosan (CHT) induces plant growth but role of CHT powder in soil-plant system remains to be clarified. We examined role of soil application of CHT powder on growth and development of (BARI puisak-1). The experiment was conducted in the net house by using earthen pot containing 12 kg soil (red brown terrace soils, under the Tejgaon soil series, Modhupur Tract, Bangladesh) in each pot. Four treatments and five replications were used in the experiment with different doses of CHT powder i.e. T_1 = Control (0 g/pot), T_2 = (100 g/pot), T_3 = (200 g/pot), and T_4 = (400 g/pot). The CHT powder was applied in the pot soil as a basal dose before sowing the seeds. The vegetative growth and biomass production increased in a dose dependent manner due to the application of CHT powder. Fresh weight, oven dry weight, plant height significantly increased over the control plants. Maximum fresh weight (3662 g/plant) and oven dry weight (400.67 g/plant) obtained in the treatment T4 but the maximum plant height (271.44 cm) was observed in the T3 treatment. Total nitrogen content in the post-harvest soils and in the plants increased in a dose dependent manner due to the treatments.The maximum nitrogen content in the plant was 0.513% and in the soil 0.203% in the treatment T4. The results indicate that CHT powder could be an alternative and very good source of organic nitrogen fertilizer. The organic carbon, organic matter content and soil pH of the post-harvest soil also increased in a dose dependent manner with the application of CHT powder. These results might be due to the alkalization effect of the CHT powder and might be a prominent source of organic carbon. Taken together, our results suggest that CHT powder may play a vital role in organic agriculture.

Keywords: CHT powder, BARI puisak-1, biomass production, soil chemical properties

INTRODUCTION

Chitosan (CHT) is a natural biopolymer which stimulates growth and increases yield of plants as well as induces the immune system of plants (Boonlertnirun *et al.*, 2008). Plant treated with CHT showed significantly greater number of branches/plant than untreated control (Reddy *et al.*, 2000). CHT has strong effects on agriculture such as acting as the carbon source for microbial population in the soil, accelerating the transformation process of organic matter into inorganic matter and assisting the root system of plants to absorb more nutrients from the soil. CHT is absorbed by the roots after being decomposed by bacteria in the soil and chitin secreted by the roots (Somashekar and Ricard, 1996, Brian *et al.*, 2004). CHT promotes growth of cabbage (*Brassica oleracea* L. var. *capitata* L.) callus in vitro (Hirano, 1988). Application of CHT in agriculture, even without chemical fertilizers can increase the microbial population by large numbers and transforms organic nutrient into inorganic nutrient which is easily absorbed by the plant roots (Bolto *et al.*, 2004). CHT is considered an environmental friendly product that has been widely used in agricultural applications mainly for enhancing soil characteristics which is suitable for plant growth and also stimulation of plant defense (Ibrahim *et al.*, 2015). It has been used in seed, leaf, fruit and vegetable coating, as well as a fertilizer and in controlled agrochemical release (Ibrahim *et al.*, 2015). CHT promotes shoot and root growth of daikon radish (*Raphanus sativus* L.) (Tsugita *et al.*, 1993) and hastens flowering time and increases number of flowers in passion fruit (*Passiflora edulis*) (Utsunomiya and Kinai, 1994). Use of CHT increases the water use efficiency through reducing the stomatal aperture (Issak *et al.*, 2013). CHT is able to enhance the growth of many crops and the underlying mechanisms for this plant growth promoting action may

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be attributed to effects on plant physiological processes such as nutrient uptake, cell elongation, cell division, enzymatic activation and protein synthesis (Amin *et al.*, 2007). Application of CHT enhances growth and yield attributes in rice (Liu *et al.*, 2007) and soybean (Chibu *et al.*, 2002).

The CHT powder is the raw material of the CHT and it is prepared from the shrimp shell byproducts through the sequential process of drying, grinding, and sheaving. The objective of this study was to introduce the CHT powder in Bangladesh agriculture and to examine its effect on the vegetative growth and development of BARI puisak-1.

MATERIALS AND METHODS

The CHT powder was supplied from the department of soil science, Sher-e-Banga Agricultural University, Dhaka. The experiment was done with randomized complete block design with five replications. There were four treatments in the experiment i.e. T_1 = Control (0 g/pot), T_2 = (100 g/pot), T_3 = (200 g/pot), and T_4 = (400 g/pot). Treatments were applied in the soil before sowing the seeds and properly mixed with the soil. Earthen pots were used in the experiment and 12 kg soils were used in each pot. Initially five to six seeds were sown in each pot and finally one healthy seedling was used in the experiment. No chemical fertilizers were used in the pot soil. Irrigation and intercultural operations were done properly. The organic carbon content, total nitrogen content and soil pH of the initial soil were 0.65%, 0.065% and 5.83 respectively. Plant height, fresh weight, dry weights were recorded at the harvesting time. The data were recorded at 30 DAS and 60 DAS. Fresh wet was taken after harvesting at room temperature (25^0C) and oven dry weight was measured after drying the harvesting materials at 70^0C in an oven. Total nitrogen of soil and plant were determined by Micro Kjeldahl method. Organic carbon of the soil and plant were determined by wet oxidation method of Walkley and Black method. All the data were subjected to analysis of variance according to the experimental design used in the study and least significant difference (LSD) was utilized to compare the different means of treatment. The chemical composition (Table 1) of the CHT powder indicated that it was a good source of many macro and micro nutrients elements for the plant growth. It is a good source of organic carbon and organic matter that were improved soil health for sustainable agriculture and finally its alkaline nature increased soil pH level to amendment the soil.

Table 1. Analytical Composition of the modified CHT powder

Chemical properties	Concentrations	Chemical properties	Concentrations
Total nitrogen (N)	4.36%	Available zinc (Zn)	99.03 ppm
Available phosphorus (P)	0.683%	Available boron (B)	162 ppm
Exchangeable potassium (K)	0.38%	Organic carbon	7.62 %
Available sulphur (S)	0.096%	Organic matter	13.14%
Available calcium (Ca)	2.63%	pH	8.8
Available magnesium (Mg)	0.39%		

RESULTS AND DISCUSSION

Influence of CHT powder on growth of BARI puisak-1

The plant height was significantly increased with the soil application of CHT powder. Maximum plant height (271.44 cm) was found in the treatment T_3 (200 g CHT powder/pot) which was significantly different with the treatments T_4 (240.61 cm), T2 (210.45 cm) and T_1 (45.27cm) treatments (Fig. 1). The second highest plant height was found in the treatment T_4 which was significantly different with the treatments T_2 & T_1 (Fig. 1). The minimum plant height was observed in the control treatment T_1 (45.27 cm.) These results indicate that soil application of CHT powder can supplement the required plant nutrients for their growth and development of BARI puisak-1. These results suggest that CHT powder could be used in organic vegetable cultivation. These results might be due to the alkaline nature of the CHT powder and functions as a good source of plant nutrients.

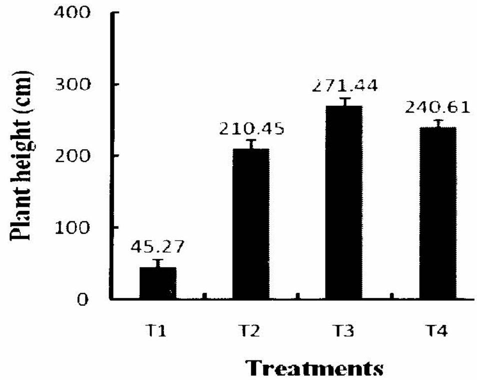

Fig.1. CHT-Powder-Influenced plant height of BARI puisak-1

Effect of CHT powder on fresh and dry mass weight production of BARI puisak-1

Soil application of CHT powder significantly increased the fresh weight and oven dry weight of BARI puisak-1. The fresh weight production at 30 DAS was increased in a dose dependent manner and the maximum fresh weight production was found in the treatment T4 (588 g/plant) and the minimum fresh weight production was found in the treatment T_1 (120 g/plant) (Fig. 2).

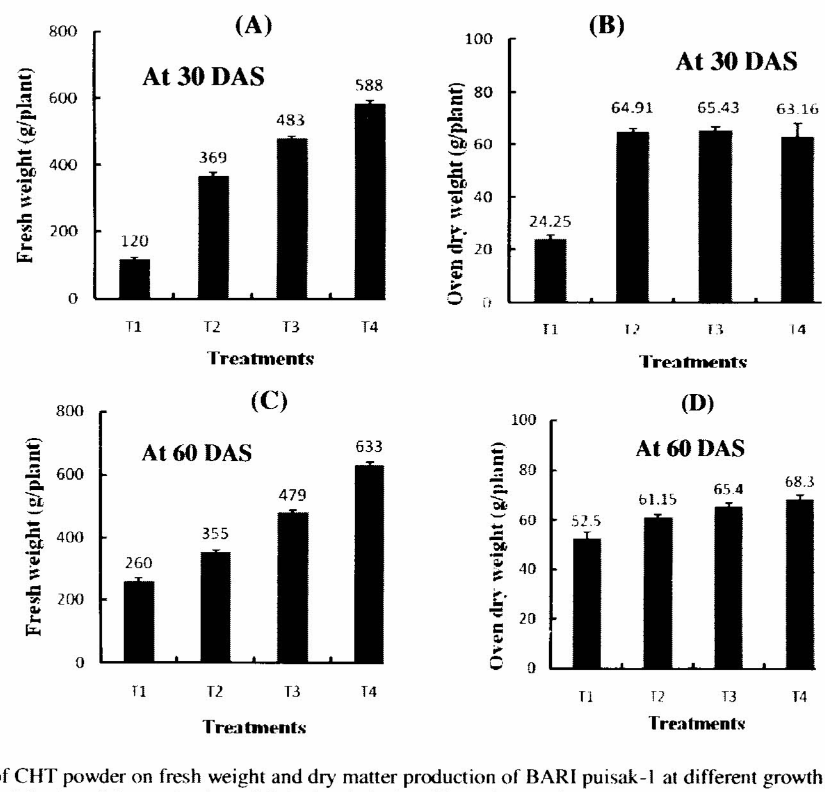

Fig. 2. Effect of CHT powder on fresh weight and dry matter production of BARI puisak-1 at different growth stages. (A) CHT-powder-increased fresh weight production of BARI puisak-1 at 30 DAS. (B) CHT-powder-increased dry matter production of BARI puisak-1 at 30 DAS. (C) CHT-powder-increased fresh weight production of BARI puisak-1 at 60 DAS. (D) CHT-powder-increased dry matter production of BARI puisak-1 at 60 DAS.

The fresh weight production trend was found $T_4<T_3<T_2<T_1$. The oven dry weight at 30 DAS was increased significantly up to 200 g/pot and the maximum oven dry weight was found in the treatment T3 (65.43 g/plant) which was statistically identical with the treatments T_2 (64.91 g/plant) and T_4 (63.16 g/plant) treatments and the minimum oven dry weight was found in the control treatment T_1 (24.25 g/plant) (Fig. 2). The fresh weight production at 60 DAS was also increased in a dose dependent manner and the maximum fresh weight production was recorded in the treatment T_4 (633 g/plant) and the minimum fresh weight production was found in the treatment T_1 (260 g/plant) (Fig. 2). The fresh weight production in the treatments T_3 and T_2 was 479 g/plant and 355 g/plant respectively which was significantly different with the control treatment T1. The fresh weight production trend at 60 DAS was similar to the fresh weight production trend at 30 DAS.

The oven dry weight at 60 DAS was significantly increased and the maximum oven dry weight was found in the treatment T_4 (68.3 g/plant) which was statistically identical with the treatment T3 (65.4 g/plant) (Fig. 2). The dry matter production in the treatment T_2 was 61.15 g/plant and it was statistically identical with the treatment T_3 but not with the treatment T_4.The minimum oven dry weight was found in the control treatment T_1 (52.5 g/plant). Our results indicate that soil application of the CHT powder could play significant role for the organic agriculture.

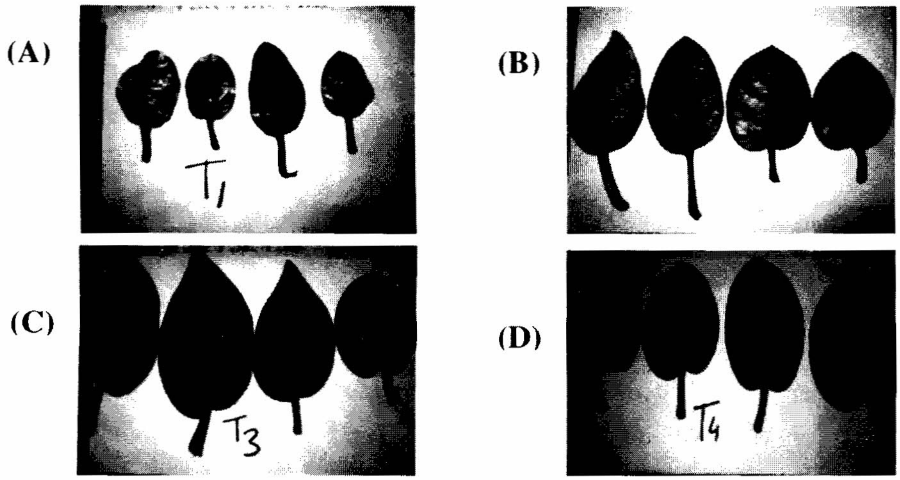

Fig. 3.Typical leaf size of the organically cultivated BARI puisak-1 (BARI Puisak-1) using CHT powder in the pot soil.(A)T1.typical leaves of organically cultivated BARI puisak-1 using no CHT powder in the pot soil.(B) T_2, typical leaves of organically cultivated BARI puisak-1 using 100 g CHT powder in the pot soil.(C)T_3. typical leaves of organically cultivated BARI puisak-1 using 200 g CHT powder in the pot soil.(D)T_4. typical leaves of organically cultivated BARI puisak-1 using 400 g CHT powder in the pot soil.

Table 2. Influence of CHT powder on total fresh weight and total dry matter production of BARI puisak-1

Treatments	Total fresh weight production (g/plant)	Fresh weight production increased over control (%)	Total dry matter production (g/plant)	Total dry matter production increased over control (%)
T_1 (0 g)	1143d	---	231.52c	---
T_2 (100 g)	2186c	91.25	380.29b	64.26
T_3 (200 g)	2885b	152.41	395.43a	70.80
T_4 (400 g)	3662a	220.39	400.67a	73.06
CV %	1.14		0.97	
LSD	53.04		6.43	
Level of Significance	**		**	

Values in a column are significantly different at $p \leq 0.05$ applying LSD. Similar letters in a column indicate the identical effect among the treatments. ** = Significant at 1% level of probability.

Influence of CHT powder on biomass production of BARI puisak-1

Total fresh weight production was increased significantly by the CHT powder. The fresh weight production was increased in a dose dependent manner. The maximum fresh weight production was recorded in the treatment $_{T4}$ (3664 g/plant) followed by T_3 (2885 g/plant), T_2 (2172 g/plant) and T1 (1138 g/plant) (Table 2). The minimum fresh weight production was recorded in the control treatment T_1. The fresh weight production was increased over control by 90.34%, 153.51% and 221.05% in the treatments T_2, T_3 and T_4 respectively. Similar to the total fresh weight the total dry matter production was significantly increased by the CHT powder. The maximum dry matter production was found in the treatment T_4 (394.4 g/plant) followed by T_3 (392.5 g/plant), T_2 (378.18 g/plant) and T_1 (230.26 g/plant) (Table 2). The total dry matter production was minimum in the treatment T_1 (control). The dry matter production was increased over control by 64.24%, 70.59% and 71.28% in the treatments T_2, T_3 and T_4 respectively. These results indicate that CHT powder could play a vital role for the practices of organic agriculture.

Table 3. CHT-powder-induced organic carbon and organic matter content in the post-harvest soils

Treatments	%OC content	OC increased over control (%)	% OM content	% OM increased over control
T_1(0 g)	0.67c		1.16c	
T_2(100 g)	0.85bc	26.87	1.47bc	26.96
T_3(200 g)	0.93ab	38.81	1.60ab	39.13
T_4(400 g)	1.10a	64.18	1.90a	64.35
CV %	7.08		7.14	
LSD	0.12		0.21	
Level of Significance	**		**	
Initial soil	0.65		1.12	

Values in a column are significantly different at $p \leq 0.05$ applying LSD. Similar letters in a column indicate the identical effect among the treatments. ** = Significant at 1% level of probability.

Table 4. CHT-powder-induced chemical properties of post-harvest soil

Treatments	pH (60 DAS)	% Total N in soil (60 DAS)	% Total N in plants (60 DAS)
T_1 (0g)	5.97c	0.097c	0.143d
T_2 (100 g)	6.63b	0.143b	0.227c
T_3 (200 g)	6.87b	0.147b	0.337b
T_4 (400 g)	7.17a	0.203a	0.513a
CV %	1.37	10.36	9.74
LSD	0.17	0.03	0.06
Level of Significance	**	**	**
Initial soil	5.83	0.065	---

Values in a column are significantly different at $p \leq 0.05$ applying LSD. Similar letters in a column indicate the identical effect among the treatments. ** = Significant at 1% level of probability.

CHT-powder-induced organic carbon and organic matter content of soil

CHT powder significantly increased organic carbon level in the soil. The increasing trend of the organic carbon level was in a dose dependent manner. Maximum organic carbon level was found in the treatment T_4 (1.10%) which was statistically identical with the treatment T_3 (0.93%) (Table 3). The minimum organic carbon level was found in the treatment T_1 (0.67%) which was statistically identical with the treatment T_2 (0.85%). However, organic carbon level in the treatment T_2 (0.85%) was statistically identical with the treatment T3 (0.93%). Similarly he maximum organic matter content was found in the treatment T4 (1.90%) which was statistically identical with the treatment T_3 (1.60%) (Table 3). The minimum organic matter content was found in the treatment T_1 (1.16%) which was statistically identical with the treatment T_2 (1.47%). On the other hand organic matter content in the treatment T_2 (1.47%) was statistically identical with the treatment T_3 (1.60%). This result suggests that CHT powder can be a good source of organic carbon in soil and hasten the organic agriculture in our country.

CHT powder-induced chemical properties of soils and plants
The effect of CHT powder was alkaline in nature. The pH of the post-harvest soil increased in a dose dependent manner due to the treatments. The highest post-harvest soil pH was found in the treatment T_4 (7.17) and the second height post-harvest soil pH was found in the treatment T_3 (6.87%) which was statistically identical with the treatment T_2 (6.63). The lowest post-harvest soil pH found in the control treatment T_1 (5.97). The results indicate that improvement of soil pH level could increase the plant nutrients availability. CHT powder significantly increased the total nitrogen level of the post-harvest soil. The nitrogen content was in a dose dependent manner. The maximum total nitrogen content in soil was 0.203% in the treatment T_4 having 400 g powder/pot soils. The second height total nitrogen content was found in the treatment T_3 (0.147%) which was statistically identical with the treatment T_2 (0.143%).The minimum total nitrogen content was found in the control treatment T1 (0.097%). The CHT powder not only increase the soil pH but also increase the post-harvest soil nitrogen level suggesting the powder may be slow releasing source of organic nitrogen in soil. Similar to the soil nitrogen level plant nitrogen level also increased due to the treatments. Maximum total nitrogen in plant was found in the Treatment T_4 (0.513%). The second highest total nitrogen in plants was found in the treatment T_3 (0.337%) and then in treatment T_2 (0.227%).The minimum total nitrogen in plant was found in the control Treatment T_1 (0.143%). The results indicate that CHT powder could be a good nutritional source for the plants.

CONCLUSION

From the above results it can be concluded that the CHT powder strongly influenced the growth and development of BARI puisak-1. The powder could be used for BARI puisak-1 cultivation @ 200g to 400 g/pot soil (12 kg soil). The CHT powder could be a good source of plant nutrients and growth enhancer which can be used for increasing the level of organic matter, soil fertility and amending the acidic soil.

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