EFFECT OF SOWING DATE AND CHITOSAN RAW MATERIAL POWDER ON BORO RICE (BRRI dhan88)

AL IMRAN

DEPARTMENT OF SOIL SCIENCE

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EFFECT OF SOWIG DATE ND CHTOSAN RAW MATERIAL POWDER ON BORO RICE (BRRI dhan88)

BY

AL IMRN

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Approved by:

……..…… ……..……

Dr. Mohammad Issak
Professor
Department of Soil Science
Sher-e-Bangla Agricultural University
Supervisor

Dr. Amena Sultana
Senior Scientific Officer
Agronomy Division
Bangladesh Rice Research Institute
Co-Supervisor

……..…….

Professor A. T. M. Shamsuddoha
Chairman
Examination Committee
Department of Soil Science
Sher-e-Bangla Agricultural University, Dhaka-1207

Department of Soil Science

Faculty of Agriculture
Sher-e-Bangla Agricultural University

Prof. Dr. Mohammad Issak
Department of soil science
Faculty of Agriculture
Sher-e-Bangla Agricultural University
Mobile: 01716-238645
Email: mdissaksau07@yahoo.com

CERTIFICATE

This is to certify that thesis entitled, "**EFFECT OF SOWING DATE AND CHITOSAN RAW MATERIAL POWDER ON BORO RICE (BRRI dhan88)"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE** in **SOIL SCIENCE**, embodies the result of a piece of bona fide research work carried out by **AL IMRAN**, Registration No. **19-10230,** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has been duly acknowledged.

Date: December, 2022

Place: Dhaka, Bangladesh

Prof. Dr. Mohammad Issak

Supervisor

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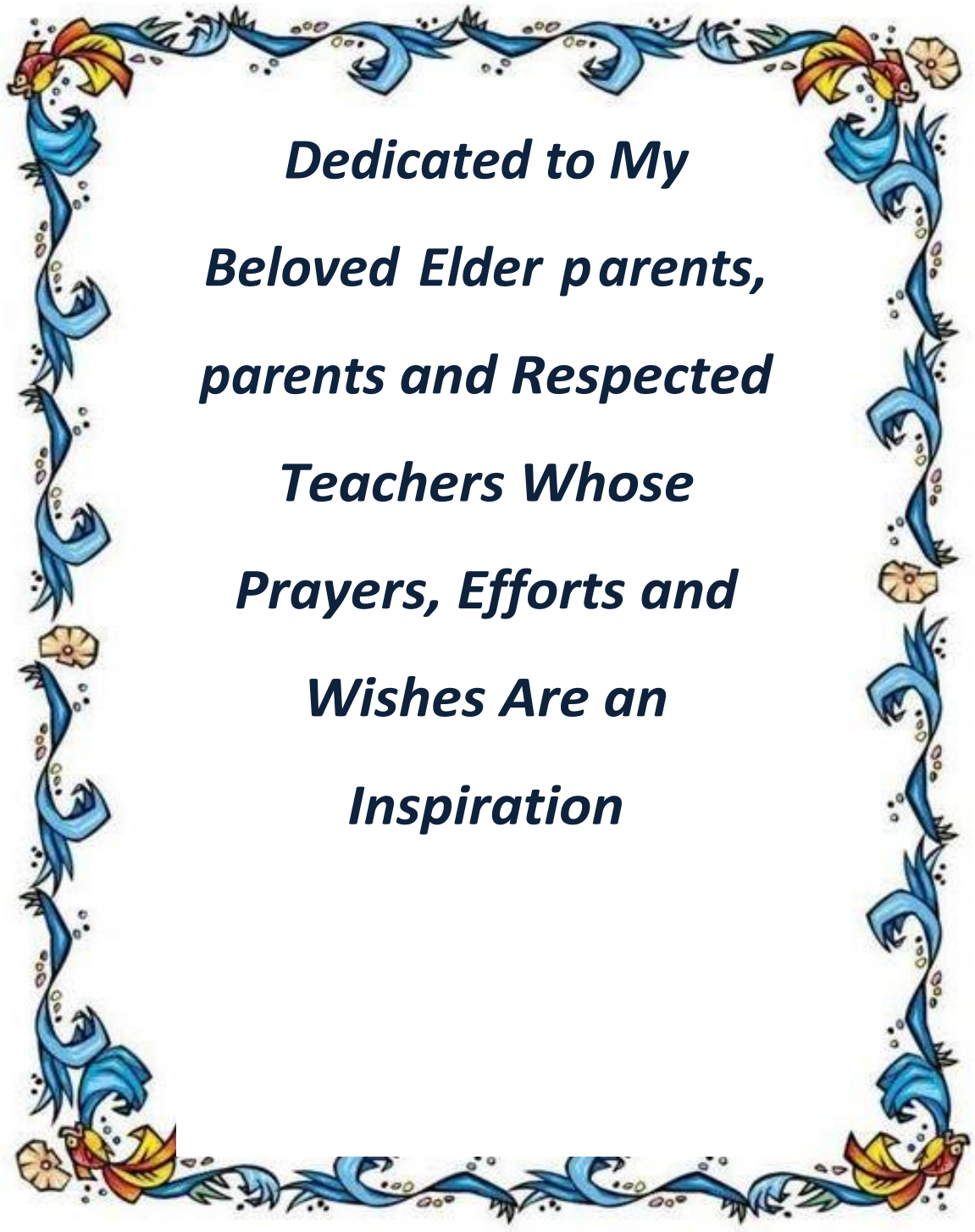
Dedicated to My
Beloved Elder parents,
parents and Respected
Teachers Whose
Prayers, Efforts and
Wishes Are an
Inspiration

EFFECT OF SOWING DATE AND CHITOSAN RAW MATERIAL POWDER ON BORO RICE (BRRI dhan88)

ABSTRACT

A pot experiment was conducted under the net house of Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh, during November 2019 to April 2020, to investigate the effect of sowing date and chitosan raw material powder on Boro seedling character. The experiment was consisted of two factors with three replications following Completely Randomized Block Design (RCBD). Factor A: Different sowing dates (08) viz: S_1= 23 Nov, 2019 S_2= 25 Nov, 2019 S_3= 27 Nov, 2019 S_4= 29 Nov, 2019; S_5= 01 Dec, 2019; S_6= 03 Dec, 2019 S_7= 05 Dec, 2019 and S_8= 07 Dec, 2019. Factor B: Level of chitosan raw material powder (w/w) (06) *viz:* T_1 = 0%, T_2 = 0.1%, T_3 = 0.2%, T_4 = 0.3%, T_5 = 0.4% and T_6 = 0.5%. A significant variation was observed in the Boro seedlings characters including seedling height, fresh weight, oven dry weight, seedling strength and chemical properties of the seedbed soils in all the sowing dates. Seedling characters values in all the sowing dates were lowest in the control against the treatments. Seedbed application of the chitosan raw material powder significantly improved the Boro seedling characters at 25 days after sowing (DAS), 30 DAS, and 35 DAS in the different sowing dates. The seedling height, fresh weight, oven dry weight and seedling strength were increased in a dose dependent manner with the application of chitosan raw material powder up to sowing date S_8. In the 1st sowing date values of the seedling characters were maximum then gradually decreased and lowest value was found in the last (8th) sowing dates. Seedlings produced in the 1st sowing date at 35 DAS were performed superior than the seedlings of 30 DAS and 25 DAS. But the some treated seedlings of the 25 DAS and 30DAS were performed significantly better than control seedlings of the 35 DAS. Grain yield production of the S_1 seedlings (25, 30 and 35 days old seedlings) was higher in the treated seedlings over the control seedlings. 35 day aged seedling treated with 0.3% chitosan raw materials powder ($35DT_3$) was shown higher yield pot^{-1} (65.02 g) performance which 21% yield increase over control. On the other hand, a significant improvement was observed on the seedbed soil properties including organic carbon, organic matter, soil pH and total nitrogen content. The maximum value of the seedbed soil properties was recorded in the T_6 treatment and minimum level was recorded in the control treatment (T_1). The increments of the organic matter content and total nitrogen content were in a dose dependent manner. The results indicated that chitosan raw material powder could play a significant role in the improvement of Boro seedling characters and yield performance under the optimum sowing dates and also after the optimum sowing dates. Chitosan raw material treated 30-35 days old Boro seedling could be recommended for the farmers use. Low temperature induced seedling growth reduction could be manipulated through using CHT raw material powder in seedbed.

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ABBREVIATIONS

Full form	Abbreviations	Full form	Abbreviations
Agriculture	Agric.	Liter	L
Agro-Ecological Zone	AEZ	Milliliter	mL
And others	et al.	Mill equivalents	Meqs
Applied	App.	Triple super phosphate	TSP
Asian Journal of Biotechnology and Genetic Engineering	AJBGE	Milligram(s)	Mg
Bangladesh Agricultural Research Institute	BARI	Millimeter	Mm
Bangladesh Bureau of Statistics	BBS	Mean sea level	MSL
Biology	Biol.	Metric ton	MT
Biotechnology	Biotech.	North	N
Botany	Bot.	Nutrition	Nutr.

Centimeter	Cm	Regulation	Regul.
Cultivar	Cv.	Research and Resource	Res.
Degree Celsius	°C	Review	Rev.
Department	Dept.	Science	Sci.
Development	Dev.	Society	Soc.
Dry Flowables	DF	Soil plant analysis development	SPAD
East	E	Soil Resource Development Institute	SRDI
Editors	Eds.	Technology	Technol.
Emulsifiable concentrate	EC	Tropical	Trop.
Entomology	Entomol.	Thailand	Thai.
Environments	Environ.	United Kingdom	U.K.
Food and Agriculture Organization	FAO	University	Univ.
Gram	G	United States of America	USA
Horticulture	Hort.	Wet table powder	WP
International	Intl.	Serial	Sl.
Journal	J.	Percentage	%
Kilogram	Kg	Number	No.
Least Significant Difference	LSD	Microgram	µ

CHAPTER I

INTRODUCTION

Rice (Oryza sativa L.) is the mostly consumption able cereal crop of the world and is a staple food for more than a half population of the world (Ahmad *et al.,* 2020; Singh *et al.,* 2019). The global demand of rice is augmenting day by day. Current average world rice production is 676 million tons, while the global demand will rise to 852 million tons for the year 2035 (Khush, 2013). However, the productivity of rice needs to be increased from 10 to 12.5 t/ha to fulfill the requirement of 176 million tons more rice (Khush, 2013).

Rice is the staple food for about 156 million people of the country. The population growth rate is 2 million per year, and if the population increases at this rate, the total population will reach 238 million by 2050 (Shelly *et at.,* 2016). An increase in total rice production is required to feed this ever-increasing population. At the same time, the total cultivable land is decreasing at a rate of more than 1% per year owing to the construction of industries, factories, houses, roads, and highways. It provides nearly 48% of rural employment, about two-third of total calorie supply and about one-half of the total protein intake of an average person in the country. Rice sector contributes one-half of the agricultural GDP and one-sixth of the national income in Bangladesh.

Among the three rice rowing seasons in Bangladesh, Boro contributes lion's share (53%) in total rice production. Aman, the second biggest crop after Boro in terms of production, provided 38.8% of total 36.6 million tons of rice output in 2019-2020 fiscal year. (BBS, 2020). According to the latest estimation made by BBS, per capita rice consumption is about 166 kg/year. Rice alone provides 76% of the calorie intake and 66% of the total protein requirement and shares about 95% of the total cereal food supply (Alam, 2012). The population of Bangladesh is growing by two million every year may increase by another 30 million over the next 20 years. During this time total rice area will also shrink to 10.28 million hectares. Rice yield therefore, needs to be increased by 53.3% (Mahamud *et al.*, 2013). The average yield of rice is about 4.5 t/ha in Bangladesh whereas it is about 6-6.5 t/ha in Japan, Korea, China (BRRI, 2020). But it is not sufficient to meet the food demand of increasing population. So,

increasing rice production in a sustainable manner is vital for ensuring food security for the increasing population in Bangladesh.

BRRI dhan88 is a lodging resistant, slightly aromatic, high yielding variety which has been released by Bangladesh Rice Research Institute (BRRI) in 2018. It could be ideal rice variety for Bangladesh, because the life cycle is around 140 days, average height 101-110 cm and yield is around 7 t ha^{-1} it may increase 8.5 t ha^{-1} if it taken proper care and management (BRRI, 2020).

Chitosan is a natural biopolymer modified from chitin, which is the main structural component of squid pens, cell walls of some fungi and shrimp and crab shells. Chitin and chitosan are copolymers found together in nature. Hirano (1996) reported that chitin and chitosan have various biological functions, for instance, antimicrobial activity, growth inhibitor of some pathogens, elicitor of phytoalexins, inducer of chitinase including accelerator of lignification in plants. They are inherent to have specific properties of being environmentally friendly and easily degradable. Compared with chitin, chitosan has high degrees of deacetylation. Chitosan is highly soluble in dilute organic acid such as acetic acid, lactic acid etc making it easy and useful in applications in agriculture and in aqueous solutions at various concentrations. Bangladesh is one of the largest exporters and producers of shrimp along with the production 1200 tones chitosan in every year to make an annual export of Chitosan worth $1.2 billion, which is 3.34 percent of the country's present export earnings (BBS 2020). By 2022, overall global supply of Chitosan will be only 70,000 tons against a demand for 155,500 tons. Therefore, we have abundant raw materials for chitosan production. Chitosan has a wide scope of application. With high affinity and nontoxicity, it does no harm to humans and livestock (Hamed *et al.,* 2016). Chitosan regulates the immune system of plants and induces the excretion of resistant enzymes. It has strong effects on agriculture such as acting as the carbon source for microbes in the soil, accelerating of transformation process of organic matter into inorganic nutrients and assisting the root system of plants to absorb more nutrients from the soil (Ibrahim *et al.,* 2015). Chitosan is absorbed to the root after being decomposed by bacteria in the soil. Application of chitosan in agriculture, even without chemical fertilizer, can increase the microbial population by large numbers, and transforms organic nutrient into inorganic nutrient, which is easily absorbed by the plant roots (Choi, 2016). It play a significant role in the quality rice seedling

production that help to increase the grain yield. (Issak *et al.,* 2017). The organic manures viz. sludge and spray of chitosan raw materials powder (CHT) may be used as an alternative source of Nitrogen which increases efficiency of applied Nitrogen (Sarvanan *et al.,* 1987). Integrated use of organic manures with the combination of inorganic fertilizers can contribute to increase Nitrogen content of rice soil as well as to increase long term productivity and enhancement of ecological sustainability. Chemical properties of rice growing soils improve due to the residual effect of the raw material of CHT powder (Sultana *et al.,* 2020). Combined application of sludge and spray of CHT along with nitrogen fertilizer improves soil health and soil productivity but only use of nitrogenous fertilizer for a long period causes deterioration of physical condition and organic matter status and reduces crop yield. When sludge and spray of CHT are applied along with chemical fertilizers for efficient growth of crop, decline in organic carbon is arrested and the gap between potential yield and actual yield is bridged to large extent (Mishra *et al.,* 2005). This work determines the suitable doses of chitosan powder in seed bed, and focuses on its applications in rice production, in particular with respect to its activity in self-defense system of plants and growth promoter to increase rice production.

Limited information is available on the effect of organic growth promoting substance like chitosan raw materials on the growth and yield of rice in Bangladesh. A pot experiment was conducted to investigate yield performance of Boro rice variety (BRRI dhan88) as influenced by the chitosan raw materials under the Agro Ecological Zone (AEZ-28) Modhupur Tract.

Objective

1. Effect of sowing date and chitosan raw materials powder on Boro seedling characters
2. To examine yield performance of the treated Boro seedlings (Chitosan raw materials Powder treated Boro seedlings)

CHAPTER II

REVIEW OF LITERATURE

An endeavor was made in this section to collect and study the consequential information available in the country and abroad regarding the tillering pattern of BRRI dhan88 using chitosan raw materials in the seedbed to accrue knowledge helpful in executing the present research work and subsequently writing up the results and discussion.

Chitosan is well known for its role in stem elongation. The effect of chitosan on plant height was studied in various parts of the world by various workers on a variety of crops. It was observed in most cases that chitosan remarkably increases plant height of different crops.

Wan Ahmad Sofian *et al.,* (2022) observed the highest length of fruits was achieved at 75 ppm and the highest average diameter at 100 ppm chitosan concentration. The impact of chitosan on the total number of fruits and the total weight showed a positive result. Chitosan concentrations of 75–100 ppm showed the best performance in controlling diseases that affect fruits and leaves. Foliar applications of chitosan resulted in increased vegetative growth, better cucumber fruit quality and plant disease control compared to control plants (0 ppm).

Roja *et al.,* (2021) revealed that, irrespective of varieties, the foliar application of chitosan at 75 ppm significantly increased the biometric as well as yield related attributes of mulberry over other concentrations. Among the three varieties, VI showed more response to chitosan application than G4 and MR^2. At 75 ppm, chitosan showed marked effect on VI variety of mulberry and significantly increased shoot length (170.67 cm), number of shoots per plant (9.03), number of leaves per shoot (29.48), leaf area (220.26 cm^2) and leaf area index (2.72) were observed when compared with control. The application of chitosan at 75 ppm significantly enhanced the yield traits namely weight of 100 leaves (448.10 g), leaf shoot ratio (1.45) and leaf yield (14.01 mt ha^{-1} $harvest^{-1}$) in VI.

Sultana *et al.,* (2020) conducted a field experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh from July 2016 to December 2016 to find out the effect of seedlings age and different nitrogen (N) levels on the yield performance of transplant Aman rice (cv. Binadhan-15). The experiment comprised four ages of seedlings viz., 15, 20, 25, 30 days old and four levels of nitrogen viz., 0 , 55, 75 and 95 kg N ha^{-1} following randomized complete block design (RCBD) with three replications. The effect of age of seedling, nitrogen levels and their interactions were significant on growth, yield and yield contributing characters of transplant Aman rice. By using optimum seedling age at 15 DAT recorded the highest number of effective tillers $plant^{-1}$(8.29) at harvest respectively.

Shehzad *et al.,* (2020) reported that the effects of individual Chitosan application on growth, physiological processes and anti-oxidative defense system of sunflower under drought stress. At first, various doses of Chitosan (0, 0.1, 0.2, 0.3, 0.4, 0.5 g L^{-1}) were foliar applied to evaluate their role in improving plant biomass, water status and total chlorophyll in drought-induced seedlings of sunflower. The optimized Chitosan (0.28 g L^{-1}) doses impacted more pronounced at vegetative than reproductive stage and positive effects of Chitosan application were related to improved physiological and metabolic processes to improve yield and quality of sunflower under drought stress.

Ahmed *et al.,* (2020) conducted an experiment at the research field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, to examine effect of chitosan-raw-materials on yield maximization of BRRI dhan49 laid out in RCBD having four treatments with five replications). The treatment combinations were as follows: T_1: Seedbed applied @ 0 gm^{-2} + Main field applied @ 0 t ha^{-1} (Control); T_2: Seedbed applied @ 0 gm^{-2} + Main field applied @ 0.5 t ha^{-1}; T_3: Seedbed applied @ 250 gm^{-2} + Main field applied @ 0 t ha^{-1}; T_4: Seedbed applied @ 250 gm^{-2} + Main field applied @ 0.5 t ha^{-1}. Average 25.88 mg dry matter of a treated single seedling was increased. In producing the total number of tillers $hill^{-1}$ the treatments were found as $T_3>T_4>T_2>T_1$. It showed that the application of chitoan-raw-materials in soil increases the total tillers $hill^{-1}$.

Priyaadharshini *et al.,* (2019) conducted an experiment to study the effect of chitosan nano-emulsion in pearl millet under water deficit condition. Foliar spray of 0.1% chitosan nano-emulsion along with control was done at flowering stage under moisture stress condition. Physiological traits on gas exchange parameters

(photosynthetic rate, stomatal conductance, and transpiration rate and leaf temperature), chlorophyll index, relative water content and yield attributes were recorded after foliar spraying of chitosan. The results showed that the treatment with chitosan causes reduction in stomatal conductance thereby limiting the photosynthesis, transpiration rate and raise in leaf temperature than unsprayed plants. The yield was also significantly increased in treated plants than control under drought condition. Hence, foliar spray of chitosan plays an important role in alleviating the harmful effects of water stress by improving the plant water status and yield.

Ananthaselvi *et al.,* (2019) conducted an experiment to investigate the effect of foliar spray of chitosan on morphological, growth and flowering characters of the African marigold under induced drought condition. The experiment consists of three levels of water stress i.e. 100%, 70% & 50% field capacity and three levels of chitosan sprays viz., 0, 0.2 g & 0.4 g. The result indicated that 70% field capacity with 0.2 g of chitosan improved morphological parameter like plant height (cm).

Islam *et al.,* (2018) conducted an experiment in which different concentration of oligochitosan which were prepared from chitosan and were examined to study the effect on chilli and tomato plant. Four chitosan levels @ 25, 50, 75 and 100 ppm with control were taken as treatments. In case of the tomato, morphological parameters like plant height, leaves per plant and branches per plant were observed at 100 ppm concentration. In case of chili increase in the morphological characters like plant height, leaves per plant and branches per plant were observed at 75 ppm concentration.

Deotale *et al.,* (2018) conducted a field experiment to investigate the effect of different concentration of chitosan and IBA @ 25, 50, 75, 100, 125 ppm. The foliar spray was given at 30 DAS on soybean. The increase in morphological characters like plant height, number of branches and leaf area were recorded at 25 ppm concentration of chitosan.

Deotale *et al.,* (2018) conducted a field experiment to evaluate the effect of different concentrations of chitosan and IBA @ 25, 50, 75, 100 and 125 ppm. The foliar application was at 30 DAS. The increase in physiological parameters like total dry weight, relative growth rate and net assimilation rate was found best @ 25 ppm chitosan in soybean.

Al-Tawaha *et al.,* (2018) conducted an experiment to investigation the quality and productivity of barley by the fertilizer and chitosan application. Chitosan, in three different concentrations (0, 5, and 10 g L^{-1}), was randomly applied to all fertilized plots as subplot treatments. However, other parameters, namely the number of grains, number of spikes, and number of grains were also found to be influenced by the chitosan treatment. Significant variation ($P<0.01$) were also high between the lines in the presence and absence of chitosan application. The highest number of grain yield, number of spikes, and grains/spike were found by the foliar treatment of 10 g L^{-1} chitosan to barley plants at the tillering stage. Similarly, the grain quality, particularly with respect to protein and starch, was found to be enhanced significantly over control.

Phothi and Theerakarunwong (2017) conducted a study to know the effects of chitosan on physiology, photosynthesis and biomass of rice cultivar RD47. For combined effects of chitosan and ozone, rice was soaked and sprayed with chitosan 0.05% (W/V) under elevated ozone concentration at 40 ppb (Chi+EO340) and 70 ppb (Chi+EO370). Samples were analyzed weekly for tiller number per plants, leaf area, leaf chlorophyll, photosynthesis, shoot biomass, root biomass and total biomass. For the samples soaked and sprayed with chitosan under elevated ozone for 21 days, Chi+EO340 and Chi+EO370 significantly gathered more shoot biomass than EO340 and EO370, respectively ($p \leq 0.05$). In addition, chitosan could reduce the ozone negative effects and increased higher physiology and photosynthesis rate.

Phothi and Theerakarunwong (2017) conducted a study to know the effects of chitosan on physiology, photosynthesis and biomass of rice cultivar RD47. For combined effects of chitosan and ozone, rice was soaked and sprayed with chitosan 0.05% (W/V) under elevated ozone concentration at 40 ppb (Chi+EO340) and 70 ppb (Chi+EO370).Samples were analyzed weekly for tiller number per plants, leaf area, leaf chlorophyll, photosynthesis, shoot biomass, root biomass and total biomass. In addition, chitosan could reduce the ozone negative effects and increased higher physiology and photosynthesis rate.

Issak and Sultana (2017) carried out an experiment to observe the Role of chitosan raw material powder on the production of quality rice seedlings of BRRI dhan29 was examined in the field of Sher-e-Bangla Agricultural University, Dhaka. There were six treatments and three replications in the experiment. The treatments were as follows: T_1 = 100 g chitosan (CHT) powder m^{-2}, T_2 = 200 g CHT powder m^{-2}, T_3 = 300 g CHT powder m^{-2}, T_4 = 400 g CHT powder m^{-2}, T_5 = 500 g CHT powder m^{-2}, T_6 = 0 g CHT powder m^{-2}. A significant variation was observed in the seedlings height, biomass production, dry matter production and chemical properties of the seedbed soils due to the application of chitosan powder in the seedbed. The maximum seedlings height, fresh weight, oven dry weight was observed in the treatment T_4 and the minimum level in the treatment T_6 (control). On the other hand, the maximum level of organic carbon, organic matter and soil pH was recorded in the treatment T_5 and the minimum level in the treatment T_6 (control). Chitosan powder increased the level of organic matter in a dose dependent manner. Quality of the Boro rice seedlings were improved due to the application of chitosan powder and the seedlings strength were increased in a dose dependent manner. All the treatments were produced good quality Boro rice seedlings having more chlorophyll level and seedlings strength than the control treatments. Results indicated that treatment T_4 shows the superior results than other treatments. These results could be due some nature of soil alkalization and other some macro-micro nutritional supplementation which may be improving the strength of the seedlings.

Rabbi et al. (2016) carried out experiment comprising of different concentrations of chitosan viz., 0 (control), 25, 50, 75 and 100 ppm at 30 and 40 DAS on mungbean plant. Results showed that foliar application of chitosan @ 50 ppm significantly enhanced morphological characters such as plant height, number of branches, number of leaves and leaf area $plant^{-1}$.

Malekpoor *et al.*, (2016) noticed the effect of chitosan on morphology and physiology characteristics of sweet basil (Ocimum basilicum) under different irrigation regimes. Treatments comprised control, 0.0, 0.2 and 0.4 g L^{-1} chitosan applied to plants under normal irrigation, and slight and mild drought stress. Drought stress decreased the

content of photosynthetic pigments and growth parameters. Foliar-applied chitosan, in particular 0.4 g L^{-1} increased plant growth under stressed or non-stressed conditions compared with untreated plants.

Islam *et al.,* (2016) performed an experiment to evaluate the effect of foliar sprays of chitosan on summer and winter tomato, summer mungbean, maize and Aman and Boro rice. Chitosan was sprayed at four concentrations viz., 25, 50, 75 and 100 ppm for two times at vegetative and flowering stages of tomato and mungbean. For maize and rice chitosan was sprayed three times at vegetative and flowering stages at concentration of 50, 75, 100 and 125 ppm for maize and @ 25, 50 and 75 ppm for rice. The result showed that increase in physiological character like reproductive efficiency was observed best at 75 ppm for summer and winter tomato. In summer mungbean physiological parameters were observed more at 50 ppm concentration of chitosan. For maize more physiological characters were observed at 100 ppm concentration. For boro and aman rice physiological characters were increased at 50 ppm concentration of chitosan.

Anusuya *et al.,* (2016) noticed that the growth parameters (shoot height, leaf number/plant, and plant fresh weight) were increased with application of chitosan. Foliar application of chitosan induced the activity levels of defense enzymes such as protease inhibitors (PI), β-1, 3 glucanases, peroxidases (PO) and polyphenol oxidases (PPO) in the leaves and rhizomes of turmeric plants. Chitosan treatment to turmeric plants results in high yield and cur cumin content.

Ahed *et al.,* (2016) conducted an experiment to study the effect of foliar application of chitosan. Two concentrations of chitosan @ 250 and 500 ppm were sprayed on novel orange. The result indicated that increase in morphological parameters like shoot length, leaves number and leaf area were recorded at concentration of 500 ppm chitosan.

Sultana *et al.,* (2015) conducted a field experiment on rice plant. This experiment was carried out by using four different concentrations of oligomeric chitosan that is 0, 40, 80 and 100 ppm and four times foliar spray after germination. This experiment showed that plant height does not play any statistically significant differences between control and 40 ppm oligo-chitosan sprayed plants. But in case of 80 and 100

ppm oligo-chitosan sprayed rice plants show significant differences with compared to control.

Sultana et al. (2015) conducted a field experiment on rice plant. This experiment was carried out by using four different concentrations of oligomeric chitosan that is 0, 40, 80 and 100 ppm and four times foliar spray after germination. Finally it is observed that straw yield show significant differences between control plants and foliar sprayed chitosan plants and highest straw yield was observed under 100 ppm oligomeric chitosan and lowest straw yield was observed under 0 ppm oligomeric chitosan.

Martínez *et al.,* (2015) observed that Seeds treated with chitosan 100 mg L^{-1} stimulated shoot length and dry matter in saline medium grown seedlings and lowered malondialdehyde and increased proline levels. Both chitosan concentrations enhanced the activities of catalase and peroxidase enzymes, although a higher effect was obtained with chitosan 500 mg L^{-1}.

Kananont *et al.,* (2015) carried out an experiment with Fermented chitin waste (FCW) with three levels of FCW @ (0.25%, 0.50% and 1.0% (w/w)) along with CF = soil supplemented with chemical fertilizer and CMF = soil supplemented with chicken manure fertilizer. The results revealed that FCW @ 1% the grain yield differ significantly from 0.5% FCW, 0.25% FCW and the rest of the treatment.

Chamnanmanoontham *et al.,* (2015) noticed that the combination of the degree of deacetylation (DD), molecular weight and concentration of chitosan had differing effects on the rice seedling growth. For the best enhancement, oligomeric chitosan with an 80 % DD applied at 40 mg L^{-1} significantly enhanced the vegetative growth, in terms of the leaf and root fresh weights and dry weights of rice seedlings compared to the control. Chitosan enhanced the plant growth of rice seedlings via multiple and complex networks between the nucleus and chloroplast.

Agbodjato *et al.*, (2015) carried out an experiment to assess the combined effects of three plant growth promoting Rhizobacteria (Azospirillum lipoferum, Pseudomonas fluorescens and Pseudomonas putida), chitosan (a biostimulating molecule) and half or complete dose of nitrogen-phosphorus-potassium (NPK) and urea. Results obtained that the combination of Phosphorus putida along with chitosan and half dose of NPK-Urea increased height and circumference of maize plant.

Salachna and Zawadzinska (2014) carried out the experiment aiming to determine the effect of chitosan molecular weight on growth and yield of flowers and corms of potted fressia (an ornamental plant). Fressia corms were soaked in 0.5% chitosan solution with low molecular weight (2 kDa), medium molecular weight (50 kDa) and high molecular weight (970 kDa). The result revealed that the high molecular weight (970 kDa) showed increase in morphological characters like plant height, number of leaves and days to flowering.

Sathiyabama *et al.,* (2013) conducted an experiment to evaluate the effect of foliar application of chitosan on tomato plants. 0.1% (m/w) of chitosan was used. The result revealed that there was an increase in morpho-physiological characters like number of flowers and fresh weight in chitosan treated plants than control.

Nguyen Toah and Tran Hanh (2013) conducted an experiment where the field data of their studies showed that the yields of rice significantly increased (~31%) after applying chitosan solution. In general, applying chitosan increased rice production and reduced cost of production significantly.

Mondal *et al.*, (2013, b) carried out an experiment to evaluate the effect of foliar application of chitosan on mungbean plants. In the experiment five concentrations of chitosan viz., 0, 25, 50, 75 and 100 ppm were applied at 25 and 35 DAS. Results showed that 50 ppm chitosan increase growth parameters like plant height, number of branches, number of leaves and leaf area plant^{-1}.

Mondal *et al.,* (2013) noticed that foliar application of chitosan at early growth stages improved the plant height, leaf number plant^{-1}, leaf length and breadth, leaf area plant^{-1}, physiological (total dry mass plant^{-1}, absolute growth rate and harvest index) parameters and yield components thereby increased seed yield of maize. The highest

seed yield was recorded in 100 and 125 ppm of chitosan in maize. Therefore, foliar application of chitosan at 100 ppm may be used at early growth stage for getting maximum seed yield in maize.

El-Miniawy *et al.,* (2013) conducted an experiment to investigate the effect of foliar spray of chitosan viz., 2.5 ml L^{-1} or 5.0 ml L^{-1} with different number of application i.e. once, twice and three times on strawberry. The result shows that foliar spraying of chitosan at 5.0 ml three times showed significant increase in morphological characters like plant length, number of leaves per plant and leaf area as compared to control.

Berger *et al.,* (2013) conducted an experiment which results revealed the potential of rock biofertilizer mixed with earthworm compound inoculated with free living diazotrophic bacteria and Chitosan elegans (Fungi chitosan) for plant production and nutrient uptake. The bio-fertilizer, such as may be an alternative for NPK fertilization that slows the release of nutrients, favoring long-term soil fertility.

Abu-Muriefah, S. S. (2013) did an experiment to study the effect of chitosan @ 100, 200 and 400 ppm on common bean. The result reported that application of chitosan @ 200 ppm has significantly increased plant growth viz., number of branches, leaf number, plant height and leaf area $plant^{-1}$.

Van Toan *et al.,* (2012) The chitosan produced from shrimp shells using dilute acetic acid proved effective in controlling plants infection by microbial agents leading to higher yields of rice significantly increased (~31%) after applying chitosan solution. In general, applying chitosan increased rice production and reduced cost of production significantly.

Mondal *et al.,* (2012) studied the effect of different concentrations of chitosan viz., 0, 50, 75, 100 and 125 ppm on okra. The result indicated that spraying of chitosan @ 100 or 125 ppm at 25, 40 and 55 DAS has significantly increased morphological parameters like plant height, leaf number of okra.

John Berber *et al.,* (2012) conducted a pot experiment in an open greenhouse during March to June 2012. The results were revealed saying that all studied traits of inoculated and non-inoculated rice plants applied with various application methods were not significantly different. Chemical fertilizer application in combination with chitosan did not significantly differ from application of chemical fertilizer alone on leaf greenness, plant height, dry matter, grain yield and panicle numbers but significantly differed from those unapplied both chemical fertilizer and chitosan. Nevertheless, seeds of dirty panicle disease were significantly affected by various application methods, the lowest numbers were obtained from application of chemical fertilizer in combination with chitosan whereas no application of both chemical fertilizer and chitosan showed negative effect on controlling dirty panicle disease in inoculated and non-inoculated rice plant.

John Berber *et al.,* (2012) conducted a pot experiment in an open greenhouse during March to June 2012. The results were revealed saying that all studied traits of inoculated and non-inoculated rice plants applied with various application methods were not significantly different. Chemical fertilizer application in combination with chitosan did not significantly differ from application of chemical fertilizer alone on leaf greenness, plant height, dry matter, grain yield and panicle numbers but significantly differed from those unapplied both chemical fertilizer and chitosan.

Chookhongkha *et al.,* (2012) showed that the seedlings grown in the soil mixed with 1.0% (w/w) high MW presented the greatest growth rate and chlorophyll content, and a higher number of dark green leaves followed by medium and low MW at 30 days after transplant (DAT). A comparison of chitosan concentrations at 0.5 and 1.0% (w/w) on the growth and seed productivity was also performed in the green house. As a result, the significantly greatest seed yield indicated by fruit fresh weight plant^{-1}, fruit numbers plant^{-1}, seed numbers fruit^{-1}, and seed weight plant^{-1} was observed in the plants grown in the soil mixed with 1.0% high MW of chitosan

Mondal *et al.,* (2011) noticed that Application of Chitosan had a profound influence on morphological characters such as plant height, branch and leaf number, physiological characters such as specific leaf weight (SLW), chlorophyll content in

leaves and nitrate reductase activity (NRA) in leaves and yield characters such leaf area (LA), leaf and stem fresh weight as well as total fresh weight. The highest plant height and leaf number plant^{-1}, chlorophyll and NRA were recorded in 100 ppm followed by 75 ppm Chitosan. The highest number of branches plant-1, LA plant^{-1}, SLW, leaf and stem fresh weight as well as total fresh weight was observed in 75 ppm followed by 100 ppm Chitosan. The economic parts of Indian spinach, leaf and stem fresh weight as well as total fresh weight was the highest when Chitosan was sprayed @ 75 ppm. Application of Chitosan @ 75 ppm was optimum for maximizing plant growth and development of Indian spinach.

Ziani *et al.,* (2010) reported that seeds treated with chitosan resulted in a better growth of the seedlings (e.g. longer and better developed radicle and greener hypocotyls) and lower chance of being infected by fungi in comparison with the untreated seeds. The observed growth improvement by chitosan could be also related to the incorporation of nutrients (nitrogen) from chitosan.

Sultana (2010) from BAEC, Bangladesh reported that on growth and productivity of Maize (Zea mays. L) Plants the oligochitosan was applied for its potential use as plant growth promoter. The application of oligochitosan (molecular weight 7,000 Da) as foliar spraying with the concentration of 25, 50 and 75 m$^{g\ L-1}$. The results revealed that the application of oligochitosan plays a significant role at the concentration of 75 mg L^{-1} in terms of weight of cob and weight of seeds per Maize and ultimately maize yield.

Abdel-Mawgoud *et al.,* (2010) conducted an experiment to investigate the effect of foliar application of chitosan on strawberry plants. Chitosan sprays were carried out three times starting from ten weeks after transplanting with four weeks intervals in concentration of 0, 1, 2, 3 and 4 cm^3 L^{-1}. chitosan application improved plant height, number of leaves, fresh and dry weights of the leaves and yield components (number and weight). The responses were positively related to the applied concentrations with the highest peak recorded with 2 cm^3 L^{-1} then started to decline with higher applied concentrations but still significantly higher than control treatment. Fruit quality in terms of average weight of individual fruits and TSS showed similar trends. The result

revealed the increase in morphological characters like plant height, dry weight and number of leaves were found significant in 2 cm^3 L^{-1}concentration in strawberry.

Krishna *et al.,* (2009) conducted an experiment in Karnataka and revealed that the 12 days old seedling produced more number of tillers hill-1 at harvest. The 8 days old seedling flowered and matured about four to five days early compared to 5 days old seedlings. The treatment combination of 12 days old seedling with wider spacing recorded maximum seed yield per hectare. Significantly higher seed yield (3.27 t ha-1) and less spikelet sterility (16.72 per cent) recorded by 12 days old seedlings.

Guan *et al.,* (2009) showed that application of oligo-chitosan also increased mineral uptake of maize and stimulated the growth of maize seedlings. Spraying oligo-chitosan with concentration of 60 mg L^{-1}. A positive effect of chitosan was observed on the growth of roots, shoots and leaves of several crop plants. Chitosan under low temperature increased shoot height and root length in maize plants compared to that of the control.

El-Tantawy *et al.,* (2009) performed an experiment to study the effect of organic manure, goat manure and spraying with amendment substances like chitosan on tomato plants and noticed that tomato plants fertilized by spraying of chitosan significantly increased all vegetative parameters (plant height and number of both branches and leaves/plant), fresh and dry weight of different plant organs (roots, branches, leaves, and total of both fresh and dry weight of plant), photosynthetic pigments, yield/plant and marketable yield and Meanwhile, application of chitosan decreased the diseased yield. On the other hand, pH and TSS (%) were not significantly affected.The result indicates the positive effect on morphological characters like plant height, number of branches and leaves per plant were observed by chitosan spray.

Asghari-Zakaria et al. (2009) observed that Application of 500 mg/l of soluble chitosan chitosan in vitro resulted in improved acclimatization of plantlets in the

greenhouse as expressed by significant ($P < 0.05$) increased the shoot fresh weight, mini tuber number and yield, compared to the control but its lower concentrations did not significantly affect this trait ($P < 0.05$). The 5 and 15 mg/l of soluble chitosan led to a significant increase in root fresh and dry weight of in vitro plantlets, whereas, higher concentrations, especially 500 mg L^{-1}, significantly decreased root fresh weight of in vitro plantlets.

Limpanavech *et al.,* (2008) carried out an experiment to observed that the effects on Dendrobium "Eiskul" floral production with six types of chitosan molecules, P-70, O-70, P-80, O-80, P-90, and O-90. Compared to the non-chitosan treated controls,9 chitosan O-80 induce early flowering at all concentrations tested, 1, 10, 50, and 100 mg/L and during the 68 weeks of the experimental periodic time it increase the accumulative inflorescence number.

Gornik *et al.,* (2008) conducted an experiment to evaluate the effect of treatment to grape vine cuttings with chitosan on their rooting, subsequent plant development and reaction to drought stress. Biochikol 020 PC solution was used at concentrations of 0.5, 1 and 2% for 24 hours at 250 c. The result indicated that biochikol 020 PC applied at 1% stimulated the growth of cuttings by increasing number of internodes in comparison with control.

Boonlertnirun *et al., (*2008) carried out an experiment with 4 treatments. The treatments were T_1- control (no chitosan application), T_2 seed soaking with chitosan solution, T_3 - seed soaking and soil application with chitosan solution and T_4 seed soaking and foliar spraying with chitosan solution. The results revealed that chitosan 15 application by seed soaking and then soil significantly stimulates growth and increases yield of plants over the other treatments of rice plants.

Bhuvaneswari and Chandrasekharan *et al.,* (2008) showed varying chitosan application methods did not affect tiller numbers per plant. The maximum tiller numbers obtained from treatment of seed soaking in chitosan solution before planting and soil application, however did not differ significantly from the control. Their treatment combination were Tr_1- no chitosan application (control), Tr_2- seed soaking with chitosan solution Tr3- seed soaking and soil application with chitosan solution and Tr_4 -seed soaking and foliar spraying with chitosan solution.

Boonlertnirun *et al.*, (2007) conducted a greenhouse experiments for determining the effect of chitosan on drought recovery and grain yield of rice under drought conditions. Results showed that the before drought treatment application of chitosan gave the highest yield and yield contributing character and also showed good recovery of rice plants.

Boonlertnirun *et al.,* (2006) reported that the application of polymeric chitosan by seed soaking before planting followed by four foliar sprayings of chitosan doses throughout cropping season significantly increased the number of tillers per plant and yield of cultivar Suphan Buri 1 was significantly increased over the control (no chitosan) conditions.

Bolto *et al.,* (2004) carried out and experiment on Ion exchange for the removal of natural organic matter and found that CHT (chitosan) can increase the microbial population and transforms organic nutrient into inorganic nutrient which is easily absorbed by the plant roots.

Ouyang and Xu (2003) carried out an experiment with Chinese cabbage (Brassica campestris) cv. Dwarf hybrid No.1 and observed that when seed dressed with chitosan at the rate of 0.4-0.6 mg L^{-1} seed and leaf sprayed 20-40 micro g L^{-1} plant height, fresh weight and leaf area of Chinese cabbage was increased.

Hoque (2002) conducted field experiment on a high yielding variety (Shatabdi) of wheat to evaluate the effect of CI-IAA, GABA and TNZ-303 by soaking seeds in 0.16 ml L^{-1}, 0.33 ml $L^{-1}$and 0.66 ml L^{-1}aqueous solutions and revealed that the GABA at 0.33 ml/L produced the tallest shoot at 60 and 90 DAS. Shoot height was significantly higher over that produced in control.

Gani *et al.,* (2002) reported that young seedlings (7 or 14 days old) performed better than 21 days old seedlings. The plants of young seedlings were taller and they produced longer and heavier roots, more number of effective tillers and biomass.

Hong *et al.,* (1998) showed that chitin or derivatives chitosan level improves the durability and resistance of the plant, makes it not easily infected by germs, not proliferate even infected, and cures the disease by itself. Application of chitosan in agriculture reduce the use of chemical fertilizer, increases the production of different kinds of plant, by 15-20%.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at Sher-e-Bangla Agricultural University, Dhaka to investigate the improvement of early sowing Boro seedling characters by using chitosan raw material powder and their yield performance at different seedling age. Materials used and methodologies followed in the present investigation have been described in this chapter.

3.1. Experimental period

The experiment was conducted during the period from November-2019 to April 2020 in Boro season.

3.2. Description of the experimental site

3.2.1. Geographical location

The experiment was conducted in the Agronomy field of Sher-e-Bangla Agricultural University (SAU). The experimental site is geographically situated at 23°77′ N latitude and 90°33′ E longitude at an altitude of 8.6 meter above sea level (Anon., 2004).

3.2.2. Agro-Ecological Zone

The experimental site belongs to the Agro-ecological zone (AEZ) of "The Modhupur Tract", AEZ-28 (Anon., 1988 a). This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as 'islands' surrounded by floodplain (Anon., 1988 b). For better understanding about the experimental site has been shown in the Map of AEZ of Bangladesh in Appendix-I.

3.2.3. Soil

The soil of the experimental field belongs to the General soil type, Shallow Red Brown Terrace Soils under Tejgaon soil series. Soil pH ranges from 5.4–5.8(Anon., 1989). The land was above flood level and sufficient sunshine was available during the experimental period. Soil samples from 0–15 cm depths were collected from the Sher-e-Bangla Agricultural University (SAU) Farm, field. The soil analyses were

done at Soil Resource and Development Institute (SRDI), Dhaka. The morphological and physicochemical properties of the soil are presented in below table.

Table 1: Morphological characteristics of the experimental area.

Morphological features	Characteristics
Location	Sher-e-Bangla Agricultural University Farm, Dhaka
AEZ	Madhupur Tract
General Soil Type	Red Brown Terrace Soil
Land type	Medium high land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

Table 2: The initial physical and chemical characteristics of soil used in this experiment

Soil Physical characteristics	
Constituents	Percent (%)
Sand	26
Silt	45
Clay	29
Textural class	Clay loam
Soil chemical characteristics	
pH	5.8
Organic carbon (%)	0.6
Organic matter (%)	1.03
Total nitrogen (%)	0.04
Available P (ppm)	20.54

3.2.4. **Climate and weather**

The climate of the experimental site was subtropical, characterized by the winter season from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Edris *et al.*, 1979). Meteorological data related to the temperature, relative humidity and rainfall during the experiment period was collected from Bangladesh Meteorological Department (Climate division), Sher-e-Bangla Nagar, Dhaka and has been presented in Appendix-III and Appendix- IV

3.3. Experimental materials

BRRI dhan88 and different level of chitosan raw material powder were used as experimental materials for this experiment. The important characteristics of these are mentioned below:

3.3.1. **Test crop (BRRI dhan88)**

Rice (Oryza sativa) variety BRRI dhan88 was used as planting material. BRRI developed this variety and released in 2018. It is the most popular & high yielding Boro variety suitable for planted at 15th Dec-30th December. This variety attains a height of 100 cm. The life cycle of this variety is 140-143 days. Amylose present 26.6 % and protein 9.8%. Grain yield is around 8.5 t ha^{-1} and 1000 grain weight is 20-22 g. The seeds of this variety were collected from Bangladesh Rice Research Institute (BRRI), Gazipur. Seeds contain 76% carbohydrate, 26.3% amylose and 9.8% protein.

3.3.2. **Chitosan raw material powder**

The composition of chitosan raw material powder is given below

Table 3: Composition of the chitosan raw material powder which was used in the research work.

Name of the nutrients	Nutrient content	Methods name
pH	8.19	Glass Electrode Method (Max Cremer, 1906)
Total Nitrogen (N)	7.42-11.41%	Micro-Kjeldahl Metod (Kjeldahl, J. (1883)
Available Phosphorus (P)	0.45%	Spectrophotometric Molybdovanadate Method (Boltz, D. F., and Mellon, M. G. 1948)
Exchangable Potassium (K)	0.14%	Flame Photometric Method (Deal, S. B.1954)
Available Sulphur (S)	0.10%	Spectrophotometric Method (Jones, A. S., & Letham, D. S. 1956)
Available Boron (B)	17.94 ppm	
Available Calcium (Ca)	75 ppm	Atomic Absorption Spectrophotometric Method (Trudeau, D. L., & Freier, E. F. 1967).
Available Magnesium (Mg)	2.7 ppm	
Available Zinc (Zn)	0.096%	
Organic Carbon (OC)	18.39%	Wet Oxidation Method (Walkley and Black, 1934)
Organic Matter (OM)	31.70%	Organic carbon x 1.724 (Van Bemmelen factor)

3.4. Seed collection and sprouting

BRRI dhan88 was collected from BRRI (Bangladesh Rice Research Institute), Joydebpur, Gazipur. Healthy and disease free seeds were selected, following standard technique. Seeds were immersed in water in a bucket for 24 hrs. These were then taken out of water and kept in gunny bags. The seeds started sprouting after 48 hrs. Which were suitable for sowing in 72 hrs.

3.5. Experimental treatments

There were two factors in the experiment namely Chitosan raw material powder level and different age of seedling as mentioned below:

Factor A: Level of Chitosan raw material powder (w/w) (6) viz;

T_1= 0%, CHT raw material powder
T_2= 0.1%, CHT raw material powder
T_3= 0.2%, CHT raw material powder
T_4= 0.3%, CHT raw material powder
T_5= 0.4% CHT raw material powder
T_6= 0.5% CHT raw material powder

Factor B: Sowing date (8) viz;

S_1= Sowing date 23 Nov, 2019
S_2= Sowing date 25 Nov, 2019
S_3= Sowing date 27 Nov, 2019
S_4= Sowing date 29 Nov, 2019
S_5= Sowing date 01 Dec, 2019
S_6= Sowing date 03 Dec, 2019
S_7= Sowing date 05 Dec, 2019
S_8= Sowing date 07 Dec, 2019

3.6. Seedbed pot preparation and application of Chitosan raw material powder

6-inch plastic pots were used for raising seedling. Field moist soil was collected from Sher-e-Bangla Agricultural University farm then mixed with at **0%, 1%, 2%, 3%, 4% and 5%** of Chitosan raw material powder in soil according with par treatment requirement. Then the pot was filled with chitosan raw material treated soil. After that 100 seeds were sown in the pot for raising seedlings.

3.7. Seed sowing in pot

Generally, farmers prepared the seedbed and sows their seed in the seedbed during the month of October to November and transplant seedling in the main filed at the month of November to December. But in this experiment seed sowing was done at 20 November 2019 to 10 December 2020 in two days interval and total seed sown set was 10 but last two set wasted for mis-management and cold stress effect. Seed were sown in pot of on one kg soil treated with several treatment of chitosan powder in seed pot. (Table 4)

Table 4: Seed sowing date

1st set	23 November,2019
2nd set	25 November,2019
3rd set	27 November,2019
4th set	29 November,2019
5th set	01,December,2019
6th set	03,December,2019
7th set	05,December,2019
8th set	07,Dceember,2019

3.8. Seedling management

As the seedling were prepared in seed pot, it required regular water application and checking of water level in seedbed.

3.8.1. **Seedling height**

The sample of 100 seedling were collected for measuring seedling height (cm). The heights of 25, 30 and 35-days-old seedlings in several date were measured on a Centimeter scale from the ground level to the tip of the seedlings. 100 seedlings average height were measured and then and then heights were expressed in centimeters.

3.8.2. **Seedling fresh weight**

The sample of 100 seedling were collected for measuring fresh weight. Fresh seedlings of 25, 30, 35 days old were collected and then weighed by using a digital electric balance. Hundreds seedlings fresh weight were measured and expressed in gram. To get the single seedling fresh weight, the seedlings fresh weight were divided by 100 and was got single seedling fresh weight and was expressed in milligram.

3.8.3. **Seedling dry weight**

The sample of 100 seedling were collected for measuring dry weight which was dried in oven after taking fresh weight. Seedlings of 25, 30, 35 days old were dried in oven and weighed by using a digital electric balance. The hundred seedlings oven dry weight were measured and expressed in gram.

3.9. Details of experimental preparation of field trial set (S_1)

3.9.1. **Selection and preparation of the pot for field trail first set (S_1)**

Earthen pots of having 12 inches' diameter, 12 inches' height with a hole at the center of the bottom were used. Silt soil was used in the experiment. The upper edge diameter of the pots was 30 cm (r= 15 cm). While filling with soil, the upper one inch of the pot was kept vacant so that irrigation can be provided using a hose pipe. As such the diameter of the upper soil surface was 15 inch (30 cm) and the area of the upper soil surface was (πr^2 = 3.14x 0.015x 0.015=0.07 m^2). The preparation of the pot was done in 16 January 2020.

3.9.2. **Seedling transplanting in the pot**

Seedling were transplanted at three seedlings age such as 25,30 and 35 days aged seedlings uprooted carefully from the seedbed pot and transplanted in final pots on 18 December,2019 ,23 December 2019 and 28 December, 2019. Single seedling was transplanted in each hill. (Table-6)

3.9.3. **Fertilizer management**

Table 5: The following doses of fertilizer were applied for cultivation of Boro rice (FRG, 2012).

Fertilizers	Quantity (kg/ha)	Fertilizer given pot^{-1} (g)
Urea	300	2.1
TSP	100	0.7

MP	120	0.84
Gypsum	60	0.42

Plant Macronutrients (viz. nitrogen, phosphorus, potash, sulfur) for rice were given through urea, triple super phosphate, muriate of potash, and gypsum, respectively. All the fertilizers including 1/2 dose of urea and 1/2 dose of MoP were applied at 12 days after transplanting. In Second split of fertilizer application 1/4 th of urea applied in 28 days after transplanting. In final dose ¼ th of urea and ½ of MoP fertilizer applied in 43 days after transplanting at maximum tillering stage recommended by BRRI.

Table 6: Fertilizer application Schedule

Seedling Age (day)	Transplanting date	Application of fertilizers (1/3rd Urea, TSP, MP, Gypsum	2nd split application of urea and weeding	3rd split application of urea and 2nd weeding)
25	18 Nov, 2019	30-12-2019	15-1-2020	30-01-2020
30	23 Nov, 2019	04-01-2020	20-1-2020	04-02-2020
35	28 Nov, 2019	09-01-2020	25-1-2020	09-02-2020

3.10. Intercultural operations

Intercultural operations were done for ensuring and maintaining the normal growth of the crop. The detailed intercultural operations were recorded in the (table 6).

3.10.1. Application of irrigation water

After transplanting 5-6 cm water was maintained in each pot through irrigation during the growth period. Frequency of irrigation water was reduced after panicle emergence and grain filling stage. The field was kept dried 7 days before harvesting. (Table-6)

3.10.2. Weeding

The crop was infested with some weeds during the early stage of crop establishment. Three hand weeding were done to reduce crop competition with weed. First weeding was done at 20 days after transplanting followed by second weeding at 15 days after first weeding. Third weeding was done 15 days after second weeding. (Table-6)

3.10.3. Plant protection measures

The crop was attacked by yellow rice stem borer (Scirpopagain certulas) at the panicle initiation stage which was successfully controlled with Sumithion @ 1.5 L ha^{-1}. Yet to keep the crop growth in normal, Basudin was applied at tillering stage @ 17 kg ha^{-1} while Diazinon 60 EC @ 850 ml ha^{-1} were applied to control rice bug and leaf hopper. Application of insecticide was applied at 1 January 2020. Crop was protected from birds during the grain filling period by using net and covering the experimental site.

3.11. General observations of the experimental field

Regular observations were made to see the growth and visual different of the crops, due to application of different treatment were applied in the experimental pot. In general, the plant looked nice with normal green plants. Incidence of stem borer, green leaf hopper, leaf roller was observed during tillering stage and there was also some rice bug were present in the experimental pot. But any bacterial and fungal disease was not observed. The flowering was not uniform.

3.12. Field operation

The different field operations performed during the course of present investigation are given below in chronological order in list form

Table 7: Dates of different operations done during the field study

Operations		Working Dates
Collection of field moist soil		15 November, 2019
Different level of chitosan raw material powder was mixed with field moist soil		20 November,2019
Seed sowing	1st set	23 November,2019
	2nd set	25 November,2019
	3rd set	27 November,2019
	4th set	29 November,2019
	5th set	01,December,2019
	6th set	03,December,2019
	7th set	05,December,2019
	8th set	07,Dceember,2019
Collection and preparation of the transplanted pot		16 December 2019
Transplanting of seedlings	25 Days seedlings	18 December, 2019
	30 days Seedlings	23 December, 2019
	35 Days seedlings	28 December, 2019
Insecticide application		10 March, , 2020
Harvesting and threshing		28 April and 1 May 2020

3.13. Crop sampling and data collection

Pot from each replication were randomly selected and marked with sample card. Different data were recorded from selected plants at various growth stage. The rice plant was harvested depending upon the maturity of grains and harvesting was done manually from each plot. Maturity of crop was determined when 80–90% of the grains become golden yellow in color. Harvesting date were 28.04.2020 and 1.05.2020. Harvesting was done in the morning to avoid shattering. Prior to

harvesting, randomly selected plant from each replication pot were separately harvested for recording yield attributes and other data. The harvested plants were tied into bundles and carried to the threshing floor of the Soil Field Laboratory. Threshing was done by hand. The grains were cleaned and sun dried to moisture content of 12%. Straw was also sun dried properly. Finally grain and straw yields pot-1 were recorded.

3.14. Harvest and Threshing

The crop was harvested depending upon the maturity of plant. Harvesting was done by serrated edged sickles manually from each pot. Maturity of crop was determined when 80% of the grains became matured. The harvested crops from each pot were bundled, properly tagged and then brought to the threshing floor for recording grain and straw yield. Threshing was done plot wise by pedal thresher. The grains were cleaned and sun dried to a moisture content of 12%. Straw was also sun dried properly. Finally grain and straw yields per pot were determined and expressed in gram (g).

3.15. Data collection

The data were recorded on the following parameters

i. Average seedling height (cm)
ii. Fresh weight seedling^{-1} (g)
iii. Oven dry weight seedling^{-1} (g)
iv. Seedling strength (mg cm^{-1})
v. Number of tillers pot^{-1}
vi. Number of effective tillers pot^{-1}
vii. Grain yield pot^{-1} (g)
viii. Straw yield pot^{-1} (g)

3.16. Procedure of data collection

i. **Average seedling height (cm)**

The heights of 25, 30 and 35 days old seedlings were measured on a meter scale from the ground level to the tip of the seedlings. 100 seedlings average height were measured and then and then heights were expressed in centimeters.

ii. **Fresh weight seedling^{-1} (g)**

Fresh seedlings of 25, 30 and 35 days old were collected and then weighed by using a digital electric balance. Hundreds seedlings fresh weight were measured and expressed in gram. To get the single seedling fresh weight, the seedlings fresh weight were divided by 100 and was got single seedling fresh weight and was expressed in milligram.

iii. **Oven dry weight seedling^{-1} (mg)**

Seedlings of 25, 30 and 35 days old were dried in oven and weighed by using a digital electric balance. The hundred seedlings oven dry weight were measured and expressed in gram. To get the single seedling oven dry weight, the seedlings oven dry weight were divided by 100 and was got single seedling oven dry weight and was expressed in milligram.

iv. **Seedling strength (mg cm^{-1})**

Seedling strength was measured by using the following formula

$$\text{Seedling strength} = \frac{\text{Single seedling Dry weight (mg)}}{\text{Seedling height (cm)}} \quad \text{mg cm}^{-1}$$

v. **Number of tillers pot^{-1}**

Number of tillers pot^{-1} were counted at 10 days' interval up to 60 DAT from pre-selected hills and finally averaged as their number pot^{-1}. Only those tillers having three or more leaves were considered for counting.

vi. **Number of effective tillers pot^{-1}**

The total number of effective tillers pot^{-1} were counted as the number of panicle bearing tillers per hill. Data on effective tiller per pot were recorded at harvesting time and average value was recorded.

xii. **Grain yield pot^{-1} (g)**

Grain yield from each pot were taken expressed as g pot^{-1} on about 12% moisture basis. Grain moisture content was measured by using a digital moisture tester.

xiii. **Straw yield pot^{-1}(g)**

Straw obtained from each pot were sun dried and weighted carefully and finally converted to g pot^{-1}

3.17. Chemical analysis of seed pot soil after seedling transplant

3.17.1. Particle size analysis

Particle size analysis of soil was done by Hydrometer Method and then textural class was determined by plotting the values for % sand, % silt and % clay to the "MarshalL-1s Textural Triangular Coordinate" according to the USDA system.

3.17.2. Soil pH

Soil pH was measured with the help of a Glass electrode pH meter using soil and water at the ratio of 1:2.5 as described by Jackson (1962).

3.17.3. **Organic C**

Organic carbon in soil was determined by wet oxidation method of Walkley and Black (1934). The underlying principle is to oxidize the organic carbon with an excess of 1N $K_2Cr_2O_7$ in presence of conc. H_2SO_4 and to titrate the residual $K_2Cr_2O_7$ solution with 1N $FeSO_4$ solution. Dilute the mass in the flask with about 150-200 mL of distilled water by mixing conc. H_3PO_4 and 2 mL of diphenylamine indicator. The organic carbon was calculated by the following formula:

$$\% \text{ Organic carbon} = \frac{(B-T) \times N}{W} \times 0.003 \times 1.3 \times 100$$

Therefore, % Organic matter = % Organic carbon x 1.724

Where, B = Blank, T = Treatment, N = Normality, W = weight of soil, 1.724 = Van Bemmelen factor.

3.17.4. **Total nitrogen**

Nitrogen in soil was determined by Micro-Kjeldahl method of Kjeldahl, J. (1883). Soil Samples were digested with conc. H_2SO_4, 30% H_2O_2 and catalyst mixture (K_2SO_4: $CuSO_4.5H_2O$: Selenium powder in the ratio 100:10:1 respectively). Nitrogen in the digest was determined by distillation with NaOH followed by titration of the distillate absorbed in H3BO3 with 0.01 N H_2SO_4 (Jackson 1973). Total nitrogen was calculated by the following formula:

$$\% \text{ of total N in soil} = \frac{(T-B) \times N \times 0.014 \times D}{W} \times 100$$

Where, T = Treatment, B = Blank, N = Normality, D = Dilution factor, W = Weight of soil.

3.17.5. **Available phosphorus**

Available P was extracted from the soil with 0.5 M $NaHCO_3$ solutions, pH 8.5 (Olsen *et al.,* 1954). Phosphorus in the extract was then determined by developing blue color with reduction of phosphomolybdate complex and the color intensity were measured calorimetrically at 660 nm wavelength and readings were calibrated with the standard P curve.

3.18. Data analysis technique

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program name MSTAT-C. The significance of the difference among the treatment means was estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV
RESULT DISCUSSION

Results obtained from the present study have been presented and discussed in this chapter with a view to study the improvement of Boro rice seedlings characters and yield by using chitosan raw material powder in seedbed soil. The data are given in different tables and figures. The results have been discussed, and possible interpretations are given under the following headings.

4.1. Seedling characteristics

4.1.1. Seedling height (cm)

4.1.1.1. Seedling height (cm) of 25 days old Seedling at different sowing date

A significant variation was found in the Boro seedling height with sowing date and the applications of chitosan raw material powder in the rice seedbed. Seedling height significantly decreased with delay the sowing time of Boro rice. On the other hand, a significant improvement was found in the seedling height of Boro rice with the different doses of chitosan raw material powder.

Maximum seedling height was found in the 1st sowing date (23 Nov. 2019) and minimum seedling height was found in the 8th sowing date (07 Dec. 2019). Overall a decreasing trend of the seedling height was found that might be due to the effect of low temperature. Many farmers are practicing late sowing of Boro rice because of their mustard cultivation in the cropping pattern. They are using over aged Boro seedlings (some cases 70 days old seedlings) or less quality Boro seedlings due to the late sowing.

Maximum seedling height (26.73 cm) observed in T_6 (0.5% chitosan powder) at 25 day age seedlings whereas minimum seedling height (10.03 cm) in T (0.4 % chitosan Powder). Chitosan raw material have also impact against cold stress injuries. Cold stress mostly impacted on control height (Fig-4) in seedling stage overcome by the application of chitosan powder but chitosan treated seedbed had less impact. Seedling height of Control of S_5 and S_6 was fluctuated with temperature fluctuation but treated

seedbed of S_5 (sowing date 01, Dec, 2019) and S_6 (sowing date 03, Dec, 2019) were not induced by cold stress. All the treated seedbed in S_5 (sowing date 01, Dec, 2019) and S_6 (sowing date 03, Dec, 2019) is far better than these control even better than other cold stress less control seedlings. In S_5 (sowing date 01, Dec, 2019) sowing date seedling height sequence of 25 day age seedlings was $T_2>T_3>T_5>T_4>T_6>T_1$. In S_6 (sowing date seedling height sequence was $T_2>T_3>T_4>T_5>T_6>T_1$ (Fig-2). Seedling height of the Control (14.33 cm) of optimum sowing time (15 Nov-30 Nov) was statistically identical with treated seedlings of S_8T_2 (13.3 cm) and S_8T_3 (13.33 cm) which was sown 8 days later of the optimum sowing recommended (15 Nov-30 Nov) by BRRI. Seedlings treated with chitosan row material powder effect on the production of same quality seedling in 8 days later. Application CHT powder helps in production of quality seedling in cold stress condition. Treated seedlings was less impacted by cold stress. Cold stress suppress the control height then the treated seedlings.

Combined effect of chitosan raw material powder and sowing date significantly effect on seedling height of BRRI dhan88 (Fig. 1). Experimental result showed that, the maximum height of 23.93 cm in combined treatment of S_1T_6 and minimum height S_8T_5 (10.033 cm) and S_7T_6 (10.2 cm) which was 16 days later then maximum height. On the other hand the seedling height of the control (S_1T_1) of 25 days aged seedlings was 16.97 cm which was identical with the combined treatment of S_4T_5.

In Boro season, seedling height was significantly decrease in late sowing. The seedling height could be increased by using Chitosan Raw Materials powder in the seedbed. All the sowing time showed increased of seedling height. The result indicated that the materials could be functioned against cold stress in Boro seedling production. In S_1 minimum temperature was 22°C. In S_4 minimum temperature was 22°C. In S_8 minimum temperature was 19°C .Late sowing decreased the seedlings height. Treatments increased the seedling height significantly in all sowing date.

A farmer can easily produce seedling like S_1 (control) in the S_4 (T_2, T_3, T_4, T_5 treatment) and S_5 (T_2,) with the late sowing. Mustard grower farmer can also produce seedlings like S_4 control in the S_8 (T_2, T_3, T_4, T_5 treatment).Ahmed et al. (2020) Al-Tawaha et al. (2018) Issak and Sultana (2017) observed that chitosan application

increase the seedling height. Ouyang and Langlai (2003) observed that chitosan application increased plant height and leaf area.

Seedling height at Sowing date S_1 (23 Nov. 2019)

Seedling height was found to be statistically significant in all of the treatments used in the experiment Maximum seedling height was observed in T_6 (23.97 cm) which was statistically identical with T_5 (23.43 cm), T_4 (22.56 cm), T_3 (22.5 cm) whereas minimum seedling height in T_1 (16.97 cm). T_2 (21.53 cm) was identical with T_5 (23.43 cm), T_4 (22.56 cm) and T_3 (22.5 cm).

Seedling height at Sowing date S_2 (25 Nov. 2019)

Seedling height was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling height was observed in T_2 (19.76 cm) which was statistically identical with T_3 (18.7 cm) whereas minimum seedling height in T_1 (16.1 cm). T_4 (17.37 cm) was identical with T_5 (15.63 cm) and T_6 (15.58 cm).

Seedling height at Sowing date S_3 (27 Nov. 2019)

Seedling height was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling height was observed in T_6 (19.5 cm) which was statistically identical with T_4 (18.46 cm) whereas minimum seedling height in T_1 (14.53 cm). T_2 (18.03 cm) was identical with T_3 (17.23 cm) and T_5. (17.46 cm)

Seedling height at Sowing date S_4 (29 Nov. 2019)

Seedling height was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling height was observed in T_2 (18.06 cm) which was statistically identical with T_3 (17.11 cm) and T_4 (17.37 cm) whereas minimum seedling height in T_1 (14.33 cm). T_6 (14.8 cm) was identical with T_5 (15.53 cm).

Seedling height at Sowing date S_5 (01 Dec. 2019)

Seedling height was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling height was observed in T_2 (15.2 cm) which was statistically identical with T_3 (14.77 cm), T_4 (13.85 cm), T_5 (14.43 cm) whereas minimum seedling height in T_1 (11.63 cm). T_6 (12.8 cm) was identical with T_3 (14.77 cm) and T_5 (14.43 cm).

Seedling height at Sowing date S_6 (03 Dec. 2019)

Seedling height was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling height was observed in T_2 (14.1 cm) which was statistically identical with T_3 (13.6 cm), T_4 (13.16 cm), T_5 (13.26 cm) T_6 (12.36 cm) whereas minimum seedling height in T_1 (11.73 cm).

Seedling height at Sowing date S_7 (05 Dec. 2019)

Seedling height was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling height was observed in T_2 (14.03 cm) which was statistically identical with T_3 (13.8 cm), and T_4 (13.33 cm) whereas minimum seedling height in T_1 (11.17 cm). T_5 (10.69 cm) was identical with T_6 (10.2 cm).

Seedling height at Sowing date S_8 (07 Dec. 2019)

Seedling height was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling height was observed in T_3 (13.33 cm) which was statistically identical with T_2 (13.3 cm) whereas minimum seedling height in T_4 (10.03 cm) which was statistically identical with T_5 (10.03 cm) and T_1 (11.13 cm).

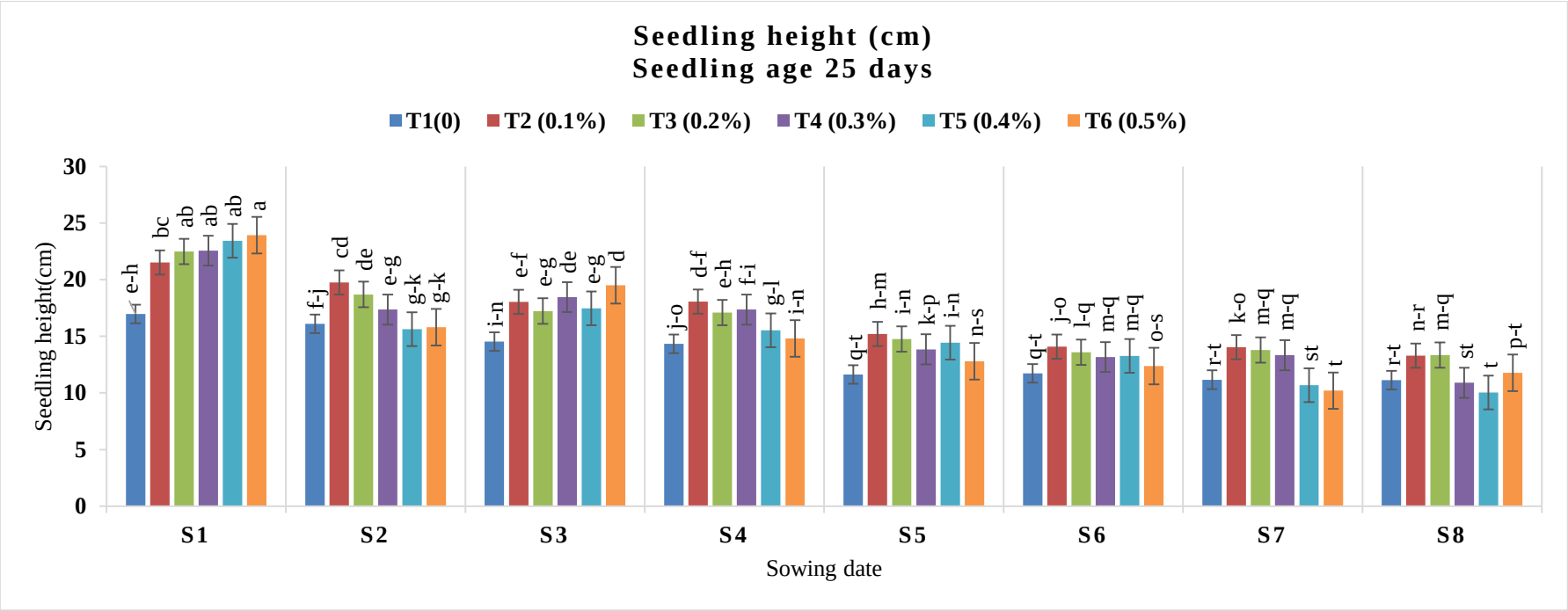

Figure 1: Effect of sowing date and chitosan raw material powder on seedling height at 25 day age seedlings of BRRI dhan88. Bars with different letters are significantly different at p ≤0.05 applying DMRT.

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability Here,			
S_1= sowing date 23,Nov,2019 S_2= sowing date 25,Nov,2019 S_3= sowing date 27,Nov,2019 S_4= sowing date 29,Nov,2019	S_5= sowing date 01,Dec ,2019 S_6= sowing date 03,Dec,2019 S_7= sowing date 05,dec ,2019 S_8= sowing date 07,Dec ,2019	T_1= 0%, CHT raw material powder T_2= 0.1%, CHT raw material powder T_3= 0.2%, CHT raw material powder	T_4= 0.3%, CHT raw material powder T_5= 0.4% CHT raw material powder T_6= 0.5% CHT raw material powder

4.1.1.2. Seedling height (cm) of 30 days old Seedling at different sowing date

Combined effect of chitosan raw material powder and sowing date significantly effect on seedling height of BRRI dhan88 (Fig. 2). Experimental result showed that, the maximum height of 25.13 cm in combined treatment of S_1T_6 and minimum height S_7T_6 which sowing date was 12 days later then maximum height resulted seedbed. At the same time the seedling height of the control (S_1T_1) of 30 days aged seedlings was 18.77 cm which was identical with the combined treatment of S_4T_2 (17.34 cm) and S_4T_6 (17.22 cm)which sowing seedling was 8 days later then the control.

A farmer can easily produce seedling like S_1 (control) in the S_4 (T_2, T_3, T_4, T_5 treatment) and S_5 (T_2,) with the late sowing. Mustard grower farmer can also produce seedlings like S_4 control in the S_8 (T_2, T_3, T_4, T_5 treatment)

Seedling height at Sowing date S_1 (23 Nov. 2019)

Seedling height was found to be statistically significant in all of the treatments used in the experiment Maximum seedling height was observed in T_6 (25.13 cm) whereas minimum seedling height in T_1 (18.77 cm) and the second highest height was T_4 (23.67) which was statistically identical with T_5 (23.43 cm), T_2 (23.20 cm), T_3 (23.5 cm).

Seedling height at Sowing date S_2 (25 Nov. 2019)

Seedling height was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling height was observed in T_2 (20.86 cm) which was statistically identical with T_3 (20.39 cm) whereas minimum seedling height in T_6 (17.75 cm).

Seedling height at Sowing date S_3 (27 Nov. 2019)

Seedling height was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling height was observed in T_6 (20.87 cm) which was statistically identical with T_4 (20.23 cm) whereas minimum seedling height in T_1 (15.37 cm). T_5 (19.52 cm) was identical with T_3 (18.9 cm) and T_2 (18.6 cm)

Seedling height at Sowing date S_4 (29 Nov. 2019)

Seedling height was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling height was observed in T_3 (19.03 cm) which was

statistically identical with T_4 (18.93 cm) whereas minimum seedling height in T_1 (13.97 cm).

Seedling height at Sowing date S_5 (01 Dec. 2019)

Seedling height was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling height was observed in T_3 (15.83 cm) which was statistically identical with T_2 (15.17 cm) and T_5 (15.48 cm) whereas minimum seedling height in T_1 (11.7 cm).

Seedling height at Sowing date S_6 (03 Dec. 2019)

Seedling height was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling height was observed in T_4 (14.3 cm) which was statistically identical with T_2 (14.07 cm), T_3 (13.90 cm) whereas minimum seedling height in T_1 (10.13 cm).

Seedling height at Sowing date S_7 (05 Dec. 2019)

Seedling height was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling height was observed in T_2 (15.5 cm) which was statistically identical with T_6 (11.43 cm) whereas minimum seedling height in T_1 (12.3 cm).

Seedling height at Sowing date S_8 (07 Dec. 2019)

Seedling height was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling height was observed in T_2 (15.41 cm) which was statistically identical with T_6 (14.55 cm) whereas minimum seedling height in T_4 (11.28 cm).

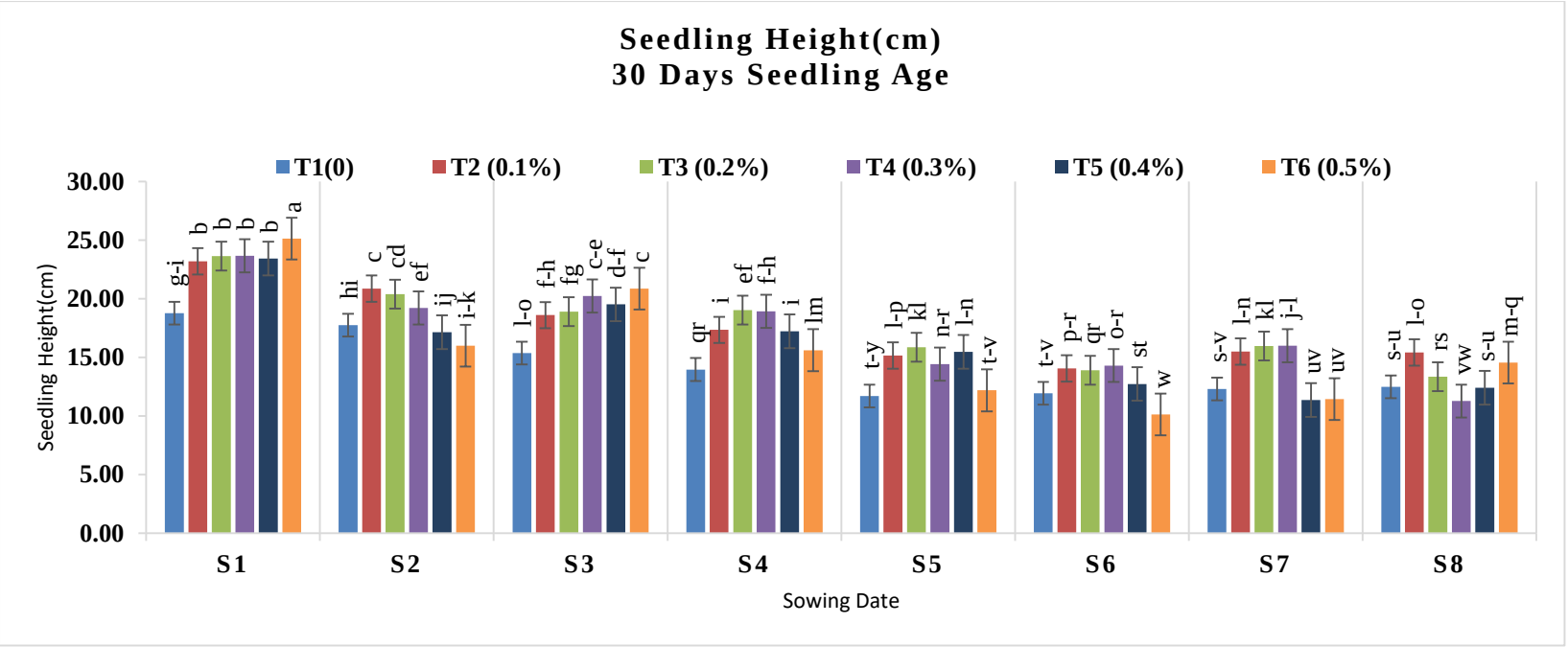

Figure 2: Effect of sowing date and chitosan raw material powder on average seedling height at 30 day age seedlings of BRRI dhan88. Bars with different letters are significantly different at p ≤0.05 applying DMRT.

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability Here,		
S_1= sowing date 23,Nov,2019 S_2= sowing date 25,Nov,2019 S_3= sowing date 27,Nov,2019 S_4= sowing date 29,Nov,2019	S_5= sowing date 01,Dec ,2019 S_6= sowing date 03,Dec,2019 S_7= sowing date 05,dec ,2019 S_8= sowing date 07,Dec ,2019	T_1= 0%, CHT raw material powder T_2= 0.1%, CHT raw material powder T_3= 0.2%, CHT raw material powder T_4= 0.3%, CHT raw material powder T_5= 0.4% CHT raw material powder T_6= 0.5% CHT raw material powder

4.1.1.3. Seedling height (cm) of 35 days old Seedling at different sowing date

Seedling Height (cm) of BRRI dhan88 rice seedlings were significantly increased with the chitosan powder treatments in the seedbed. Experimental result showed that, the maximum height of 26.72 cm in combined treatment of S_1T_6 and minimum height was 11.46 cm in S_6T_1 which sowing date was 12 days later then maximum height resulted seedbed. At the same time the seedling height of the control (S_1T_1) of 35 days aged seedlings was 14.83 cm which was identical with the combined treatment of S_8T_3 and S_8T_4 which sowing seedling was 16 days later then the control.(Fig:3)

In Boro season, seedling height was significantly decrease in late sowing. The seedling height could be increased by using Chitosan Raw Materials powder in the seedbed. All the sowing time showed increased of seedling height. The result indicated that the materials could be functioned against cold stress in Boro seedling production. In S_1 minimum temperature was 22°C. In S_4 minimum temperature was 21°C. In S_8 minimum temperature was 19°C .Late sowing decreased the seedlings height. Treatments increased the seedling height significantly in all sowing date.

A farmer can easily produce seedling like S_1 (control) in the S_4 (T_2, T_3, T_4, T_5 treatment) and S_5 (T_2,) with the late sowing. Mustard grower farmer can also produce seedlings like S_4 control in the S_8 (T_2, T_3, T_4, T_5 treatment)

Seedling height at Sowing date S_1 (23 Nov. 2019)

Seedling height was found to be statistically significant in all of the treatments used in the experiment Maximum seedling height was observed in T_6 (26.73 cm) whereas minimum seedling height in T_1 (19.83 cm) and the second highest height was T_4 (24.1 cm) which was statistically identical with T_5 (24 cm), T_2 (20.93 cm), T_3 (21.06 cm).

Seedling height at Sowing date S_2 (25 Nov. 2019)

Seedling height was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling height was observed in T_2 (19.36 cm) whereas minimum seedling height in T_1 (15.67 cm). T_3 (18.63 cm) was identical with T_6 (18.06 cm).

Seedling height at Sowing date S_3 (27 Nov. 2019)

Seedling height was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling height was observed in T_6 (21.36 cm) which was statistically identical with T_5 (21.26 cm) and T_4 (19.43 cm) whereas minimum seedling height in T_1 (15.1 cm).

Seedling height at Sowing date S_4 (29 Nov. 2019)

Seedling height was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling height was observed in T_5 (20.45 cm) whereas minimum seedling height in T_1 (15.1 cm). T_5 (20.45 cm) was identical with T_4 (19.3 cm).

Seedling height at Sowing date S_5 (01 Dec. 2019)

Seedling height was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling height was observed in T_4 (17.73 cm) whereas minimum seedling height in T_1 (11.96 cm). T_3 (16.65 cm) was identical with T_5 (15.96 cm)

Seedling height at Sowing date S_6 (03 Dec. 2019)

Seedling height was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling height was observed in T_2 (15.36 cm) whereas minimum seedling height in T_1 (11.46 cm).

Seedling height at Sowing date S_7 (05 Dec. 2019)

Seedling height was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling height was observed in T_2 (17.7 cm) whereas minimum seedling height in T_1 (13.26 cm). T_2 (10.69 cm) was identical with T_3 (13.1 cm).

Seedling height at Sowing date S_8 (07 Dec. 2019)

Seedling height was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling height was observed in T_2 (17.13 cm) whereas minimum seedling height in T_6 (12.33 cm) which was statistically identical with T_5 (12.46 cm) and T_1 (12.46 cm).

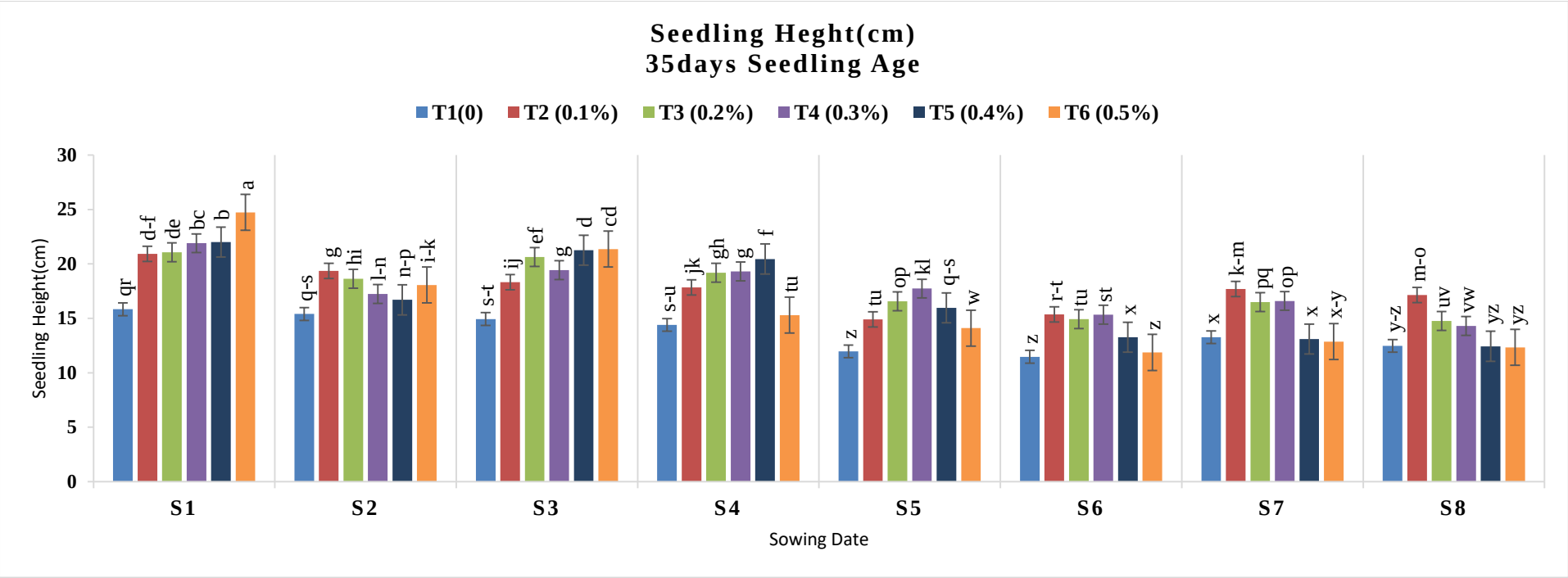

Figure 3: Effect of sowing date and chitosan raw material powder on average seedling height at 35 day age seedlings of BRRI dhan88. Bars with different letters are significantly different at p ≤0.05 applying DMRT.

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability Here,		
S_1= sowing date 23,Nov,2019 S_2= sowing date 25,Nov,2019 S_3= sowing date 27,Nov,2019 S_4= sowing date 29,Nov,2019	S_5= sowing date 01,Dec ,2019 S_6= sowing date 03,Dec,2019 S_7= sowing date 05,dec ,2019 S_8= sowing date 07,Dec ,2019	T_1= 0%, CHT raw material powder T_2= 0.1%, CHT raw material powder T_3= 0.2%, CHT raw material powder T_4= 0.3%, CHT raw material powder T_5= 0.4% CHT raw material powder T_6= 0.5% CHT raw material powder

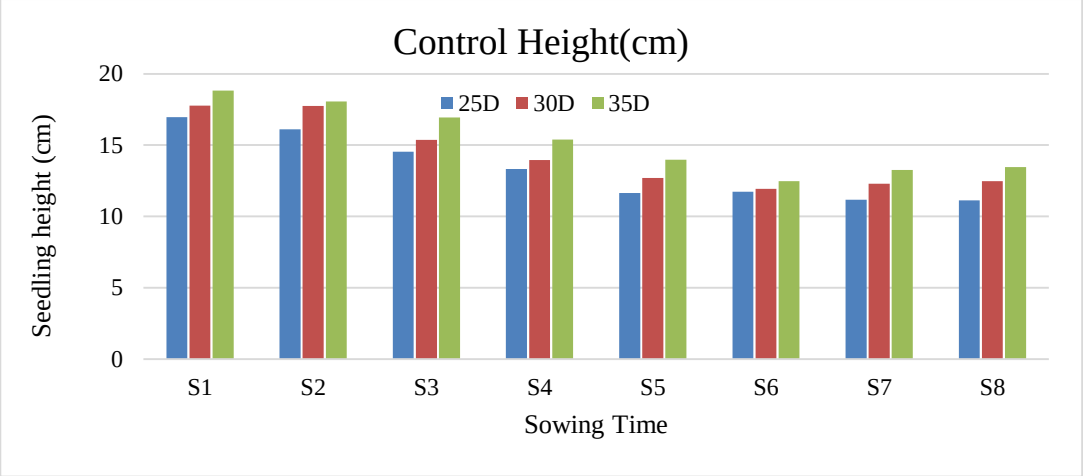

Figure 4: Seedling height of control in 25, 30, 35 day after sowing

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability Here,		
S_1= Sowing date 23 Nov,2019 S_2= Sowing date 25 Nov,2019 S_3= Sowing date 27 Nov,2019 S_4= Sowing date 29 Nov,2019	S_5= Sowing date 01 Dec ,2019 S_6= Sowing date 03 Dec,2019 S_7= Sowing date 05 Dec ,2019 S_8= Sowing date 07 Dec ,2019	T_1= 0%, CHT raw material powder T_2= 0.1%, CHT raw material powder T_3= 0.2%, CHT raw material powder T_4= 0.3%, CHT raw material powder T_5= 0.4% CHT raw material powder T_6= 0.5% CHT raw material powder

The experimental result of all control sown several two days interval was impacted by the cold stress during the sowing time. At 25 day aged seedling height in gradually decreasing with the fluctuation of temperature. Similar result observed in the 30 and 35 day age seedling height.

4.1.2. Seedling fresh weight (g)

4.1.2.1. Seedling fresh weight (g) of 25 days old Seedling at different sowing date

Seedling fresh weight (g) of BRRI dhan88 rice seedlings were significantly increased with the chitosan powder treatments in the seedbed The application of chitosan raw materials powder in rice seedbed have massive impact on the growth of seedling fresh weight. The experimental result shows that different doses of chitosan raw materials substantiated statistically diversified result. Maximum seedling weight (68.3 g) observed in T_6 (0.5% chitosan powder) at 35 day age seedlings whereas minimum seedling fresh weight in S_7T_1 (0% chitosan Powder). Chitosan raw material have also impact against cold stress injuries. Cold stress mostly impacted on control fresh weight (Fig-6) in

seedling stage overcome by the application of chitosan powder but chitosan treated seedbed had less impact. Seedling fresh weight of Control of S_5 and S_6 was fluctuated with temperature fluctuation but treated seedbed of S_5 and S_6 were not induced by cold stress. All the treated seedbed in S_5 and S_6 is far better than these control even better than other cold stress less control seedlings. In S_5 sowing date seedling fresh weight sequence of 25 day age seedlings was $T_5>T_6>T_4>T_2>T_3>T_1$. In S_6 sowing date seedling fresh weight sequence was $T_5>T_6>T_4>T_3>T>T_1$ (Fig-6). These results indicate that fresh weight productions of BRRI dhan88 rice seedlings were influenced with the treatments and this might be due its nutritional supplementations to the soil as well as the improvement of growth promoting hormonal activity. Asghari-Zakaria *et al*. (2009) observed that Application of 500 mg/l of soluble chitosan increased the shoot fresh weight. Chamnanmanoontham, et al. (2015) noticed that the combination of the degree of deacetylation (DD), molecular weight and concentration of chitosan significantly enhanced the vegetative growth, in terms of the leaf and root fresh weights and dry weights of rice seedlings compared to the control. Tsugita *et al.,* (1993) reported that chitosan promotes shoot and root growth. CHT can increase the microbial population and transforms organic nutrient into inorganic nutrient which is easily absorbed by the plant roots (Bolto *et al.,* 2004).

Seedling fresh weight (19.33 g) of the Control (S_4T_1) of optimum sowing time (15 Nov-30 Nov) was statistically identical with treated seedlings of S_8T_4 (13.3 g), S_6T_2 (13.33 g) S_6T_3 (13.33 g) in all other treated seedling fresh weight are far better than the control of optimum date recommended by BRRI (15 Nov-30 Nov) which was sown 8, 6 and 4 days later. Seedlings treated with chitosan row material powder effect on the production of same quality seedling in 8 days later. Application CHT powder helps in production of quality seedling in cold stress condition. Treated seedlings was less impacted by cold stress. Cold stress suppress the control height then the treated seedlings.

The experimental result shows that the maximum and minimum fresh weight of 100 seedling sown in 2 days interval in several sowing date (23 Nov-7 Dec) in 25 day age were 65.37 g and 10.97 g respectively in S_1T_6 and S_7T_1. Sowing difference of two set was 14 days. On the other hand 100 seedling fresh weight of first control 25.93 g was identical with S_8T_2 which was sown in 14 days later of first control seedlings. Even Experimental result shows that seedling obtained in S_8T_2, S_8T_3, S_8T_5, and S_8T_6 better quality which was sown in 8 days letter after BRRI recommendation. It reviled that CHT raw materials

treated seedbed help to produce better quality seedling which may be a small hope of farmers who want to cultivate BRRI dhan after harvesting Mustard.

In Boro season, seedling fresh weight was significantly decrease in late sowing. The seedling fresh weight could be increased by using Chitosan Raw Materials powder in the seedbed. All the sowing time showed increased of seedling height. The result indicated that the materials could be functioned against cold stress in Boro seedling production. In S_1 minimum temperature was 22°C. In S_4 minimum temperature was 21°C. In S_8 minimum temperature was 19°C .Late sowing decreased the seedlings fresh weight. Treatments increased the seedling fresh weight significantly in all sowing date.

A farmer can easily produce seedling like S_1 (control) in the S_4 (T_2, T_3, T_4, T_5 treatment) and S_5 (T_2,) with the late sowing. Mustard grower farmer can also produce seedlings like S_4 control in the S_8 (T_2, T_3, T_4, T_5 treatment)

Seedling fresh weight at Sowing date S_1 (23 Nov. 2019)

Seedling fresh weight was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling fresh weight was observed in T_6 (65.37 g) which was statistically identical with T_5 (50.8 g) whereas minimum seedling height in T_1 (25.93 g). T_4 (48.93 g) was identical with T_3 (40.5 g).

Seedling fresh weight at Sowing date S_2 (25 Nov. 2019)

Seedling fresh weight was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling fresh weight was observed in T_4 (48.97 g) which was statistically identical with T_3 (45.53 g), T_6 (42.83 g) and T_5 (46.2 g) whereas minimum seedling height in T_1 (16.1 cm).

Seedling fresh weight at Sowing date S_3 (27 Nov. 2019)

Seedling fresh weight was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling fresh weight was observed in T_6 (47.93 g) which was statistically identical with whereas minimum seedling height in T_1 (21.23 g). T_3 (39.4 g) was identical with T_4 (39.46 g) and T_5 (37.93 g)

Seedling fresh weight at Sowing date S_4 (29 Nov. 2019)

Seedling fresh weight was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling fresh weight t was observed in T_4 (45.46 g) which was statistically identical with T_2 (41.03 g), T_5 (41.3 g) and T_6 (39.63) whereas minimum seedling height in T_1 (19.33 g).

Seedling fresh weight at Sowing date S_5 (01 Dec. 2019)

Seedling fresh weight was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling fresh weight was observed in T_6 (26.67 g) which was statistically identical with T_5 (26.63 g), T_2 (24.06) and T_4 (25.7) whereas minimum seedling height in T_1 (12.33 g). T_3 (16.13 g) was statistically different with all other treatments.

Seedling fresh weight at Sowing date S_6 (03 Dec. 2019)

Seedling fresh weight was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling fresh weight was observed in T_5 (23.63 g) which was statistically identical with T_6 (21.46 g), T_4 (20.83 g), T_3 (19.53 g) and T_2 (19.27 g) whereas minimum seedling height in T_1 (13.07 g).

Seedling fresh weight at Sowing date S_7 (05 Dec. 2019)

Seedling fresh weight was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling fresh weight was observed in T_4 (14.03 cm) which was statistically identical with T_2 (13.8 g), and T_6 (13.33 g) whereas minimum seedling height in T_1 (11.17 g). T_5 (10.69 g) was identical with T_3 (10.2 g).

Seedling fresh weight at Sowing date S_8 (07 Dec. 2019)

Seedling fresh weight was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling fresh weight was observed in T_2 (23.96 g) which was statistically identical with T_3 (23.73 g) whereas minimum seedling height in T_1 (14.43 g). T_6 (22.13 g) was statistically identical with T_5 (22.07 g) and T_4 (18.97 g) statistically different with all other treated seedling fresh weight.

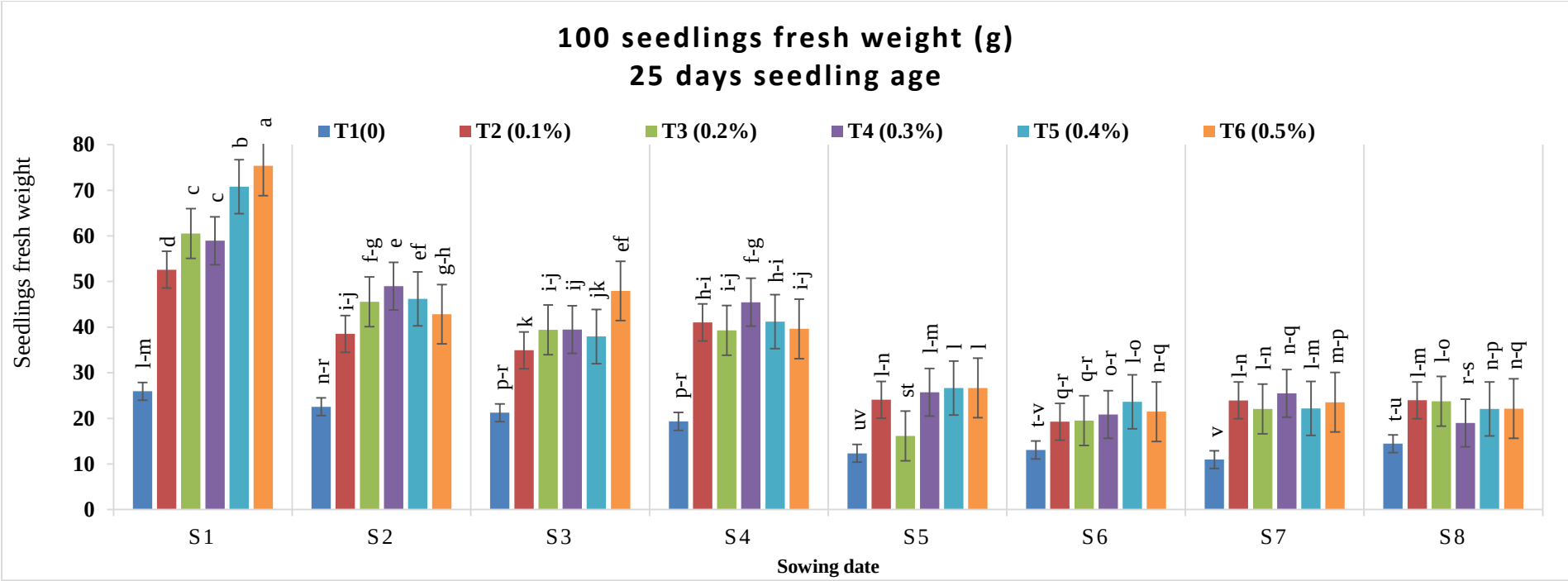

Figure 5: Effect of sowing date and chitosan raw material powder on fresh weight at 25 day age seedlings of BRRI dhan88. Bars with different letters are significantly different at p ≤0.05 applying DMRT.

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability Here,		
S_1= Sowing date 23 Nov,2019 S_2= Sowing date 25 Nov,2019 S_3= Sowing date 27 Nov,2019 S_4= Sowing date 29 Nov,2019	S_5= Sowing date 01 Dec ,2019 S_6= Sowing date 03 Dec,2019 S_7= Sowing date 05 Dec ,2019 S_8= Sowing date 07 Dec ,2019	T_1= 0%, CHT raw material powder T_2= 0.1%, CHT raw material powder T_3= 0.2%, CHT raw material powder T_4= 0.3%, CHT raw material powder T_5= 0.4% CHT raw material powder T_6= 0.5% CHT raw material powder

4.1.2.2. Seedling fresh weight (g) of 30 days old Seedling at different sowing date

Seedling fresh weight (15.1 g) of the Control (S_4T_1) of optimum sowing time (15 Nov-30 Nov) was statistically identical with treated seedlings of S_8T_4 (26.48 g), S_7T_3 (30.33 g) S_6T_5 (32.20 g) and S_5T_3 (28.37 g) in all other treated seedling fresh weight are far better than the control of optimum date recommended by BRRI (15 Nov-30 Nov) which was sown 8, 6 and 4 days later. Seedlings treated with chitosan row material powder effect on the production of same quality seedling in 8 days later. Application CHT powder helps in production of quality seedling in cold stress condition. Treated seedlings was less impacted by cold stress. Cold stress suppress the control height then the treated seedlings. . It reviled that CHT raw materials treated seedbed help to produce better quality seedling which may be a small hope of farmers who want to cultivate BRRI dhan after harvesting Mustard.

In Boro season, seedling fresh weight was significantly decrease in late sowing. The seedling fresh weight could be increased by using Chitosan Raw Materials powder in the seedbed. All the sowing time showed increased of seedling height. The result indicated that the materials could be functioned against cold stress in Boro seedling production. In S_1 minimum temperature was 22°C. In S_4 minimum temperature was 21°C. In S_8 minimum temperature was 19°C .Late sowing decreased the seedlings fresh weight. Treatments increased the seedling fresh weight significantly in all sowing date.

A farmer can easily produce seedling like S_1 (control) in the S_4 (T_2, T_3, T_4, T_5 treatment) and S_5 (T_2,) with the late sowing. Mustard grower farmer can also produce seedlings like S_4 control in the S_8 (T_2, T_3, T_4, T_5 treatment).

Seedling fresh weight at Sowing date S_1 (23 Nov. 2019)

Seedling fresh weight was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling fresh weight was observed in T_6 (67.87 g) whereas minimum seedling height in T_1 (30.47 g). T_4 (49.5 g) was identical with T_3 (43.63 g).

Seedling fresh weight at Sowing date S_2 (25 Nov. 2019)

Seedling fresh weight was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling fresh weight was observed in T_4 (60.36 g) whereas minimum seedling height in T_1 (26.43 g).

Seedling fresh weight at Sowing date S_3 (27 Nov. 2019)

Seedling fresh weight was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling fresh weight was observed in T_6 (55.13 g) minimum seedling height in T_1 (22.07 g). T_3 (38 g) was identical with T_4 (43.63 g) and T_5 (49.24 g)

Seedling fresh weight at Sowing date S_4 (29 Nov. 2019)

Seedling fresh weight was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling fresh weight t was observed in T_4 (43.63 g) whereas minimum seedling height in T_1 (15.10 g).

Seedling fresh weight at Sowing date S_5 (01 Dec. 2019)

Seedling fresh weight was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling fresh weight was observed in T_5 (32.83 g) which was statistically identical with T_2 (30.92 g) whereas minimum seedling height in T_1 (14.08 g).

Seedling fresh weight at Sowing date S_6 (03 Dec. 2019)

Seedling fresh weight was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling fresh weight was observed in T_4 (34.07 g) which was statistically identical with T_5 (32.83 g) whereas minimum seedling height in T_1 (19.87 g).

Seedling fresh weight at Sowing date S_7 (05 Dec. 2019)

Seedling fresh weight was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling fresh weight was observed in T_2 (38.53 g) whereas minimum seedling height in T_1 (16.67 g). T_5 (33.53 g) was identical with T_6 (34.53 g).

Seedling fresh weight at Sowing date S_8 (07 Dec. 2019)

Seedling fresh weight was found to be statistically significant in all of the treatments used in the experiment. The experimental result shows that the maximum and minimum fresh weight of 100 seedling in 30 day age were 67.87 g and 14.08 g respectively in S_1T_6 and S_5T_1. Sowing difference of two set was 10 days. On the other hand 100 seedling fresh weight of first control 30.47g was identical with S_7T_3 which was sown in 14 days later of first control seedlings

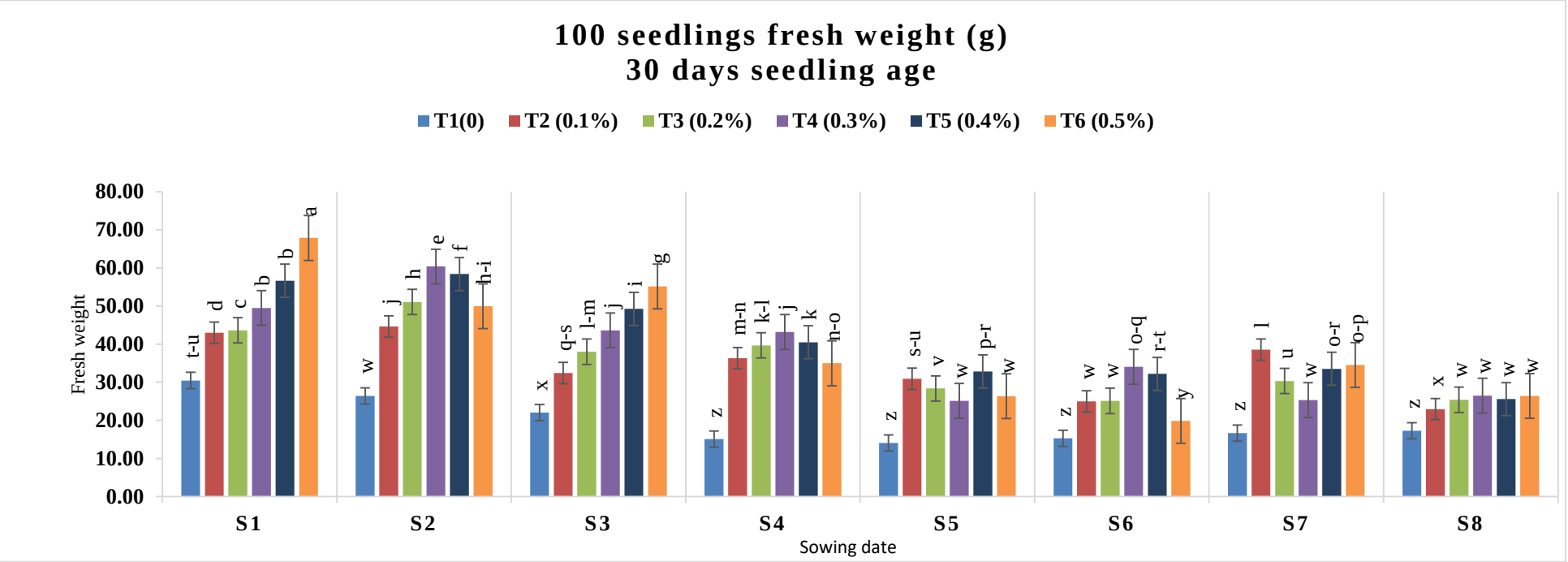

Figure 6: Effect of sowing date and chitosan raw material powder on fresh weight at 30 day age seedlings of BRRI dhan88. Bars with different letters are significantly different at p ≤0.05 applying DMRT.

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability Here,		
S_1= Sowing date 23 Nov,2019 S_2= Sowing date 25 Nov,2019 S_3= Sowing date 27 Nov,2019 S_4= Sowing date 29 Nov,2019	S_5= Sowing date 01 Dec ,2019 S_6= Sowing date 03 Dec,2019 S_7= Sowing date 05 Dec ,2019 S_8= Sowing date 07 Dec ,2019	T_1= 0%, CHT raw material powder T_2= 0.1%, CHT raw material powder T_3= 0.2%, CHT raw material powder T_4= 0.3%, CHT raw material powder T_5= 0.4% CHT raw material powder T_6= 0.5% CHT raw material powder

4.1.2.3. Seedling fresh weight (g) of 35 days old Seedling at different sowing date

Seedling fresh weight was found to be statistically significant in all of the treatments used in the experiment. The experimental result shows that the maximum and minimum fresh weight of 100 seedling in 30 day age were 68.30 g and 14.93 g respectively in S_1T_6 and S_6T_1. Sowing difference of two set was 12 days.

The experimental result shows that the maximum and minimum fresh weight of 100 seedling sown in 2 days interval in several sowing date (23 Nov-7 Dec) in 35 day age were 68.30 g and 17.33 g respectively in S_1T_6 and S_8T_1. Sowing difference of two set was 16 days. On the other hand 100 seedling fresh weight of first control 31.47 g was identical with S_8T_3 which was sown in 16 days later of first control seedlings. Even Experimental result shows that seedling obtained in S_8T_2, S_8T_3, S_8T_5, and S_8T_6 better quality which was sown in 8 days letter after BRRI recommendation. It reviled that CHT raw materials treated seedbed help to produce better quality seedling which may be a small hope of farmers who want to cultivate BRRI dhan after harvesting Mustard.

In Boro season, seedling fresh weight was significantly decrease in late sowing. The seedling fresh weight could be increased by using Chitosan Raw Materials powder in the seedbed. All the sowing time showed increased of seedling height. The result indicated that the materials could be functioned against cold stress in Boro seedling production. In S_1 minimum temperature was 22°C. In S_4 minimum temperature was 21°C. In S_8 minimum temperature was 19°C .Late sowing decreased the seedlings fresh weight. Treatments increased the seedling fresh weight significantly in all sowing date.

A farmer can easily produce seedling like S_1 (control) in the S_4 (T_2, T_3, T_4, T_5 treatment) and S_5 (T_2,) with the late sowing. Mustard grower farmer can also produce seedlings like S_4 control in the S_8 (T_2, T_3, T_4, T_5 treatment)

Seedling fresh weight at Sowing date S_1 (23 Nov. 2019)

Seedling fresh weight was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling fresh weight was observed in T_6 (67.87 g) whereas minimum seedling height in T_1 (25.93 g). T_5 (56.93 g) was identical with T_4 (49.5 g).

Seedling fresh weight at Sowing date S_2 (25 Nov. 2019)

Seedling fresh weight was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling fresh weight was observed in T_4 (60.97 g) whereas minimum seedling height in T_1 (16.1 cm). T_5 (58.53 g) was statistically identical with T_4 (60.2 g)

Seedling fresh weight at Sowing date S_3 (27 Nov. 2019)

Seedling fresh weight was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling fresh weight was observed in T_6 (55.13 g) which was statistically identical with T_5 (49.4 g) whereas minimum seedling height in T_1 (22.23 g).

Seedling fresh weight at Sowing date S_4 (29 Nov. 2019)

Seedling fresh weight was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling fresh weight t was observed in T_5 (45.46 g) whereas minimum seedling height in T_1 (19.33 g).

Seedling fresh weight at Sowing date S_5 (01 Dec. 2019)

Seedling fresh weight was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling fresh weight was observed in T_5 (26.67 g) whereas minimum seedling height in T_1 (12.33 g). T_3 (16.13 g) was statistically identical with T_6 (21.46 g).

Seedling fresh weight at Sowing date S_6 (03 Dec. 2019)

Seedling fresh weight was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling fresh weight was observed in T_2 (23.63 g) whereas minimum seedling height in T_1 (13.07 g).

Seedling fresh weight at Sowing date S_7 (05 Dec. 2019)

Seedling fresh weight was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling fresh weight was observed in T_2 (14.03 cm) which was statistically identical with T_5 (13.8 cm), and T_6 (13.33 cm) whereas minimum seedling height in T_1 (11.17 cm). T_2 (10.69 cm) was identical with T_3 (10.2 cm).

Seedling fresh weight at Sowing date S_8 (07 Dec. 2019)

Seedling fresh weight was found to be statistically significant in all of the treatments used in the experiment. Maximum seedling fresh weight was observed in T_4 (23.96 g) which was statistically identical with T_6 (23.73 g) whereas minimum seedling height in T_1 (14.43 g). T_5 (22.13 g) was statistically identical with T_2 (22.07 g).

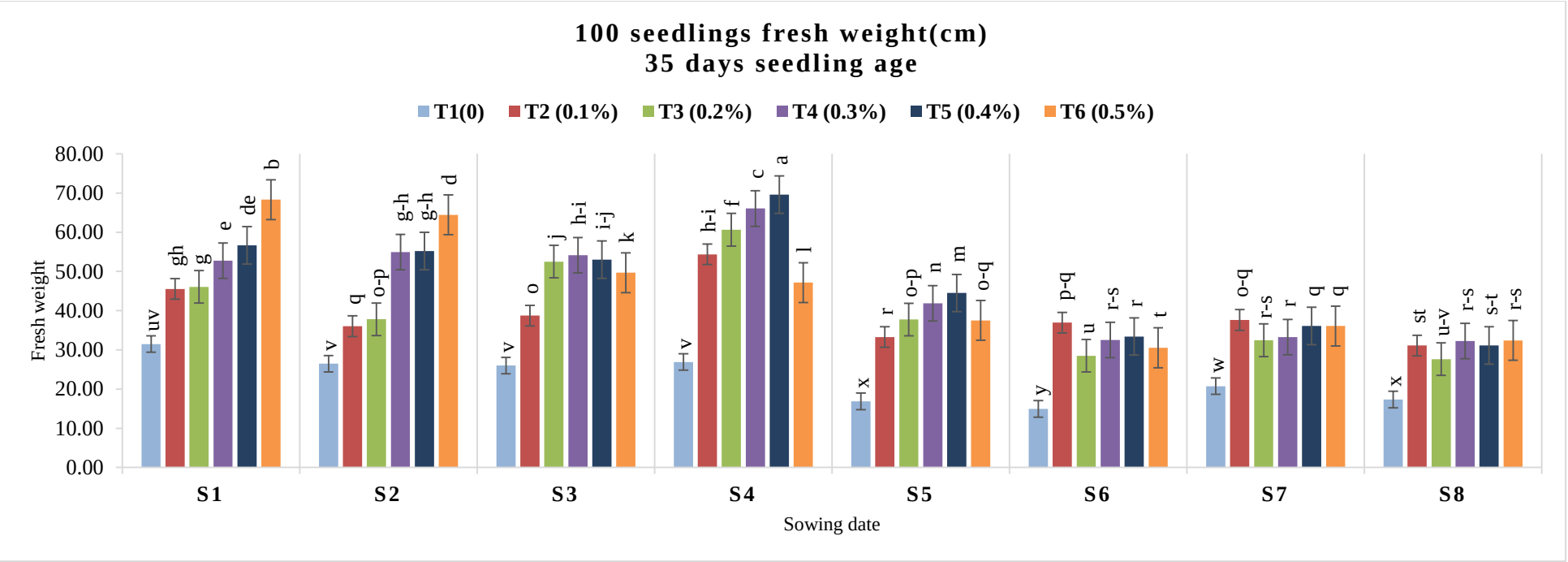

Figure 7: Effect of sowing date and chitosan raw material powder on fresh weight at 35 day age seedlings of BRRI dhan88. Bars with different letters are significantly different at p ≤0.05 applying DMRT.

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability Here,		
S_1= Sowing date 23 Nov,2019 S_2= Sowing date 25 Nov,2019 S_3= Sowing date 27 Nov,2019 S_4= Sowing date 29 Nov,2019	S_5= Sowing date 01 Dec ,2019 S_6= Sowing date 03 Dec,2019 S_7= Sowing date 05 Dec ,2019 S_8= Sowing date 07 Dec ,2019	T_1= 0%, CHT raw material powder T_2= 0.1%, CHT raw material powder T_3= 0.2%, CHT raw material powder T_4= 0.3%, CHT raw material powder T_5= 0.4% CHT raw material powder T_6= 0.5% CHT raw material powder

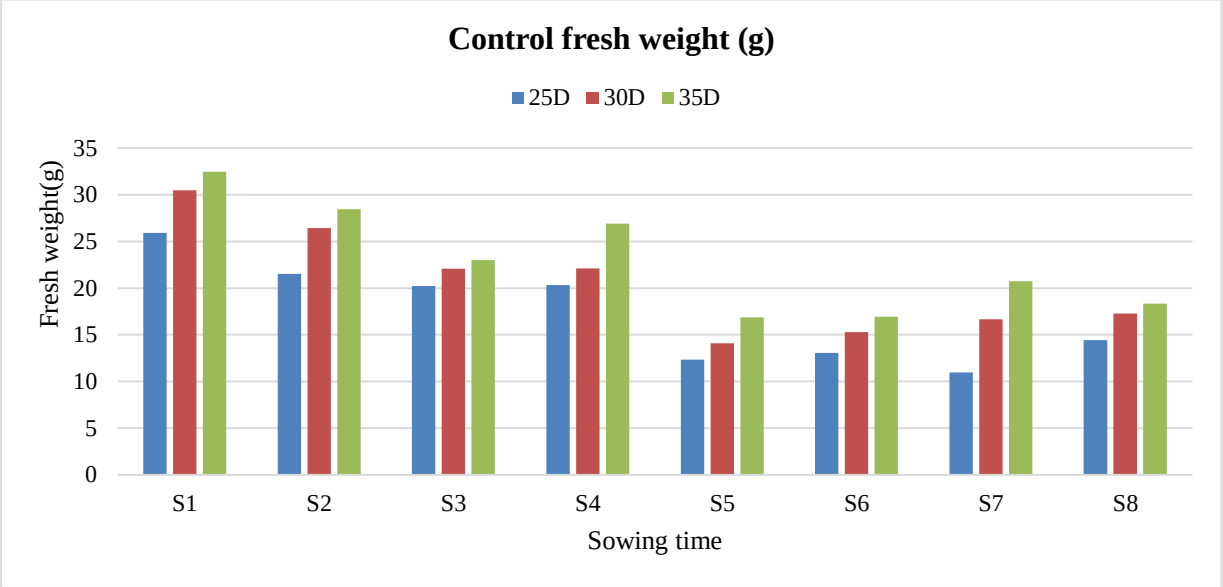

Figure 8: Seedling fresh weight of control in 25, 30, 35 day after sowing

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability Here,		
S_1= Sowing date 23 Nov,2019 S_2= Sowing date 25 Nov,2019 S_3= Sowing date 27 Nov,2019 S_4= Sowing date 29 Nov,2019	S_5= Sowing date 01 Dec ,2019 S_6= Sowing date 03 Dec,2019 S_7= Sowing date 05 Dec ,2019 S_8= Sowing date 07 Dec ,2019	T_1= 0%, CHT raw material powder T_2= 0.1%, CHT raw material powder T_3= 0.2%, CHT raw material powder T_4= 0.3%, CHT raw material powder T_5= 0.4% CHT raw material powder T_6= 0.5% CHT raw material powder

The experimental result of all control sown several two days interval was impacted by the cold stress during the sowing time. At 25 aged seedling fresh weight is gradually fluctuating with the fluctuation of temperature. Similar result observed in the 30 and 35 day age seedling oven dry weight.

4.1.3. Seedling dry weight (g)

4.1.4.3. Seedling Dry weight (g) of 25 days old Seedling at different sowing date

Seedling oven dry weight (g) of BRRI dhan88 rice seedlings were significantly increased with the chitosan powder treatments in the seedbed The application of chitosan raw materials powder in rice seedbed have massive impact on the growth of seedling dry weight. The experimental result shows that different doses of chitosan raw materials substantiated statistically diversified result. Maximum seedling dry weight observed in T6 (0.5% chitosan powder) whereas minimum seedling fresh weight in control (0% chitosan Powder). Chitosan raw material have also impact against cold stress injuries. Cold stress

mostly impacted on control dry weight (Fig-12) in seedling stage overcome by the application of chitosan powder but chitosan treated seedbed had less impact. Seedling fresh weight of Control of S_5 and S_6 was fluctuated with temperature fluctuation but treated seedbed of S_5 and S_6 were not induced by cold stress. All the treated seedbed in S_5 and S_6 is far better than these control even better than other cold stress less control seedlings. In S5 sowing date seedling dry weight sequence of 25 day age seedlings was $T_6>T_5>T_3>T_4>T_2>T_1$ In S_6 sowing date seedling fresh weight sequence was $T_6>T_5>T_4>T_2>T_3>T_11$ (Fig-10). John Berber et al. (2012) observed that Chemical fertilizer application in combination with chitosan increased dry matter. These results indicate that oven dry weight productions of BRRI dhan88 rice seedlings were influenced by the chitosan powder applications and this might be due its nutritional support to the seedlings, improvement of growth promoting hormonal activity and could improve the biological as well as physioco-chemical properties of the seedbed soils (Tsugita *et al.*, 1993; Rahman *et al.*, 2015).

Seedling oven dry weight (3.4 g) of the Control (S_4T_1) of optimum sowing time (15 Nov-30 Nov) was statistically identical with treated seedlings of S_6T_2 (3.33 g), S_6T_3 (3.26 g) and all other treated seedling oven dry weight are far better than the control of optimum date recommended by BRRI (15 Nov-30 Nov) which was sown 8, 6 and 4 days later. Seedlings treated with chitosan row material powder effect on the production of same quality seedling in 8 days later. Application CHT powder helps in production of quality seedling in cold stress condition. Treated seedlings was less impacted by cold stress. Cold stress suppress the control oven dry weight then the treated seedlings.

The experimental result shows that the maximum and minimum oven dry weight of 100 seedling sown in 2 days interval in several sowing date (23 Nov-7 Dec) in 25 day age were 9.7 g and 2.3 g respectively in S_1T_6 and S_8T_1. Sowing difference of two set was 16 days. On the other hand 100 seedling fresh weight of first control (S_1T_6) 9.7 g was identical with S_8T_5 which was sown in 16 days later of first control seedlings. Even Experimental result shows that seedling obtained in S_8T_2 (3.96 g), S_8T_3 (4 g), S_8T_5 (4.43 g), and S_8T_6 (3.96 g) better quality which was sown in 8 days letter of S_4 which was sown in last date BRRI recommendation. It reviled that CHT raw materials treated seedbed help to produce better quality seedling which may be a small hope of farmers who want to cultivate BRRI dhan after harvesting Mustard.

In Boro season, seedling oven dry weight was significantly decrease in late sowing. The seedling height could be increased by using Chitosan Raw Materials powder in the seedbed. All the sowing time showed increased of seedling height. The result indicated that the materials could be functioned against cold stress in Boro seedling production. In S_1 minimum temperature was 22°C. In S_4 minimum temperature was 21°C. In S_8 minimum temperature was 19°C .Late sowing decreased the seedlings oven dry weight. Treatments increased the seedling oven dry weight significantly in all sowing date.

A farmer can easily produce seedling like S_1 (control) in the S_4 (T_2, T_3, T_4, T_5 treatment) and S_5 (T_2,) with the late sowing. Mustard grower farmer can also produce seedlings like S_4 control in the S_8 (T_2, T_3, T_4, T_5 treatment)

Seedling Oven Dry weight at Sowing date S_1 (23 Nov. 2019)

Seedling oven dry weight (g) of BRRI dhan88 rice seedlings were significantly increased with the chitosan powder treatments in the seedbed. Maximum seedling oven dry weight was observed in T_6 (9.7 g) whereas minimum seedling height in T_1 (4.93 g). The second maximum seedling oven dry weight was observed in T_5 (8.7 g) .T_4 (6.7g) was identical with T_2 (6.4 g).

Seedling Oven Dry weight at Sowing date S_2 (25 Nov. 2019)

Seedling oven dry weight (g) of BRRI dhan88 rice seedlings were significantly increased with the chitosan powder treatments in the seedbed. Maximum seedling oven dry weight was observed in T_4 (7.1 g) which was statistically identical with T_3 (6.63 g) whereas minimum seedling height in T_1 (3.93 g). T_6 (6.03 g) and T_5 (6.07 g) was statistically identical.

Seedling Oven Dry weight at Sowing date S_3 (27 Nov. 2019)

Seedling oven dry weight (g) of BRRI dhan88 rice seedlings were significantly increased with the chitosan powder treatments in the seedbed. Maximum seedling oven dry weight was observed in T_6 (7.47 g) whereas minimum seedling height in T_1 (3.66 g). T_5 (6.5 g) was identical with T_4 (6.23 g) and T_3 (6.4 g)

Seedling Oven Dry weight at Sowing date S_4 (29 Nov. 2019)

Seedling oven dry weight (g) of BRRI dhan88 rice seedlings were significantly increased with the chitosan powder treatments in the seedbed. Maximum seedling oven dry weight

was observed in T_6 (7 g) which was statistically identical with T_4 (6.6 g) whereas minimum seedling height in T_1 (3.4 g). T_5 (6.27 g) and T_2 (6.27 g) were statistically identical with each other.

Seedling Oven Dry weight at Sowing date S_5 (01 Dec. 2019)

Seedling oven dry weight (g) of BRRI dhan88 rice seedlings were significantly increased with the chitosan powder treatments in the seedbed. Maximum seedling oven dry weight was observed in T_6 (4.83 g) which was statistically identical with T_2 (4.43 g), T_5 (4.53) and T_4 (4.4) whereas minimum seedling height in T_1 (12.33 g). T_3 (16.13 g) was statistically different with all other treatments.

Seedling Oven Dry weight at Sowing date S_6 (03 Dec. 2019)

Seedling oven dry weight (g) of BRRI dhan88 rice seedlings were significantly increased with the chitosan powder treatments in the seedbed. Maximum seedling oven dry weight was observed in T_6 (4.2g) which was statistically identical with T_5 (4.13 g) whereas minimum seedling height in T_1 (2.36 g).T_4 (3.63 g) was identical with T_3 (3.26 g) and T_2 (3.33 g)

Seedling Oven Dry weight at Sowing date S_7 (05 Dec. 2019)

Seedling oven dry weight (g) of BRRI dhan88 rice seedlings were significantly increased with the chitosan powder treatments in the seedbed. Maximum seedling oven dry weight was observed in T_4 (5.33 cm) which was statistically identical with T_6 (4.6 g) whereas minimum seedling height in T_1 (2.36 g). T_4 (4.10 g) was identical with T_5 (4.13 g) and T_2 (4.3 g)

Seedling Oven Dry weight at Sowing date S_8 (07 Dec. 2019)

Seedling oven dry weight (g) of BRRI dhan88 rice seedlings were significantly increased with the chitosan powder treatments in the seedbed. Maximum seedling oven dry weight was observed in T_5 (4.4 g) whereas minimum seedling height in T_1 (2.3 g). T_6 (3.9 g) was statistically identical with T_4 (3.9 g), T_3 (4 g), and T_2 (3.96 g).

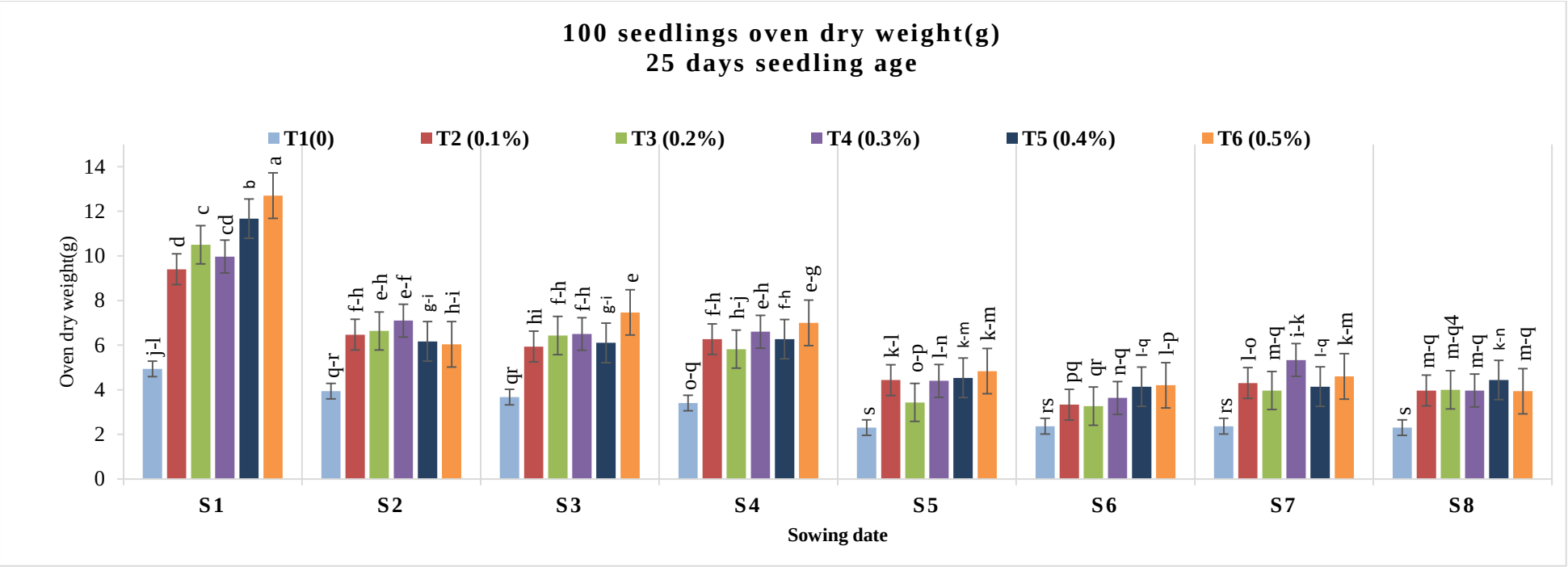

Figure 9: Effect of sowing date and chitosan raw material powder on oven dry weight at 25 day age seedlings of BRRI dhan88. Bars with different letters are significantly different at p ≤0.05 applying DMRT.

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability Here,		
S_1= Sowing date 23 Nov,2019 S_2= Sowing date 25 Nov,2019 S_3= Sowing date 27 Nov,2019 S_4= Sowing date 29 Nov,2019	S_5= Sowing date 01 Dec ,2019 S_6= Sowing date 03 Dec,2019 S_7= Sowing date 05 Dec ,2019 S_8= Sowing date 07 Dec ,2019	T_1= 0%, CHT raw material powder T_2= 0.1%, CHT raw material powder T_3= 0.2%, CHT raw material powder T_4= 0.3%, CHT raw material powder T_5= 0.4% CHT raw material powder T_6= 0.5% CHT raw material powder

4.1.4.3. Seedling Dry weight (g) of 30 days old Seedling at different sowing date

Seedling oven dry weight (4.5 g) of the Control (S_4T_1) of optimum sowing time (15 Nov-30 Nov) was statistically identical with treated seedlings of S_8T_3 (4.25 g) and S_6T_2 (4.5 g) all other except S_8T_2 and S_8T_4 treated seedling oven dry weight are far better than the control of optimum date recommended by BRRI (15 Nov-30 Nov) which was sown 8, 6 and 4 days later. Seedlings treated with chitosan row material powder effect on the production of same quality seedling in 8 days later. Application CHT powder helps in production of quality seedling in cold stress condition. Treated seedlings was less impacted by cold stress. Cold stress suppress the control oven dry weight then the treated seedlings.

The experimental result shows that the maximum and minimum oven dry weight of 100 seedling sown in 2 days interval in several sowing date (23 Nov-7 Dec) in 30 day age were 10.7 g and 2.96 g respectively in S_1T_6 and S_6T_1. Sowing difference of two set was 12 days. On the other hand 100 seedling fresh weight of first control (S_1T_6) 10.7 g was identical with S_8T_3 which was sown in 12 days later of first control seedlings. Even Experimental result shows that seedling obtained in S_8T_5 (4.89 g) and S_8T_6 (4.82 g) better quality which was sown in 8 days letter of S_4 which was sown in last date BRRI recommendation. It reviled that CHT raw materials treated seedbed help to produce better quality seedling which may be a small hope of farmers who want to cultivate BRRI dhan after harvesting Mustard.

In Boro season, seedling oven dry weight was significantly decrease in late sowing. The seedling height could be increased by using Chitosan Raw Materials powder in the seedbed. All the sowing time showed increased of seedling height. The result indicated that the materials could be functioned against cold stress in Boro seedling production. In S_1 minimum temperature was 22°C. In S_4 minimum temperature was 21°C. In S_8 minimum temperature was 19°C .Late sowing decreased the seedlings oven dry weight. Treatments increased the seedling oven dry weight significantly in all sowing date.

A farmer can easily produce seedling like S_1 (control) in the S_4 (T_2, T_3, T_4, T_5 treatment) and S_5 (T_2,) with the late sowing. Mustard grower farmer can also produce seedlings like S_4 control in the S_8 (T_2, T_3, T_4, T_5 treatment)

Seedling Oven Dry weight at Sowing date S_1 (23 Nov. 2019)

Seedling oven dry weight (g) of BRRI dhan88 rice seedlings were significantly increased with the chitosan powder treatments in the seedbed. Maximum seedling oven dry weight was observed in T_6 (10.7 g) whereas minimum seedling height in T_1 (4.93 g). The second maximum seedling oven dry weight was observed in T_4 (8.7 g) .T_5 (9.7g) was identical with T_4 (8.7 g).

Seedling Oven Dry weight at Sowing date S_2 (25 Nov. 2019)

Seedling oven dry weight (g) of BRRI dhan88 rice seedlings were significantly increased with the chitosan powder treatments in the seedbed. Maximum seedling oven dry weight was observed in T_4 (9.78 g) whereas minimum seedling height in T_1 (4.35 g).

Seedling Oven Dry weight at Sowing date S_3 (27 Nov. 2019)

Seedling oven dry weight (g) of BRRI dhan88 rice seedlings were significantly increased with the chitosan powder treatments in the seedbed. Maximum seedling oven dry weight was observed in T_6 (7.10 g) whereas minimum seedling height in T_1 (4.1 g). T_5 (8.79 g) was identical with T_4 (8.25 g) and T_3 (7.57 g)

Seedling Oven Dry weight at Sowing date S_4 (29 Nov. 2019)

Seedling oven dry weight (g) of BRRI dhan88 rice seedlings were significantly increased with the chitosan powder treatments in the seedbed. Maximum seedling oven dry weight was observed in T_4 (7.96 g) which was statistically identical with T_3 (7.7 g) and T_5 (7.65 g) whereas minimum seedling height in T_1 (3.4 g).

Seedling Oven Dry weight at Sowing date S_5 (01 Dec. 2019)

Seedling oven dry weight (g) of BRRI dhan88 rice seedlings were significantly increased with the chitosan powder treatments in the seedbed. Maximum seedling oven dry weight was observed in T_3 (6.48 g) which was statistically identical with T_2 (6.21 g), T_5 (5.77 g) whereas minimum seedling height in T_1 (2.78 g). T_4 (4.75 g) was statistically different with all other treatments.

Seedling Oven Dry weight at Sowing date S_6 (03 Dec. 2019)

Seedling oven dry weight (g) of BRRI dhan88 rice seedlings were significantly increased with the chitosan powder treatments in the seedbed. Maximum seedling oven dry weight was observed in T_4 (6.1 g) whereas minimum seedling height in T_1 (2.96 g).T_3 (4.93 g) was identical with T_5 (5.66 g).

Seedling Oven Dry weight at Sowing date S_7 (05 Dec. 2019)

Seedling oven dry weight (g) of BRRI dhan88 rice seedlings were significantly increased with the chitosan powder treatments in the seedbed. Maximum seedling oven dry weight was observed in T_2 (7.33 g) which was statistically identical with T_6 (6.1 g) whereas minimum seedling height in T_1 (3.06 g). T_4 (3.96 g) was identical with T_5 (4.89 g) and T_3 (4.24 g)

Seedling Oven Dry weight at Sowing date S_8 (07 Dec. 2019)

Seedling oven dry weight (g) of BRRI dhan88 rice seedlings were significantly increased with the chitosan powder treatments in the seedbed. Maximum seedling oven dry weight was observed in T_5 (4.89 g) whereas minimum seedling height in T_1 (3 g). T_3 (4.24 g) was statistically identical with T_4 (3.96 g) and T_2 (3.72 g).

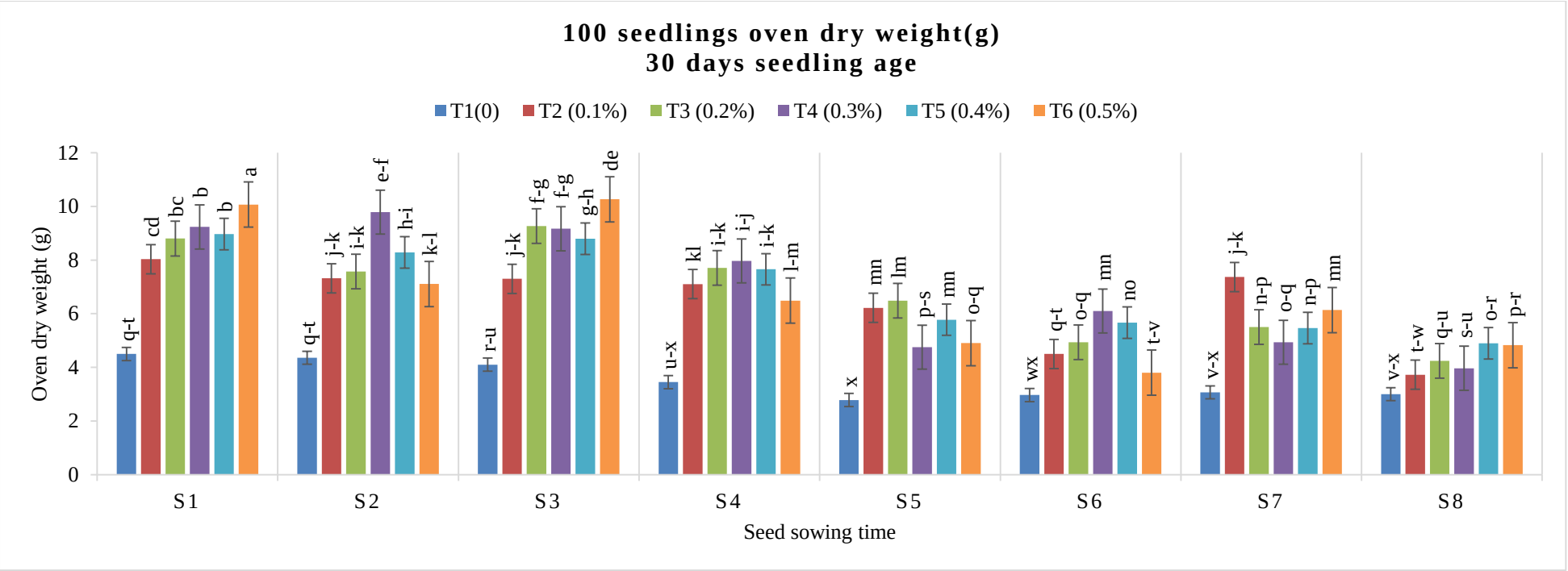

Figure 10: Effect of sowing date and chitosan raw material powder on oven dry weight at 30 day age seedlings of BRRI dhan88. Bars with different letters are significantly different at p ≤0.05 applying DMRT.

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability Here,		
S_1= Sowing date 23 Nov,2019 S_2= Sowing date 25 Nov,2019 S_3= Sowing date 27 Nov,2019 S_4= Sowing date 29 Nov,2019	S_5= Sowing date 01 Dec ,2019 S_6= Sowing date 03 Dec,2019 S_7= Sowing date 05 Dec ,2019 S_8= Sowing date 07 Dec ,2019	T_1= 0%, CHT raw material powder T_2= 0.1%, CHT raw material powder T_3= 0.2%, CHT raw material powder T_4= 0.3%, CHT raw material powder T_5= 0.4% CHT raw material powder T_6= 0.5% CHT raw material powder

4.1.4.3. Seedling Dry weight (g) of 35 days old Seedling at different sowing date

Seedling oven dry weight (g) of BRRI dhan88 rice seedlings were significantly increased with the chitosan powder treatments in the seedbed The experimental result shows that the maximum oven dry weight of 100 seedling of 35 day age was 12.2 g in combined treated of S_4T_5 and minimum oven dry weight 2.8 g both in combined treatment of S_6T_1. The sowing day interval of both was 12 days. At the same time oven dry weight of control (S_1T_1) was far less than all other treated seedlings. Seedlings treated with chitosan row material powder effect on the production of same quality seedling in 8 days later. Application CHT powder helps in production of quality seedling in cold stress condition. Treated seedlings was less impacted by cold stress. Cold stress suppress the control oven dry weight then the treated seedlings.

The experimental result shows that the maximum and minimum oven dry weight of 100 seedling sown in 2 days interval in several sowing date (23 Nov-7 Dec) in 35 day age were 12.2 g and 2.8 g respectively in S_1T_6 and S_6T_1. Sowing difference of two set was 12 days. On the other hand 100 seedling fresh weight of first control (S_1T_6) 12.7 g was identical with S_8T_5 which was sown in 16 days later of first control seedlings. Even Experimental result shows that seedling obtained in S_8T_2 (5.33 g), S_8T_3 (5.33 g), S_8T_5 (6.67 g), and S_8T_6 (5.66 g) better quality which was sown in 8 days letter of S_4 which was sown in last date BRRI recommendation. It reviled that CHT raw materials treated seedbed help to produce better quality seedling which may be a small hope of farmers who want to cultivate BRRI dhan88 after harvesting Mustard.

In Boro season, seedling oven dry weight was significantly decrease in late sowing. The seedling height could be increased by using Chitosan Raw Materials powder in the seedbed. All the sowing time showed increased of seedling height. The result indicated that the materials could be functioned against cold stress in Boro seedling production. In S_1 minimum temperature was 22°C. In S_4 minimum temperature was 21°C. In S_8 minimum temperature was 19°C .Late sowing decreased the seedlings oven dry weight. Treatments increased the seedling oven dry weight significantly in all sowing date.

A farmer can easily produce seedling like S_1 (control) in the S_4 (T_2, T_3, T_4, T_5 treatment) and S_5 (T_2,) with the late sowing. Mustard grower farmer can also produce seedlings like S_4 control in the S_8 (T_2, T_3, T_4, T_5 treatment)

Seedling Oven Dry weight at Sowing date S_1 (23 Nov. 2019)

Seedling oven dry weight (g) of BRRI dhan88 rice seedlings were significantly increased with the chitosan powder treatments in the seedbed. Maximum seedling oven dry weight was observed in T_6 (10.9 g) whereas minimum seedling height in T_1 (5.36 g). The second maximum seedling oven dry weight was observed in T_5 (10.6 g) which was statistically identical with T_4 (10.36 g) and T_3 (10.9 g).

Seedling Oven Dry weight at Sowing date S_2 (25 Nov. 2019)

Seedling oven dry weight (g) of BRRI dhan88 rice seedlings were significantly increased with the chitosan powder treatments in the seedbed. Maximum seedling oven dry weight was observed in T_4 (7.1 g) whereas minimum seedling height in T_1 (3.93 g).

Seedling Oven Dry weight at Sowing date S_3 (27 Nov. 2019)

Seedling oven dry weight (g) of BRRI dhan88 rice seedlings were significantly increased with the chitosan powder treatments in the seedbed. Maximum seedling oven dry weight was observed in T_2 (7.47 g) which was statistically identical with T_3 (6.23 g), T_4 (6.23 g), T_5 (6.23 g) and T_6 (6.4 g) whereas minimum seedling height in T_1 (3.66 g).

Seedling Oven Dry weight at Sowing date S_4 (29 Nov. 2019)

Seedling oven dry weight (g) of BRRI dhan88 rice seedlings were significantly increased with the chitosan powder treatments in the seedbed. Maximum seedling oven dry weight was observed in T_5 (7 g) whereas minimum seedling height in T_1 (3.4 g). T_3 (6.27 g) and T_4 (6.27 g) were statistically identical with each other.

Seedling Oven Dry weight at Sowing date S_5 (01 Dec. 2019)

Seedling oven dry weight (g) of BRRI dhan88 rice seedlings were significantly increased with the chitosan powder treatments in the seedbed. Maximum seedling oven dry weight was observed in T_5 (4.83 g) whereas minimum seedling height in T_1 (12.33 g).

Seedling Oven Dry weight at Sowing date S_6 (03 Dec. 2019)

Seedling oven dry weight (g) of BRRI dhan88 rice seedlings were significantly increased with the chitosan powder treatments in the seedbed. Maximum seedling oven dry weight was observed in T_5 (5.96 g) whereas minimum seedling height in T_1 (2.8 g).

Seedling Oven Dry weight at Sowing date S_7 (05 Dec. 2019)

Seedling oven dry weight (g) of BRRI dhan88 rice seedlings were significantly increased with the chitosan powder treatments in the seedbed. Maximum seedling oven dry weight was observed in T_6 (7.36 cm) whereas minimum seedling height in T_1 (4.66 cm).

Seedling Oven Dry weight at Sowing date S_8 (07 Dec. 2019)

Seedling oven dry weight (g) of BRRI dhan88 rice seedlings were significantly increased with the chitosan powder treatments in the seedbed. Maximum seedling oven dry weight was observed in T_5 (6.66 g) whereas minimum seedling height in T_1 (4.26 g).

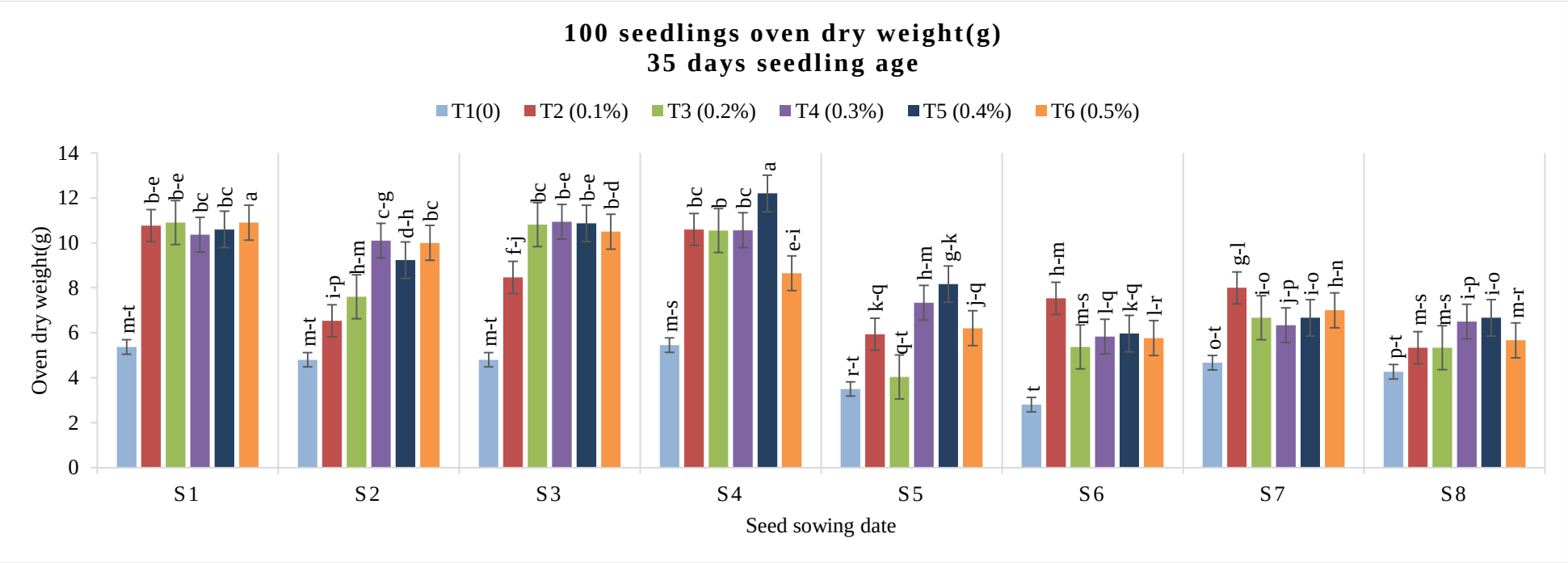

Figure 11: Effect of sowing date and chitosan raw material powder on oven dry weight at 35 day age seedlings of BRRI dhan88. Bars with different letters are significantly different at p ≤0.05 applying DMRT.

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability Here,		
S_1= Sowing date 23 Nov,2019 S_2= Sowing date 25 Nov,2019 S_3= Sowing date 27 Nov,2019 S_4= Sowing date 29 Nov,2019	S_5= Sowing date 01 Dec ,2019 S_6= Sowing date 03 Dec,2019 S_7= Sowing date 05 Dec ,2019 S_8= Sowing date 07 Dec ,2019	T_1= 0%, CHT raw material powder T_2= 0.1%, CHT raw material powder T_3= 0.2%, CHT raw material powder T_4= 0.3%, CHT raw material powder T_5= 0.4% CHT raw material powder T_6= 0.5% CHT raw material powder

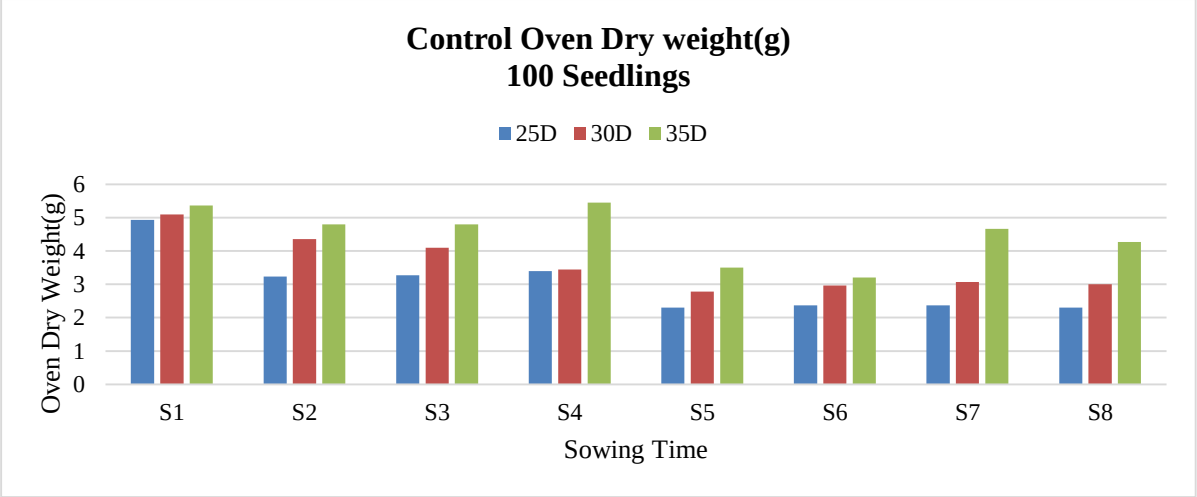

Figure 12: Seedling dry weight of control in 25, 30, 35 day after sowing

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability Here,		
S_1= Sowing date 23 Nov,2019 S_2= Sowing date 25 Nov,2019 S_3= Sowing date 27 Nov,2019 S_4= Sowing date 29 Nov,2019	S_5= Sowing date 01 Dec ,2019 S_6= Sowing date 03 Dec,2019 S_7= Sowing date 05 Dec ,2019 S_8= Sowing date 07 Dec ,2019	T_1= 0%, CHT raw material powder T_2= 0.1%, CHT raw material powder T_3= 0.2%, CHT raw material powder T_4= 0.3%, CHT raw material powder T_5= 0.4% CHT raw material powder T_6= 0.5% CHT raw material powder

The experimental result of all control sown several two days interval was impacted by the cold stress during the sowing time. At 25 aged seedling oven dry weight was gradually fluctuating with the fluctuation of temperature. Similar result observed in the 30 and 35 day age seedling oven dry weight.

4.1.4. Seedling strength (mg cm^{-1})

4.1.4.3. Seedling strength (mg cm^{-1}) of 25 days old Seedling at different sowing date

Seedling strength is a strong indicator for measuring good quality seedlings. Seedling strength of BRRI dhan88 was found to be statistically significant. The application of chitosan raw materials powder in rice seedbed have massive impact on the growth of seedling strength (mg cm^{-1}). The experimental result shows that different doses of chitosan raw materials substantiated statistically diversified result. Maximum seedling strength (mg cm^{-1}) observed in T_6 (0.5% chitosan powder) whereas minimum seedling strength (mg cm^{-1}) in control (0% chitosan Powder). Chitosan raw material have also impact against cold stress injuries. Cold stress mostly impacted on control strength (mg cm^{-1}) (Fig-16) in seedling stage overcome by the application of chitosan powder but

chitosan treated seedbed had less impact. Seedling strength (mg cm^{-1}) of Control of S_5 and S_6 were fluctuated with temperature fluctuation but treated seedbed of S_5 and S_6 were not induced by cold stress. All the treated seedbed in S_5 and S_6 is far better than these control even better than other cold stress less control seedlings. In S_5 sowing date seedling strength (mg cm^{-1}) sequence of 25 day age seedlings was $T_6>T_5>T_3>T_2>T_4>T_1$. In S_6 sowing date seedling strength (mg cm^{-1}) sequence was $T_6>T_5>T_4>T_2>T_3>T_1$ (Fig-14). Ahmed *et al*. (2020) reported that seedling strength was increased with the application of chitosan-raw-materials in the seedbed. Issak, M. and Sultana, A. (2017) observed the role of chitosan powder on the production of quality rice seedlings of BRRI dhan29 and reported that application of different level of chitosan influenced the seedling strength of rice plant

Boonlertnirun *et al.* (2008) found that application of chitosan stimulates the seedling strength significantly.

Seedling strength (2.22 mg cm^{-1}) of the Control (S_4T_1) of optimum sowing time (15 Nov-30 Nov) was statistically identical with treated seedlings of S_5T_3 (2.32 mg cm^{-1}) all other treated seedling strength are far better than the control of optimum date recommended by BRRI (15 Nov-30 Nov) which was sown 2 to 8 days later. Seedlings treated with chitosan row material powder effect on the production of same quality seedling in 8 days later. Application CHT powder helps in production of quality seedling in cold stress condition. Treated seedlings was less impacted by cold stress. Cold stress suppress the control oven dry weight then the treated seedlings.

The experimental data resulted that the maximum seedling strength of 25 day seedling age was 6.14 mg cm^{-1} in the treatment combination of S_5T_6 and minimum seedling strength was 1.98 mg cm^{-1} in combined treatment of S_5T_1. The interval of both sowing date was 10 days. Again the seedlings strength of first control (S_1T_1) was 2.91 mg cm^{-1} which was identical with the combined treatment of S_8T_2 and S_8T_3. The difference of two sowing date was 16 days.

The experimental result shows that the maximum and minimum strength of 100 seedling sown in 2 days interval in several sowing date (23 Nov-7 Dec) in 25 day age were 6.12 mg cm^{-1} and 1.97 mg cm^{-1} respectively in S_1T_6 and S_8T_1. Sowing difference of two set was 16 days. On the other hand 100 seedling fresh weight of first control (S_1T_6) 2.90 mg cm^{-1} was identical with S_8T_2 (2.98 mg cm^{-1}) which was sown in 16 days later of first

control seedlings. Even Experimental result shows that seedling obtained in S_8T_2 (2.98 mg cm^{-1}), S_8T_3 (3 mg cm^{-1}), S_8T_4 (3.63 mg cm^{-1}), S_8T_5 (4.41 mg cm^{-1}), and S_8T_6 (3.34 mg cm^{-1}) better quality which was sown in 8 days letter of S_4 which was sown in last date BRRI recommendation. It reviled that CHT raw materials treated seedbed help to produce better quality seedling which may be a small hope of farmers who want to cultivate BRRI dhan after harvesting Mustard.

In Boro season, seedling strength was significantly decrease in late sowing. The seedling strength could be increased by using Chitosan Raw Materials powder in the seedbed. All the sowing time showed increased of seedling height. The result indicated that the materials could be functioned against cold stress in Boro seedling production. In S_1 minimum temperature was 22°C. In S_4 minimum temperature was 21°C. In S_8 minimum temperature was 19°C .Late sowing decreased the seedlings strength. Treatments increased the seedling strength significantly in all sowing date.

A farmer can easily produce seedling like S_1 (control) in the S_4 (T_2, T_3, T_4, T_5 treatment) and S_5 (T_2,) with the late sowing. Mustard grower farmer can also produce seedlings like S_4 control in the S_8 (T_2, T_3, T_4, T_5 treatment).

Seedling strength at Sowing date S_1 (23 Nov. 2019)

Seedling strength of BRRI dhan88 was found to be statistically significant. Maximum seedling strength was observed in T_6 (6.14 mg cm^{-1}) which was identical with T_2 (5.29 mg cm^{-1}) whereas minimum seedling height in T_1 (2.9 mg cm^{-1}). The second maximum seedling strength was observed in T_5 (5.83 mg cm^{-1}) which was identical with T_3 (5.55 mg cm^{-1}) .T_4 (5.3 mg cm^{-1}) was identical with T_2 (5.29 mg cm^{-1}) and T_3 (5.55 mg cm^{-1}).

Seedling strength at Sowing date S_2 (25 Nov. 2019)

Seedling strength of BRRI dhan88 was found to be statistically significant. Maximum seedling strength was observed in T_4 (4.08 mg cm^{-1}) which was statistically identical with T_5 (3.94 mg cm^{-1}) and T_6 (3.81 mg cm^{-1}) whereas minimum seedling height in T_1 (2.38 mg cm^{-1}). T_2 (3.27 mg cm^{-1}) and T_3 (3.54 mg cm^{-1}) was statistically different from all other.

Seedling strength at Sowing date S_3 (27 Nov. 2019)

Seedling strength of BRRI dhan88 was found to be statistically significant. Maximum seedling strength was observed in T_6 (3.82 mg cm^{-1}) which was statistically identical with

T_3 (3.73 mg cm^{-1}) whereas minimum seedling height in T_1 (2.34 mg cm^{-1}). T_5 (3.51 mg cm^{-1}) was identical with T_4 (3.49 mg cm^{-1})

Seedling strength at Sowing date S_4 (29 Nov. 2019)

Seedling strength of BRRI dhan88 was found to be statistically significant. Maximum seedling strength was observed in T_6 (4.79 mg cm^{-1}) which was statistically identical with T_5 (4.03 mg cm^{-1}) whereas minimum seedling height in T_1 (2.22 mg cm^{-1}). T_5 (4.03 mg cm^{-1}) and T_4 (3.89 mg cm^{-1}) were statistically identical with each other. Similarly T_2 (3.46 mg cm^{-1}) and T_3 (3.4 mg cm^{-1}) were statistically identical with each other.

Seedling strength at Sowing date S_5 (01 Dec. 2019)

Seedling strength of BRRI dhan88 was found to be statistically significant. Maximum seedling strength was observed in T_6 (3.77 mg cm^{-1}) whereas minimum seedling height in T_1 (1.97 mg cm^{-1}). T_3 (3.17 mg cm^{-1}) was statistically different with all other treatments. T_5 (3.17 mg cm^{-1}) and T_4 (3.14 mg cm^{-1}) was statistically identical with each other.

Seedling strength at Sowing date S_6 (03 Dec. 2019)

Seedling strength of BRRI dhan88 was found to be statistically significant. Maximum seedling strength was observed in T_6 (3.39 mg cm^{-1}) whereas minimum seedling height in T_1 (2.01 mg cm^{-1}).T_2 (2.36 mg cm^{-1}) was identical with T_3 (2.4 mg cm^{-1}) and T_4 (2.75 mg cm^{-1}) was identical with T_5 (3.11 mg cm^{-1})

Seedling strength at Sowing date S_7 (05 Dec. 2019)

Seedling strength of BRRI dhan88 was found to be statistically significant. Maximum seedling strength was observed in T_6 (4.5 mg cm^{-1}whereas minimum seedling height in T_1 (mg cm^{-1}). T_4 (4 mg cm^{-1}) was identical with T_5 (3.87 mg cm^{-1}) and T_2 (3.06 mg cm^{-1}) was identical with T_3 (2.87 mg cm^{-1})

Seedling strength at Sowing date S_8 (07 Dec. 2019)

Seedling strength of BRRI dhan88 was found to be statistically significant. Maximum seedling strength was observed in T_5 (4.41 mg cm^{-1}) whereas minimum seedling height in T_1 (2.01 mg cm^{-1}). T_6 (3.34 mg cm^{-1}) was statistically identical with T_3 (3 mg cm^{-1}), T_2 (2.98 mg cm^{-1}).

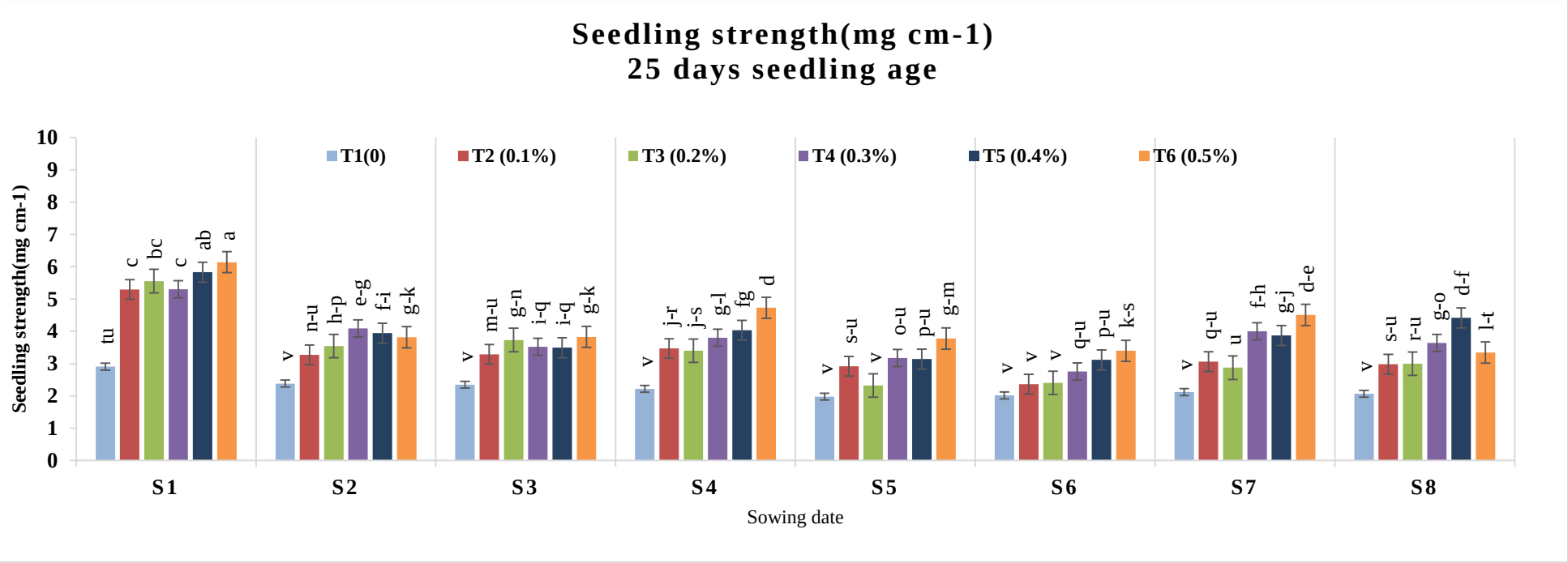

Figure 13: Effect of sowing date and chitosan raw material powder on seedling strength at 25 day age seedlings of BRRI dhan88. Bars with different letters are significantly different at p ≤0.05 applying DMRT.

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability Here,		
S_1= Sowing date 23 Nov,2019 S_2= Sowing date 25 Nov,2019 S_3= Sowing date 27 Nov,2019 S_4= Sowing date 29 Nov,2019	S_5= Sowing date 01 Dec ,2019 S_6= Sowing date 03 Dec,2019 S_7= Sowing date 05 Dec ,2019 S_8= Sowing date 07 Dec ,2019	T_1= 0%, CHT raw material powder T_2= 0.1%, CHT raw material powder T_3= 0.2%, CHT raw material powder T_4= 0.3%, CHT raw material powder T_5= 0.4% CHT raw material powder T_6= 0.5% CHT raw material powder

4.1.4.3. Seedling strength (mg cm^{-1}) of 30 days old Seedling at different sowing date

Seedling strength of BRRI dhan88 was found to be statistically significant. The experimental data resulted that the maximum seedling strength of 30 day seedling age was 5.99 mg cm^{-1} in the treatment combination of S_1T_6 and minimum seedling strength was 2.38 mg cm^{-1} in combined treatment of S_5T_1. The interval of both sowing date was 10 days. Again the seedlings strength of first control (S_1T_1) was 2.53 mg cm^{-1} which was identical with the combined treatment of S_8T_6. The difference of two sowing date was 16 days. Seedlings treated with chitosan row material powder effect on the production of same quality seedling in 8 days later. Application CHT powder helps in production of quality seedling in cold stress condition. Treated seedlings was less impacted by cold stress. Cold stress suppress the control oven dry weight then the treated seedlings.

The experimental data resulted that the maximum seedling strength of 25 day seedling age was 6.14 mg cm^{-1} in the treatment combination of S_5T_6 and minimum seedling strength was 1.98 mg cm^{-1} in combined treatment of S_5T_1. The interval of both sowing date was 10 days. Again the seedlings strength of first control (S_1T_1) was 2.91 mg cm^{-1} which was identical with the combined treatment of S_8T_2 and S_8T_3. The difference of two sowing date was 16 days.

The experimental result shows that the maximum and minimum strength of 100 seedling sown in 2 days interval in several sowing date (23 Nov-7 Dec) in 30 day age were 5.99 mg cm^{-1} and 2.37 mg cm^{-1} respectively in S_1T_6 and S_8T_1. Sowing difference of two set was 16 days. On the other hand 100 seedling strength of first control (S_1T_6) 2.53 mg cm^{-1} was identical with S_8T_2 (2.41 mg cm^{-1}) which was sown in 16 days later of first control seedlings. Even Experimental result shows that seedling obtained in S_8T_2 (2.41 mg cm^{-1}), S_8T_3 (3.17 mg cm^{-1}), S_8T_4 (3.51 mg cm^{-1}), S_8T_5 (3.94 mg cm^{-1}), and S_8T_6 (3.31 mg cm^{-1}) better quality which was sown in 8 days letter of S_4 which was sown in last date BRRI recommendation. It reviled that CHT raw materials treated seedbed help to produce better quality seedling which may be a small hope of farmers who want to cultivate BRRI dhan after harvesting Mustard.

In Boro season, seedling strength was significantly decrease in late sowing. The seedling strength could be increased by using Chitosan Raw Materials powder in the seedbed. All

the sowing time showed increased of seedling height. The result indicated that the materials could be functioned against cold stress in Boro seedling production. In S_1 minimum temperature was 22°C. In S_4 minimum temperature was 21°C. In S_8 minimum temperature was 19°C .Late sowing decreased the seedlings strength. Treatments increased the seedling strength significantly in all sowing date.

A farmer can easily produce seedling like S_1 (control) in the S_4 (T_2, T_3, T_4, T_5 treatment) and S_5 (T_2,) with the late sowing. Mustard grower farmer can also produce seedlings like S_4 control in the S_8 (T_2, T_3, T_4, T_5 treatment.

Seedling strength at Sowing date S_1 (23 Nov. 2019)

Seedling strength of BRRI dhan88 was found to be statistically significant. Maximum seedling strength was observed in T_6 (5.99 mg cm^{-1}) whereas minimum seedling height in T_1 (2.53 mg cm^{-1}). The second maximum seedling strength was observed in T_5 (5.1 mg cm^{-1}) which was identical with T_4 (5.16 mg cm^{-1}) and T_3 (4.99 mg cm^{-1})

Seedling strength at Sowing date S_2 (25 Nov. 2019)

Seedling strength of BRRI dhan88 was found to be statistically significant. Maximum seedling strength was observed in T_4 (5.09 mg cm^{-1}) whereas minimum seedling height in T_1 (2.45 mg cm^{-1}). T_5 (4.83 mg cm^{-1}) and T_6 (4.44 mg cm^{-1}) was statistically identical with each other.

Seedling strength at Sowing date S_3 (27 Nov. 2019)

Seedling strength of BRRI dhan88 was found to be statistically significant. Maximum seedling strength was observed in T_6 (4.92 mg cm^{-1}) which was statistically identical with T_3 (4.9 mg cm^{-1}) whereas minimum seedling height in T_1 (2.66 mg cm^{-1}). T_5 (4.5 mg cm^{-1}) was identical with T_4 (4.53 mg cm^{-1})

Seedling strength at Sowing date S_4 (29 Nov. 2019)

Seedling strength of BRRI dhan88 was found to be statistically significant. Maximum seedling strength was observed in T_6 (4.79 mg cm^{-1}) which was statistically identical with T_5 (4.44 mg cm^{-1}) whereas minimum seedling height in T_1 (2.46 mg cm^{-1}). T_5 (4.44 mg cm^{-1}) and T_4 (4.2 mg cm^{-1}) were statistically identical with each other. Similarly T_2 (4.03 mg cm^{-1}) and T_3 (4.04 mg cm^{-1}) were statistically identical with each other.

Seedling strength at Sowing date S_5 (01 Dec. 2019)

Seedling strength of BRRI dhan88 was found to be statistically significant. Maximum seedling strength was observed in T_3 (4.08 mg cm^{-1}) whereas minimum seedling height in T_1 (2.37 mg cm^{-1}). T_2 (4.09 mg cm^{-1}) and T_3 (4.08 mg cm^{-1}) was statistically identical with each other.

Seedling strength at Sowing date S_6 (03 Dec. 2019)

Seedling strength of BRRI dhan88 was found to be statistically significant. Maximum seedling strength was observed in T_5 (4.45 mg cm^{-1}) whereas minimum seedling height in T_1 (2.48 mg cm^{-1}).

Seedling strength at Sowing date S_7 (05 Dec. 2019)

Seedling strength of BRRI dhan88 was found to be statistically significant. Maximum seedling strength was observed in T_6 (5.36 mg cm^{-1}) whereas minimum seedling height in T_1 (2.49 mg cm^{-1}). T_6 (5.36 mg cm^{-1}) was identical with T_5 (4.8 mg cm^{-1}) and T_3 (3.17 mg cm^{-1})

Seedling strength at Sowing date S_8 (07 Dec. 2019)

Seedling strength of BRRI dhan88 was found to be statistically significant. Maximum seedling strength was observed in T_5 (3.94 mg cm^{-1}) whereas minimum seedling height in T_1 (2.4 mg cm^{-1}). T_6 (3.31 mg cm^{-1}) was statistically identical with T_3 (3.17 mg cm^{-1}).

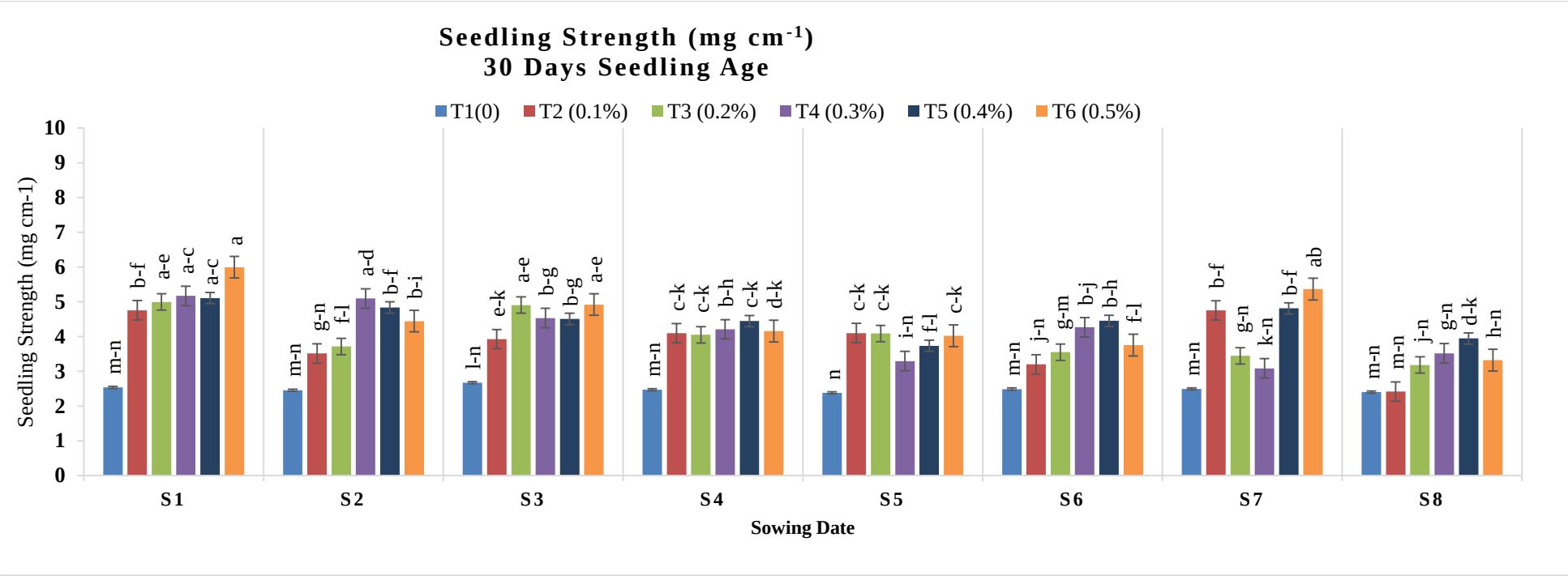

Figure 14: Effect of sowing date and chitosan raw material powder on seedling strength at 30 day age seedlings of BRRI dhan88. Bars with different letters are significantly different at p ≤0.05 applying DMRT.

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability Here,		
S_1= Sowing date 23 Nov,2019 S_2= Sowing date 25 Nov,2019 S_3= Sowing date 27 Nov,2019 S_4= Sowing date 29 Nov,2019	S_5= Sowing date 01 Dec ,2019 S_6= Sowing date 03 Dec,2019 S_7= Sowing date 05 Dec ,2019 S_8= Sowing date 07 Dec ,2019	T_1= 0%, CHT raw material powder T_2= 0.1%, CHT raw material powder T_3= 0.2%, CHT raw material powder T_4= 0.3%, CHT raw material powder T_5= 0.4% CHT raw material powder T_6= 0.5% CHT raw material powder

4.1.4.3. Seedling strength (mg cm^{-1}) of 35 days old Seedling at different sowing date

Seedling strength of BRRI dhan88 was found to be statistically significant. The experimental data resulted that the maximum seedling strength of 30 day seedling age was 6.31 mg cm^{-1} in the treatment combination of S_1T_6 and minimum seedling strength was 2.44 mg cm^{-1} in combined treatment of S_5T_1. The interval of both sowing date was 10 days. Again the seedlings strength of first control (S_1T_1) was 3.69 mg cm-1 which was identical with the combined treatment of S_5T_2 and far better the last treated sowing seedlings of S_8T_2. The difference of two sowing date was 10 days and 16 days. Seedlings treated with chitosan row material powder effect on the production of same quality seedling in 8 days later. Application CHT powder helps in production of quality seedling in cold stress condition. Treated seedlings was less impacted by cold stress. Cold stress suppress the control oven dry weight then the treated seedlings.

The experimental data resulted that the maximum seedling strength of 35 day seedling age was 8.41 mg cm-1 in the treatment combination of S_4T_5 and minimum seedling strength was 2.44 mg cm^{-1} in combined treatment of S_5T_1. The interval of both sowing date was 10 days. Again the seedlings strength of first control (S_1T_1) was 3.69 mg cm^{-1} which was identical with the combined treatment of S_8T_2 and S_8T_3. The difference of two sowing date was 16 days.

The experimental result shows that the maximum and minimum strength of 100 seedling sown in 2 days interval in several sowing date (23 Nov-7 Dec) in 35 day age were 8.41 mg cm^{-1} and 2.44 mg cm^{-1} respectively in S_1T_6 and S_8T_1. Sowing difference of two set was 16 days. On the other hand 100 seedling fresh weight of first control (S_1T_6) 3.69 mg cm^{-1} was identical with S_8T_2 (3.11 mg cm^{-1}) which was sown in 16 days later of first control seedlings. Even Experimental result shows that seedling obtained in S_8T_2 (3.11 mg cm^{-1}), S_8T_3 (3.11mg cm^{-1}), S_8T_4 (3.61 mg cm^{-1}), S_8T_5 (5.36 mg cm^{-1}), and S_8T_6 (4.59 mg cm^{-1}) better quality which was sown in 8 days letter of S_4 which was sown in last date BRRI recommendation. It reviled that CHT raw materials treated seedbed help to produce better quality seedling which may be a small hope of farmers who want to cultivate BRRI dhan after harvesting Mustard.

In Boro season, seedling strength was significantly decrease in late sowing. The seedling strength could be increased by using Chitosan Raw Materials powder in the seedbed. All the sowing time showed increased of seedling height. The result indicated that the materials could be functioned against cold stress in Boro seedling production. In S_1 minimum temperature was 22°C. In S_4 minimum temperature was 21°C. In S_8 minimum temperature was 19°C .Late sowing decreased the seedlings strength. Treatments increased the seedling strength significantly in all sowing date.

A farmer can easily produce seedling like S_1 (control) in the S_4 (T_2, T_3, T_4, T_5 treatment) and S_5 (T_2,) with the late sowing. Mustard grower farmer can also produce seedlings like S_4 control in the S_8 (T_2, T_3, T_4, T_5 treatment.

Seedling strength at Sowing date S_1 (23 Nov. 2019)

Seedling strength of BRRI dhan88 was found to be statistically significant. Maximum seedling strength was observed in T_6 (6.30 mg cm^{-1}) whereas minimum seedling height in T_1 (3.69 mg cm^{-1}). The second maximum seedling strength was observed in T_4 (5.64 mg cm^{-1}) which was identical with T_3 (5.17 mg cm^{-1}) and T_4 (5.63mg cm^{-1}).

Seedling strength at Sowing date S_2 (25 Nov. 2019)

Seedling strength of BRRI dhan88 was found to be statistically significant. Maximum seedling strength was observed in T_6 (6.64 mg cm^{-1}) whereas minimum seedling height in T_1 (3.49 mg cm^{-1}). T_4 (5.85 mg cm^{-1}) and T_5 (5.52 mg cm^{-1}) was statistically identical with each other.

Seedling strength at Sowing date S_3 (27 Nov. 2019)

Seedling strength of BRRI dhan88 was found to be statistically significant. Maximum seedling strength was observed in T_3 (5.72 mg cm^{-1}) which was statistically identical with T_4 (5.62 mg cm^{-1}) whereas minimum seedling height in T_1 (3.12 mg cm^{-1}). T_5 (5.1 mg cm^{-1}) was identical with T_4 (5.62 mg cm^{-1})

Seedling strength at Sowing date S_4 (29 Nov. 2019)

Seedling strength of BRRI dhan88 was found to be statistically significant. Maximum seedling strength was observed in T_5 (8.41 mg cm^{-1}) whereas minimum seedling height in

T_1 (3.03 mg cm^{-1}). T_2 (5.93 mg cm^{-1}), T_3 (6.53 mg cm^{-1}) and T_4 (5.99 mg cm^{-1}) were statistically identical with each other.

Seedling strength at Sowing date S_5 (01 Dec. 2019)

Seedling strength of BRRI dhan88 was found to be statistically significant. Maximum seedling strength was observed in T_5 (5.11 mg cm^{-1}) whereas minimum seedling height in T_1 (2.92 mg cm^{-1}).

Seedling strength at Sowing date S_6 (03 Dec. 2019)

Seedling strength of BRRI dhan88 was found to be statistically significant. Maximum seedling strength was observed in T_6 (4.9 mg cm^{-1}) which was identical with T_5 (4.49 mg cm^{-1}) whereas minimum seedling height in T_1 (2.44 mg cm^{-1}).T_3 (3.59 mg cm^{-1}) was identical with T_4 (3.8 mg cm^{-1}) and T_5 (4.49 mg cm^{-1})

Seedling strength at Sowing date S_7 (05 Dec. 2019)

Seedling strength of BRRI dhan88 was found to be statistically significant. Maximum seedling strength was observed in T_6 (5.44 mg cm^{-1}whereas minimum seedling height in T_1 (3.51 mg cm^{-1}).

Seedling strength at Sowing date S_8 (07 Dec. 2019)

Seedling strength of BRRI dhan88 was found to be statistically significant. Maximum seedling strength was observed in T_5 (5.36 mg cm^{-1}) whereas minimum seedling height in T_1 (3.41 mg cm^{-1}). T_6 (4.59 mg cm^{-1}) was statistically identical with T_4 (3 mg cm^{-1}).

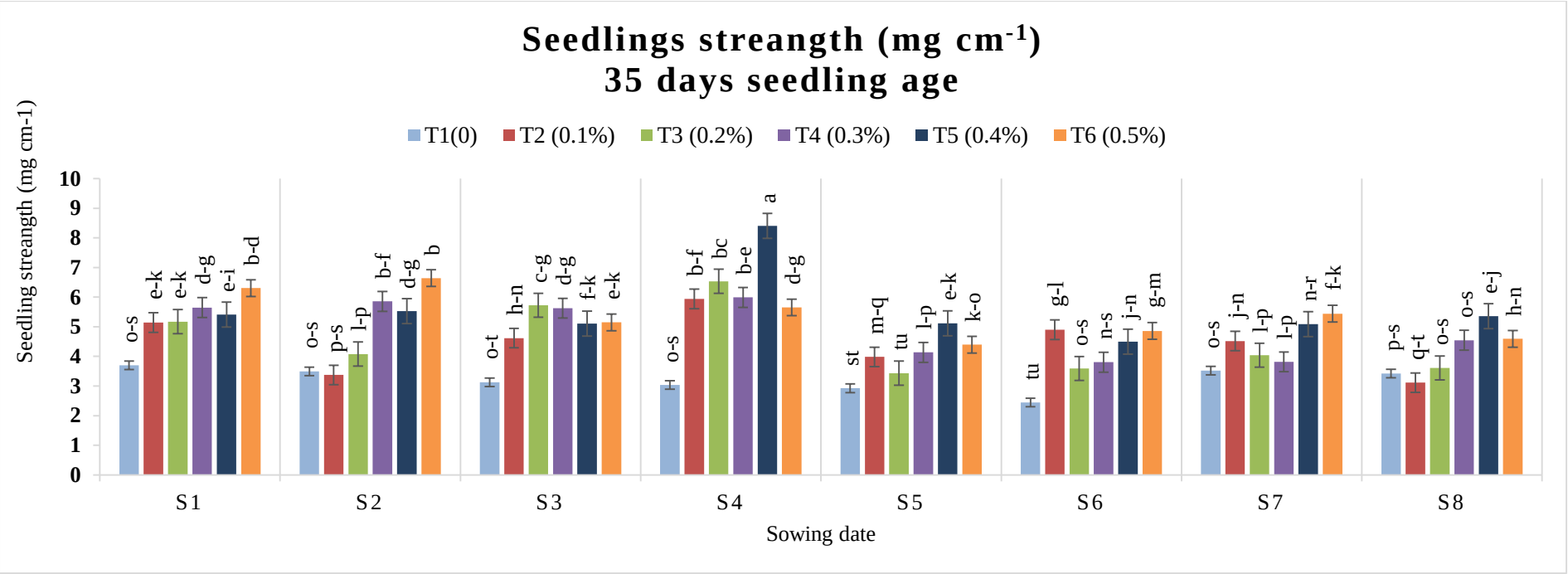

Figure 15: Effect of sowing date and chitosan raw material powder on seedling strength at 35 day age seedlings of BRRI dhan88. Bars with different letters are significantly different at p ≤0.05 applying DMRT.

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability Here,		
S_1= Sowing date 23 Nov,2019 S_2= Sowing date 25 Nov,2019 S_3= Sowing date 27 Nov,2019 S_4= Sowing date 29 Nov,2019	S_5= Sowing date 01 Dec ,2019 S_6= Sowing date 03 Dec,2019 S_7= Sowing date 05 Dec ,2019 S_8= Sowing date 07 Dec ,2019	T_1= 0%, CHT raw material powder T_2= 0.1%, CHT raw material powder T_3= 0.2%, CHT raw material powder T_4= 0.3%, CHT raw material powder T_5= 0.4% CHT raw material powder T_6= 0.5% CHT raw material powder

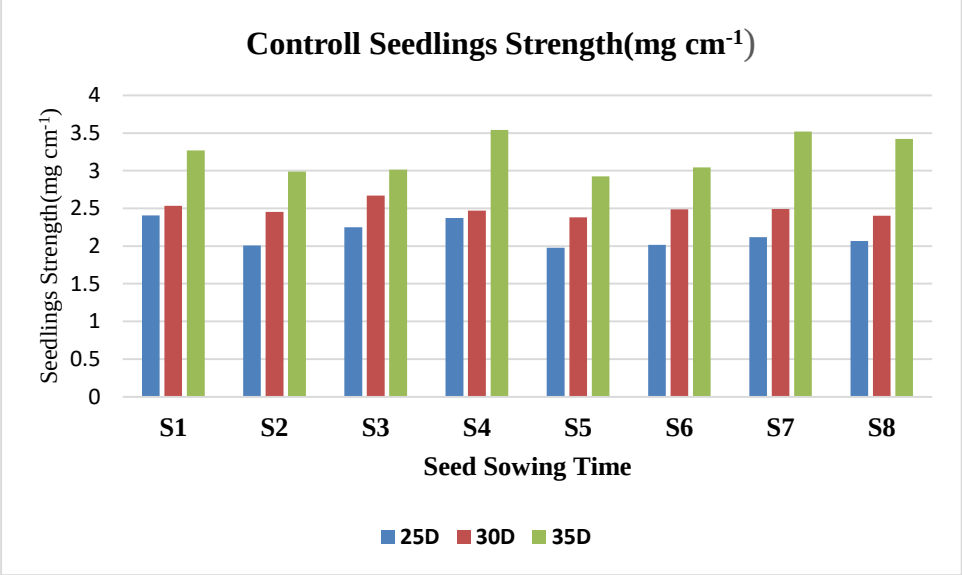

Figure 16: Seedling dry weight of control in 25, 30, 35 day after sowing

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability Here,		
S_1= Sowing date 23 Nov,2019 S_2= Sowing date 25 Nov,2019 S_3= Sowing date 27 Nov,2019 S_4= Sowing date 29 Nov,2019	S_5= Sowing date 01 Dec ,2019 S_6= Sowing date 03 Dec,2019 S_7= Sowing date 05 Dec ,2019 S_8= Sowing date 07 Dec ,2019	T_1= 0%, CHT raw material powder T_2= 0.1%, CHT raw material powder T_3= 0.2%, CHT raw material powder T_4= 0.3%, CHT raw material powder T_5= 0.4% CHT raw material powder T_6= 0.5% CHT raw material powder

The experimental result of all control sown several two days interval was impacted by the cold stress during the sowing time. At 25 aged seedling strength was gradually fluctuating with the fluctuation of temperature. Similar result observed in the 30 and 35 day age seedling strength.

4.2.Seedling characteristics of First set S_1 (23 Nov. 2019)

4.2.1. Seedling height (cm) of First set S_1 (23 Nov. 2019)

Seedling Height (cm) of BRRI dhan88 rice seedlings were significantly increased with the chitosan powder treatments in the seedbed. The experimental result reviled that the maximum height seedligs^{-1} (25.23 cm) in $30DT_6$ which is statistically identical with $35DT_6$ whereas the minimum height (14.83 cm) in control $35DT_1$ which is statistically identical with another control $25DT_1$. Issak and Sultana (2017) observed the role of chitosan powder on the production of quality rice seedlings of BRRI dhan29 and found that Boro rice seedlings production were improved by using

the chitosan powder in the seedbed. Al-Tawaha et al. (2018) observed the foliar application of chitosan improved plant growth for non-saline treated plants and ameliorated the adverse effects of salinity on shoot and root growth. Boonlertnirun et al. (2008) noticed the effect of chitosan application in growth and increases yield of plants as well as induces the immune system of plants.

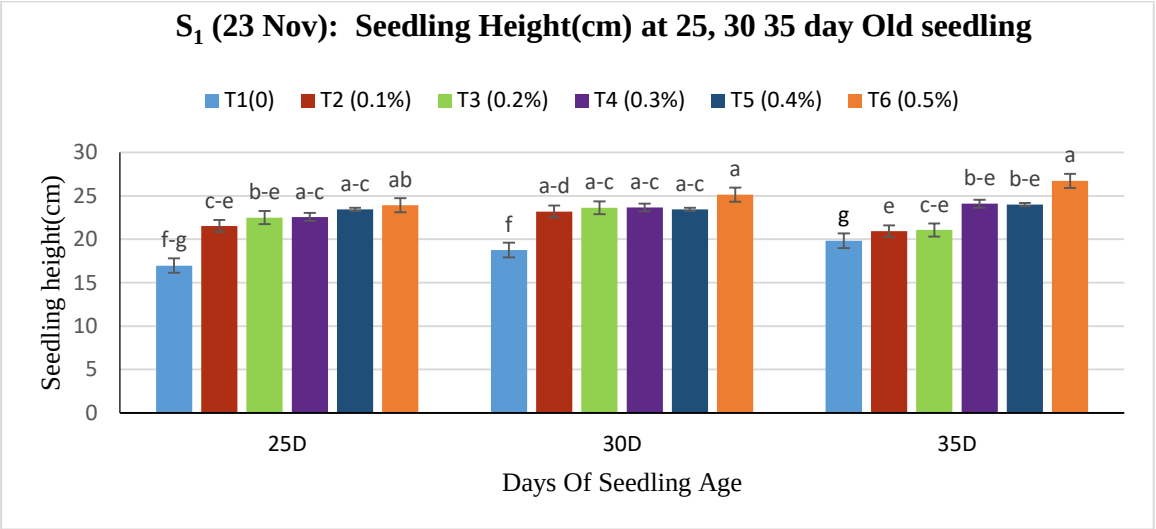

Figure 17: Effect of chitosan raw material powder level and day of seedling age on seedling height of BRRI dhan88. Bars with different letters are significantly different at p ≤0.05 applying DMRT.

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability Here,		
25D= transplanting 25 day age seedlings 30D= transplanting 30 day age seedling's 35D= transplanting 35 day age seedlings	T_1= 0%, CHT raw material powder T_2= 0.1%, CHT raw material powder T_3= 0.2%, CHT raw material powder	T_4= 0.3%, CHT raw material powder T_5= 0.4% CHT raw material powder T_6= 0.5% CHT raw material powder

4.2.2. Seedling fresh weight (g) of First set S_1 (23 Nov. 2019)

Seedling fresh weight (g) of BRRI dhan88 rice seedlings were significantly increased with the chitosan powder treatments in the seedbed. The experimental result reviled that the maximum fresh weight of 100 seedlings (68.3 g) in $35DT_6$ which was statistically identical with $30DT_6$ (67.87 g) and $25DT_6$ (65.36 g) whereas the minimum fresh weight (25.93 g) in control $25DT_1$. $35DT_5$ (56.67 g) was statistically identical with $30DT_5$ (56.67 g) and $25DT_6$ (50.8 g). Abdel-Mawgoud et al. (2010) showed that chitosan application improved fresh weights of the leaves and yield components. Asghari-Zakaria et al. (2009) observed that Application of 500 mg/l of soluble chitosan increased the shoot fresh weight.

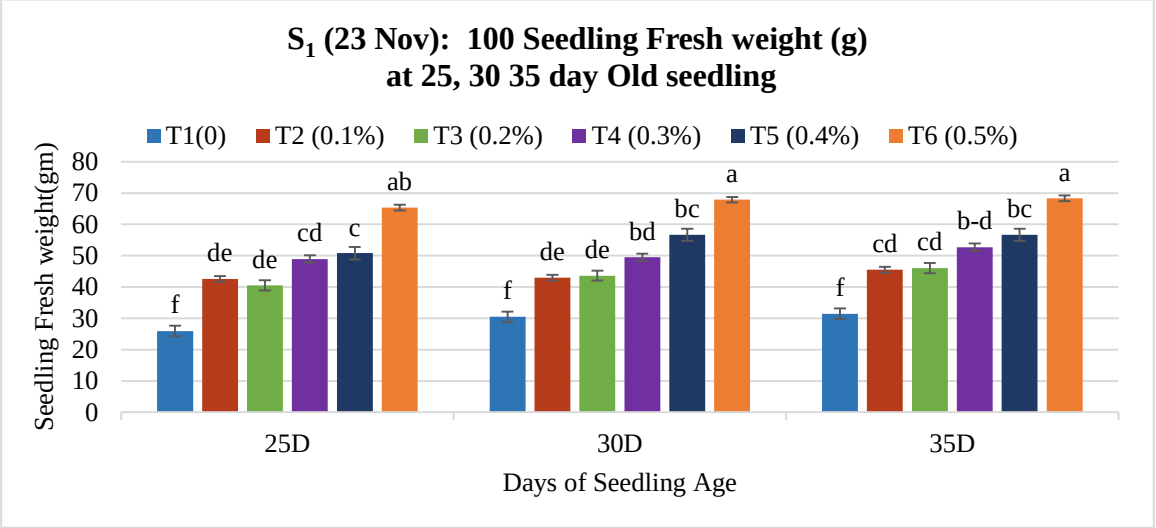

Figure 18: Effect of chitosan raw material powder level and day of seedling age on seedling fresh weight of BRRI dhan88. Bars with different letters are significantly different at p ≤0.05 applying DMRT.

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability Here,		
25D= transplanting 25 day age seedlings 30D= transplanting 30 day age seedling's 35D= transplanting 35 day age seedlings	T_1= 0%, CHT raw material powder T_2= 0.1%, CHT raw material powder T_3= 0.2%, CHT raw material powder	T_4= 0.3%, CHT raw material powder T_5= 0.4% CHT raw material powder T_6= 0.5% CHT raw material powder

4.2.3. Seedling Dry weight (g) of First set S_1 (23 Nov. 2019)

Seedling oven dry weight (g) of BRRI dhan88 rice seedlings were significantly increased with the chitosan powder treatments in the seedbed. The experimental result reviled that the maximum oven dry weight of 100 seedlings (11.67 g) in $35DT_6$ which is statistically identical with $35DT_5$ (10.9 g) whereas the minimum oven dry weight (4.9 g) in control $25DT_1$ which was statistically identical with $30DT_1$ (4.9) and $35DT_1$(5.36 g). John Berber et al. (2012) observed the application of chemical fertilizer and chitosan impacted dry matter, grain yield and panicle numbers. Martínez et al, (2015) observed that Seeds treated with chitosan 100 mg L^{-1} stimulated dry matter in saline medium grown seedlings and lowered malondialdehyde and increased proline levels.

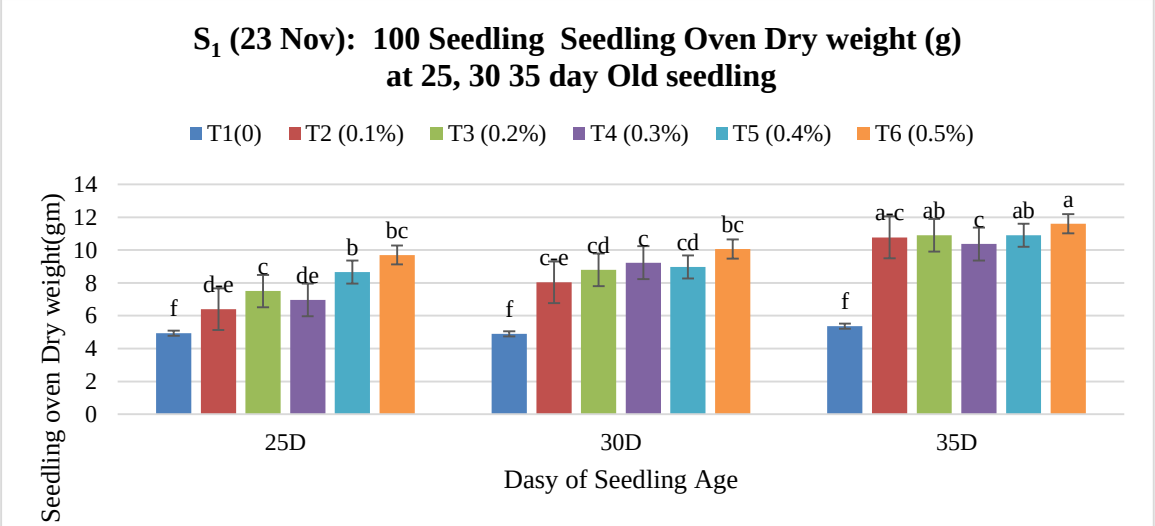

Figure 19: Effect of chitosan raw material powder level and day of seedling age on seedling oven dry weight of BRRI dhan88. Bars with different letters are significantly different at p ≤0.05 applying DMRT.

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability Here,		
25D= transplanting 25 day age seedlings 30D= transplanting 30 day age seedling's 35D= transplanting 35 day age seedlings	T_1= 0%, CHT raw material powder T_2= 0.1%, CHT raw material powder T_3= 0.2%, CHT raw material powder	T_4= 0.3%, CHT raw material powder T_5= 0.4% CHT raw material powder T_6= 0.5% CHT raw material powder

4.2.4. Seedling strength (mg cm^{-1}) of First set S_1 (23 Nov. 2019)

Seedling strength is a strong indicator for measuring good quality seedlings. Seedling strength of BRRI dhan88 was found to be statistically significant. The experimental result reviled that the maximum seedling strength of 100 seedlings (6.3 mg cm^{-1}) in $35DT_6$ which is statistically identical with $30DT_6$, $30DT_6$, $35DT_4$ and $25DT_6$ whereas the minimum oven dry weight (2.26 mg cm^{-1}) in control $35DT_1$. Ahmed *et al.* (2020) reported that seedling strength was increased with the application of chitosan-raw-materials in the seedbed. Issak, M. and Sultana, A. (2017) observed the role of chitosan powder on the production of quality rice seedlings of BRRI dhan29 and reported that application of different level of chitosan influenced the seedling strength of rice plant Boonlertnirun *et al.* (2008) found that application of chitosan stimulates the seedling strength significantly.

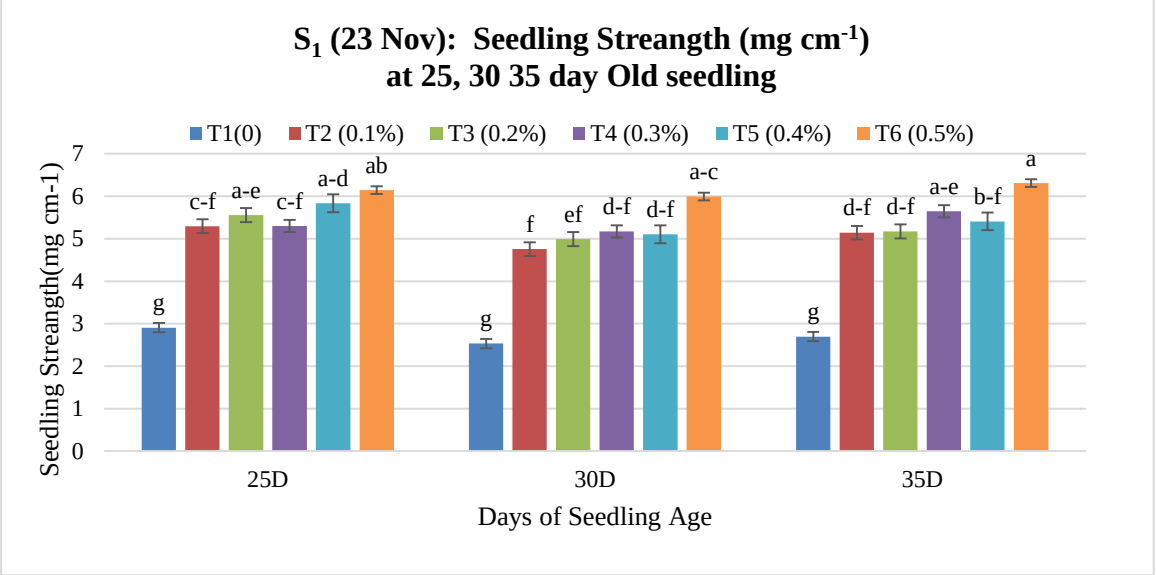

Figure 20: Effect of chitosan raw material powder level and day of seedling age on seedling strength of BRRI dhan88. Bars with different letters are significantly different at p ≤0.05 applying DMRT.

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability Here,		
25D= transplanting 25 day age seedlings 30D= transplanting 30 day age seedling's 35D= transplanting 35 day age seedlings	T_1= 0%, CHT raw material powder T_2= 0.1%, CHT raw material powder T_3= 0.2%, CHT raw material powder	T_4= 0.3%, CHT raw material powder T_5= 0.4% CHT raw material powder T_6= 0.5% CHT raw material powder

4.2.5. Tiller number of First set S_1 (23 Nov. 2019)

Tiller number of BRRI dhan88 rice seedlings were significantly increased with the chitosan powder treatments in the seedbed. Experiment result showed that the maximum tiller number hill^{-1} (7.5) of 35 day age seedlings after 40 days of transplanting date in combined treatment ($35DT_5$) whereas the minimum tiller number hill^{-1} (2.5) of 25 day age seedlings.

Phothi and Theerakarunwong (2017) found the effects of chitosan on tiller number per plants, leaf area, leaf chlorophyll, photosynthesis, shoot biomass, root biomass and total biomass. Hoque (2002) the increased number of tiller significantly.

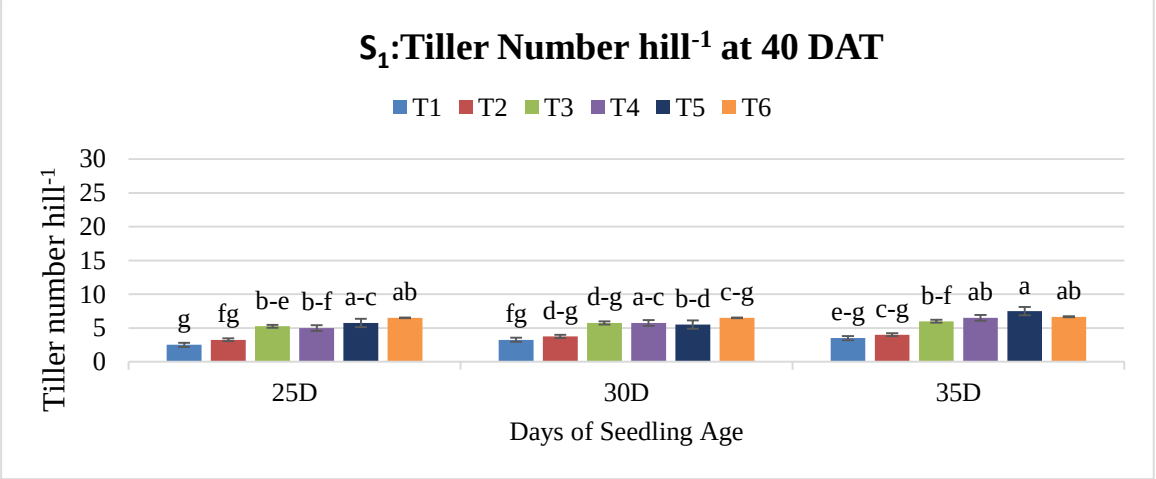

Figure 21: Effect of chitosan raw material powder level and day of seedling age on 40 DAT tiller number hill^{-1}of BRRI dhan88. Bars with different letters are significantly different at p ≤0.05 applying DMRT.

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability Here,		
25D= transplanting 25 day age seedlings 30D= transplanting 30 day age seedling's 35D= transplanting 35 day age seedlings	T_1= 0%, CHT raw material powder T_2= 0.1%, CHT raw material powder T_3= 0.2%, CHT raw material powder	T_4= 0.3%, CHT raw material powder T_5= 0.4% CHT raw material powder T_6= 0.5% CHT raw material powder

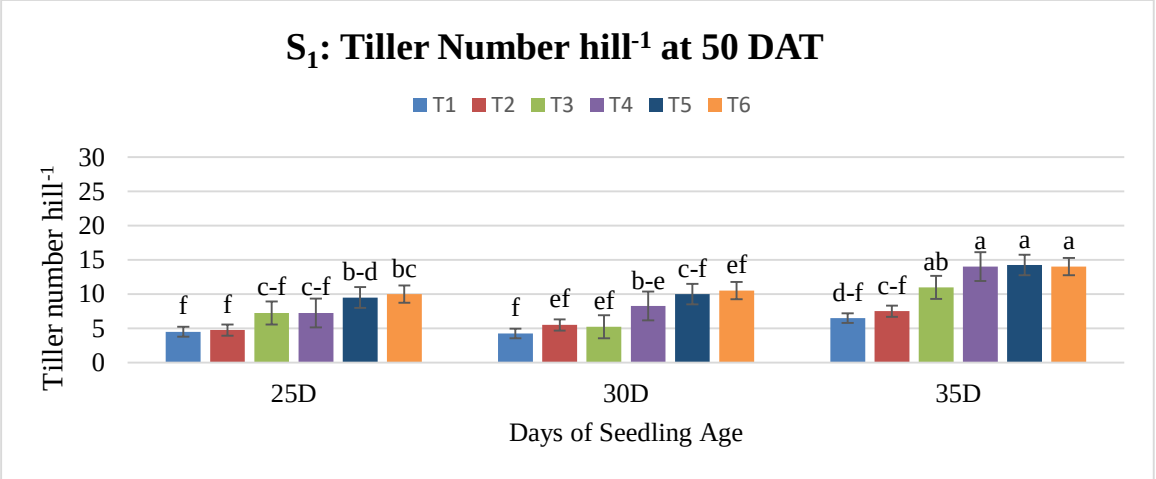

Figure 22: Effect of chitosan raw material powder level and day of seedling age on 50 DAT tiller number hill^{-1}of BRRI dhan88. Bars with different letters are significantly different at p ≤0.05 applying DMRT.

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability Here,		
25D= transplanting 25 day age seedlings 30D= transplanting 30 day age seedling's 35D= transplanting 35 day age seedlings	T_1= 0%, CHT raw material powder T_2= 0.1%, CHT raw material powder T_3= 0.2%, CHT raw material powder	T_4= 0.3%, CHT raw material powder T_5= 0.4% CHT raw material powder T_6= 0.5% CHT raw material powder

Tiller number of BRRI dhan88 rice seedlings were significantly increased with the chitosan powder treatments in the seedbed. Experiment result showed that the maximum tiller number hill^{-1} (14.5) of 35 day age seedlings after 40 days of transplanting date in combined treatment ($35DT_5$) which was statistically identical with $35DT_4$,$35DT_6$and $35DT_3$ whereas the minimum tiller number hill^{-1} (4.25) of 25 day age seedlings.

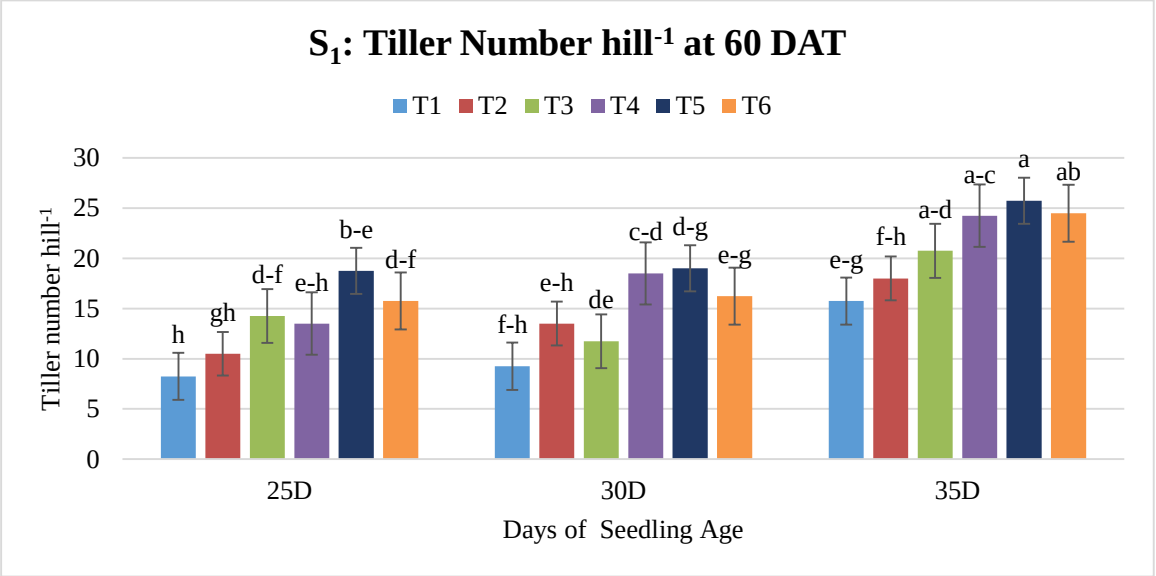

Figure 23: Effect of chitosan raw material powder level and day of seedling age on 60 DAT tiller number hill^{-1}of BRRI dhan88. Bars with different letters are significantly different at p ≤0.05 applying DMRT.

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability Here,		
25D= transplanting 25 day age seedlings 30D= transplanting 30 day age seedling's 35D= transplanting 35 day age seedlings	T_1= 0%, CHT raw material powder T_2= 0.1%, CHT raw material powder T_3= 0.2%, CHT raw material powder	T_4= 0.3%, CHT raw material powder T_5= 0.4% CHT raw material powder T_6= 0.5% CHT raw material powder

Tiller number of BRRI dhan88 rice seedlings were significantly increased with the chitosan powder treatments in the seedbed. Experiment result showed that the maximum tiller number hill^{-1} (25.75) of 35 days age seedlings after 40 days of transplanting date in combined treatment ($35DT_5$) which was statistically similar with $35DT_6$, $35DT_4$, and $35DT_3$whereas the minimum tiller number hill^{-1} (2.5) of 25 day age seedlings.

4.2.6. Effective tiller

Effective tiller number of BRRI dhan88 rice seedlings were significantly increased with the chitosan powder treatments in the seedbed Experiment result showed that the maximum effective tiller number per hill (15.5) of 35 days age seedlings after 40 days of

transplanting date in combined treatment ($35DT_5$) which was statistically similar with $35DT_4$ whereas the minimum tiller number per hill (9.41) of 25 day age seedlings. Ali et al. (2013) reported more effective tillers hill-1 (24.9) when seedlings of 15 days' age were transplanted while 30 days old seedlings gave minimum number of effective tillers (15.6). Kavitha and Ganesh raja (2012) recorded significantly higher number of productive tillers (m-2) over 18 and 22 days old seedlings. Faghani et al. (2011) found the significant effect of seedlings age on tillering pattern, and concluded that the maximum tillers hill-1 (16.3) were recorded by transplanting 25 days old seedlings while 35 days' seedlings gave minimum tillers hill-1 (15.3).Oteng and Anna (2003) from Ghana (South Africa) observed that 10-15 day sold seedlings produced more number of effective tillers than those of 15-20 days and 20- 25 days old seedlings.

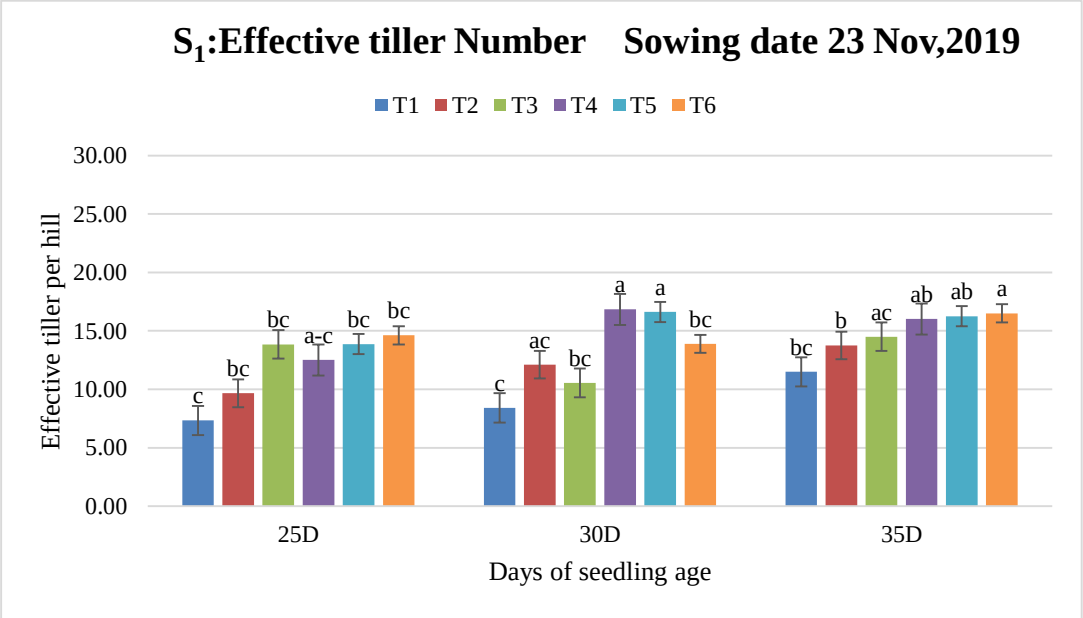

Figure 24: Effect of chitosan raw material powder level and day of seedling age on effective tiller number hill-1of BRRI dhan88. Bars with different letters are significantly different at p ≤0.05 applying DMRT.

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability Here,		
25D= transplanting 25 day age seedlings 30D= transplanting 30 day age seedling's 35D= transplanting 35 day age seedlings	T_1= 0%, CHT raw material powder T_2= 0.1%, CHT raw material powder T_3= 0.2%, CHT raw material powder	T_4= 0.3%, CHT raw material powder T_5= 0.4% CHT raw material powder T_6= 0.5% CHT raw material powder

4.3.Yield Characteristics of First set S_1 (23 Nov. 2019)

4.3.1. Grain yield (g) of First set S_1 (23 Nov. 2019)

Grain yield of BRRI dhan88 rice seedlings were significantly increased with the chitosan powder treatments in the seedbed Experiment result showed that the maximum grain yield hill^{-1} (65.02 g) was in 35 day age seedling in treatment combination $35DT_4$ which was statistically similar with $35DT_3$ and $35DT_5$ whereas minimum grain yield hill^{-1} (41.26 g) in 30 day age seedlings. Roja et al. (2021) found the foliar application of chitosan significantly increased the yield related attributes of mulberry over other concentrations. Al-Tawaha et al. (2020) noticed the highest number of grain yield, number of spikes, and grains/spike at the tillering stage. Ahmed et al. (2020) observed a profound effect on grain yield and yield traits of T. aman rice (BRRI dhan49).Shehzad et al. (2020) reported Chitosan application improved physiological and metabolic processes to improve yield and quality of sunflower under drought stress. Priyaadharshini et al. (2019) found the foliar spray of chitosan plays an important role in alleviating the harmful effects of water stress by improving the plant water status and yield. Mondal et al, (2013) noticed the foliar application of chitosan at 100 ppm may be used at early growth stage for getting maximum seed yield in maize.

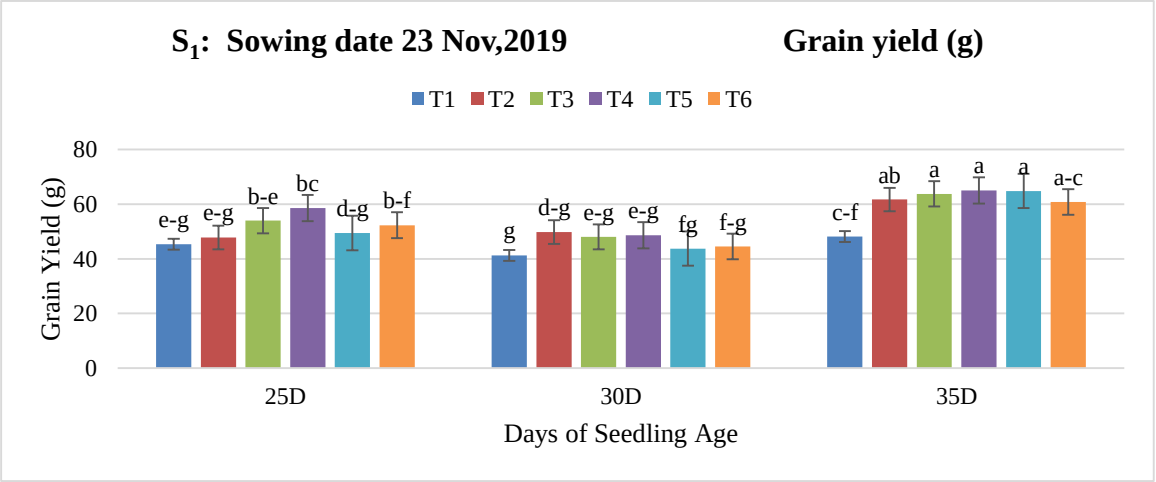

Figure 25: Effect of chitosan raw material powder level and day of seedling age on grain yield hill-1of BRRI dhan88. Bars with different letters are significantly different at p ≤0.05 applying DMRT.

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability Here,		
25D= transplanting 25 day age seedlings 30D= transplanting 30 day age seedling's 35D= transplanting 35 day age seedlings	T_1= 0%, CHT raw material powder T_2= 0.1%, CHT raw material powder T_3= 0.2%, CHT raw material powder	T_4= 0.3%, CHT raw material powder T_5= 0.4% CHT raw material powder T_6= 0.5% CHT raw material powder

4.3.2. Percent Grain yield increase over control

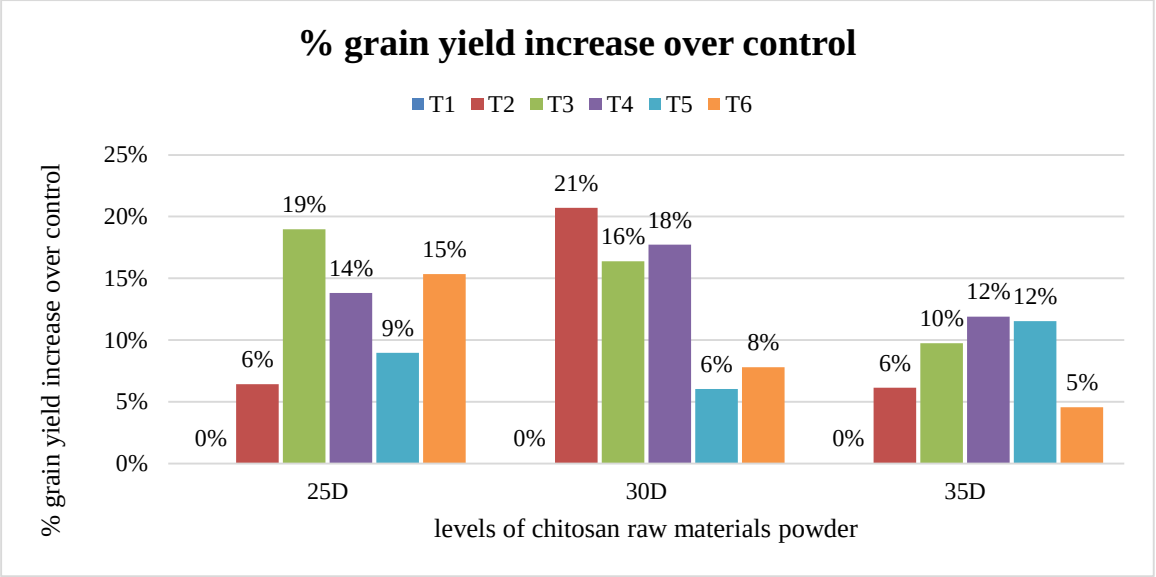

Figure 26: Effect of chitosan raw material powder level and day of seedling age on percent increase of grain yield hill-1 over control of BRRI dhan88. Bars with different letters are significantly different at p ≤0.05 applying DMRT.

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability Here,		
25D= transplanting 25 day age seedlings 30D= transplanting 30 day age seedling's 35D= transplanting 35 day age seedlings	T_1= 0%, CHT raw material powder T_2= 0.1%, CHT raw material powder T_3= 0.2%, CHT raw material powder	T_4= 0.3%, CHT raw material powder T_5= 0.4% CHT raw material powder T_6= 0.5% CHT raw material powder

4.3.3. Straw yield of First set S_1 (23 Nov. 2019)

Straw yield of BRRI dhan88 rice seedlings were significantly increased with the chitosan powder treatments in the seedbed Experiment result showed that the maximum straw yield hill^{-1} (97.52 g) was in 35 day age seedling in treatment combination 35DT_4 which was statistically similar with 35DT_3 and 35DT_5 whereas minimum grain yield hill^{-1} (61.89 g) in 30 day age seedlings.

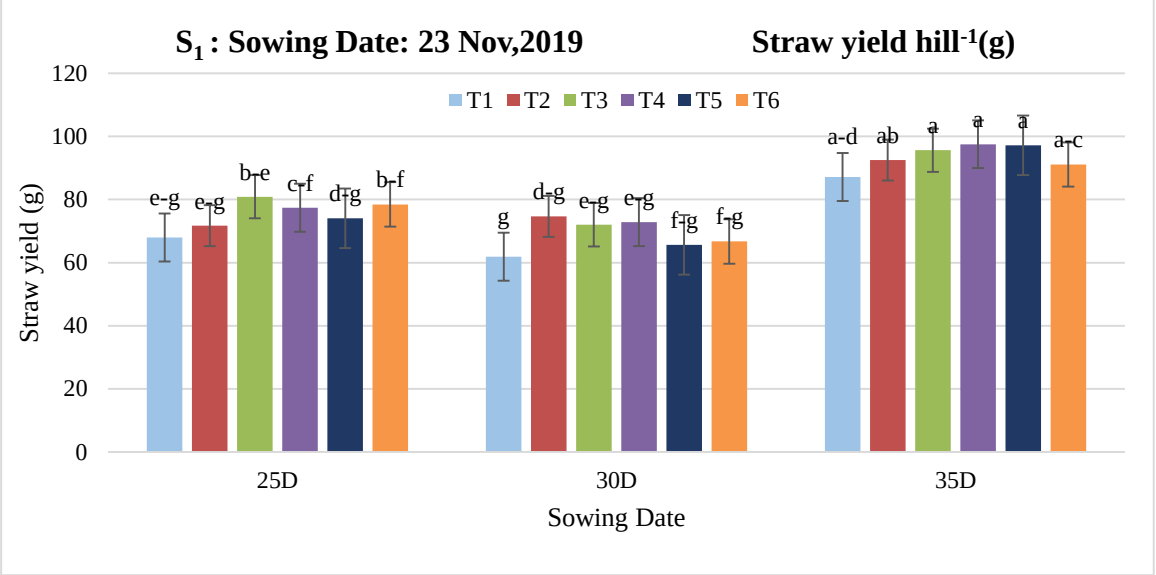

Figure 27: Effect of chitosan raw material powder level and day of seedling age on straw yield hill-1of BRRI dhan88. Bars with different letters are significantly different at p ≤0.05 applying DMRT.

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability Here,		
25D= transplanting 25 day age seedlings 30D= transplanting 30 day age seedling's 35D= transplanting 35 day age seedlings	T_1= 0%, CHT raw material powder T_2= 0.1%, CHT raw material powder T_3= 0.2%, CHT raw material powder	T_4= 0.3%, CHT raw material powder T_5= 0.4% CHT raw material powder T_6= 0.5% CHT raw material powder

4.4.Chemical Properties of seedbed soils after transplant

4.4.1. P^H and percent total nitrogen

Form the table: 8 it was noticed that application of different level of chitosan raw material powder influenced seedbed soil pH and total nitrogen percentage from initial level (5.8 and 0.04 %). Among different treatments, T_6 treatment (0.05 % chitosan raw material powder) increasing seedbed soil pH (6.5) and T_5 treatment recorded the highest total nitrogen (0.12 %) comparable control treatment due to reason that chitosan raw material powder has higher pH which influenced the soil pH whereas application of chitosan raw material powder increasing the nutrient supplying capacity to the soil result in increasing total nitrogen percentage in the seedbed soil.

Table 8: Effect of different chitosan raw material powder treatments on pH and % total nitrogen of seedbed soil after seedling transplant

Treatments	pH		% total nitrogen	
	Initial	After	Initial	After
T_1	5.8	5.80 d	0.04	0.04 e
T_2	5.8	6.00 c	0.04	0.05 e
T_3	5.8	5.90 c	0.04	0.09 c
T_4	5.8	6.30 b	0.04	0.07 d
T_5	5.8	6.30 b	0.04	0.12 a
T_6	5.8	6.50 a	0.04	0.11 b
$LSD_{(0.05)}$	NS	0.18	NS	0.003
CV (%)	--	1.97	--	2.34

Here, Level of chitosan raw material powder, T_1= 0%, T_2= 0.1%, T_3= 0.2%, T_4= 0.3%, T_5= 0.4% and T_6= 0.5%.

4.4.2. Percent organic carbon and organic matter

Chitosan raw material powder contents 7.52 % organic carbon and 12.96 % organic matter. From the table 10 it was noticed that, the application of different level of chitosan raw material powder influenced organic carbon percentages and organic matter comparable to control treatment. The maximum organic carbon (0.76 %) and organic matter (1.31 %) were recorded in T_6 treatment comparable to control treatment. More the application of chitosan raw material powder more the organic carbon and organic matter present in the seedbed soil. But higher amount of organic carbon and organic matter create toxicity and compactness of soil in the root zone of the plant. As a result, plant cannot uptake essential nutrients result in poor growth and development.

Table 9: Effect of different chitosan raw material powder treatments on Percent organic carbon and organic matter of seedbed soil after seedling transplant.

Treatments	Organic carbon (%)		Organic matter (%)	
	Initial	After	Initial	After
T_1	0.5	0.50 d	0.87	0.87 e
T_2	0.5	0.59 c	0.87	1.02 d
T_3	0.5	0.58 c	0.87	1.00 d
T_4	0.5	0.63 b	0.87	1.09 c
T_5	0.5	0.75 a	0.87	1.20 b
T_6	0.5	0.76 a	0.87	1.31 a
$LSD_{(0.05)}$	NS	0.02	NS	0.03
CV (%)	--	2.62	--	2.16

Here, Level of chitosan raw material powder, T_1= 0%, T_2= 0.1%, T_3= 0.2%, T_4= 0.3%, T_5= 0.4% and T_6= 0.5%.

CHAPTER V
SUMMARY AND CONCLUSSION

A pot experiment was conducted under the net house of Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh, during November 2019 to April 2020, to investigate the production of quality *Boro* rice seedlings and yield by using chitosan raw material powder in seedbed soil. The experiment was consisted of two stage along with two factors and following Completely Randomized Block Design (RCBD) with three replications in seedling production. First stage (seedling stage) were two factor. Factor A: Level of chitosan raw material powder (w/w) (06) *viz;* T_1 = 0%, T_2 = 0.1%, T_3 = 0.2%, T_4 = 0.3%, T_5 = 0.4% and T_6 = 0.5% of soil and Factor B: Different sowing date dates $S_{1=}$ sowing date 23 S_1= sowing date 23,Nov,2019 S_2= sowing date 25,Nov,2019 S_3= sowing date 27,Nov,2019 ,S_4= sowing date 29,Nov,2019 S_5= sowing date 01,Dec ,2019 , S_6= sowing date 03,Dec,2019 S_7= sowing date 05,dec ,2019 S_8= seed sowing date 07,Dec ,2019 At the time of 2nd stage (growth and yield stage) Factor A: Level of chitosan raw material powder (w/w) (06) *viz;* T_1 = 0%, T_2 = 0.1%, T_3 = 0.2%, T_4 = 0.3%, T_5 = 0.4% and T_6 = 0.5% and Factor B: Different seedling age (3) *viz;* 25D = 25 days old seedling, 30D = 45 days old seedling and 35D = 35 days old seedling. A significant variation was observed in the seedlings height, fresh weight, dry weight, seedling strength and chemical properties of the seedbed soils due to the combined treatment of chitosan powder and sowing date in the seedbed. The seedling height, fresh weight, dry weight and seedling strength fluctuated due to the cold temperature effect especially it's observed in control (no chitosan powder application) treated seed. Maximum height were 23.93 cm, 25.13 cm and 24.73cm respectively in 25, 30 and 35 days age seedling. Minimum height were 10.03 cm, 14.09 cm and 11.47 cm respectively in 25, 30 and 35 days age seedling. Maximum fresh weight were 63.37 g, 65.37 g and 67.69 g respectively in 25, 30 and 35 days age seedling. Minimum fresh weight were 10.27 g, 14.08 g and 14.93 g respectively in 25, 30 and 35 days age seedling. Maximum oven dry weight were 9.70 g, 10.07 g and 10.9 g respectively in 25, 30 and 35 days age seedling. Minimum oven dry weight were 2.30 g, 2.78 g and 2.8 g respectively in 25, 30 and 35 days age seedling. Maximum seedling strength were 6.14 mg cm^{-1}, 5.99 mg cm^{-1} and 6.31 mg cm^{-1} respectively in 25, 30 and 35 day age seedling. Minimum seedling strength were 2.26 mg cm^{-1}, 2.38 mg cm^{-1}

and 2.44 mg cm^{-1} respectively in 25, 30 and 35 day's age seedling. Maximum effective tiller number were 11.86, 11.83 and 15.02 respectively in 25, 30 and 35 day age seedling. Minimum effective tiller number were 10.34, 9.41and 12.5 respectively in 25, 30 and 35 days age seedling. Maximum grain yield pot^{-1} were 58.6 g, 48.8 g and 65.1 g respectively in 25, 30 and 35 day age seedling. Minimum grain yield pot^{-1} were 45.33 g, 41.26 g and 48.1g respectively in 25, 30 and 35 days age seedling. Maximum straw yield pot^{-1} were 80.9 g, 74.7 g and 97.5 g respectively in 25, 30 and 35 day age seedling. Minimum straw yield pot^{-1} were 68 g, 61.89 g and 87.15 g respectively in 25, 30 and 35 days age seedling.

Maximum height was 25.13 cm in combined treatment of T_6S_1 in 30 day age seedlings whereas minimum height 10.03 cm in combined treatment of T_5S_8 in 25 day age seedlings. Maximum fresh weight was 97.17 in combined treatment of T_6S_1 in 30 day age seedlings whereas minimum fresh weight 10.27 g in combined treatment of T_1S_7 in 25 day age seedlings. Maximum dry weight was 15.6 in combined treatment of T_6S_1 in 30 day age seedlings whereas minimum dry weight 2.30in combined treatment of T_1S_5 in 25 day age seedlings. Maximum seedling strength was 8.41 mg cm^{-1} in combined treatment of T_5S_4 in 30 day age seedlings whereas minimum seedling strength 1.98 mg cm^{-1} in combined treatment of T_1S_5.Maximum effective tiller number was 15.02 in combined treatment of $35DT_4$ whereas minimum effective tiller number 9.41 in combined treatment of $30DT_1$. Maximum grain yield pot^{-1} was 65.1 g in combined treatment of $35DT_4$ whereas minimum grain yield pot^{-1} 41.26 in combined treatment of $30DT_1$ Maximum straw yield pot^{-1} was 97.5 g in combined treatment of $35T_4$ whereas minimum straw yield pot^{-1} 61.89 g in combined treatment of $30DT_1$.

In seedling height, fresh weight, dry weight and strength of combined treatment of S_1T_6 is maximum in 25, 30 ,35 days seedlings age whereas minimum fresh weight, dry weight and seedling strength were in T_1S_5 and T_1S_6 sown in 01 December,2019 to 01 December 2019 when was cold temperature. Considering the Seedling height of optimum sowing time of control was identical with S_5T_2 in 25 day age seedlings, S_4T_2 in 30 day age seedlings and S_8T_3 in 35 day age seedlings. Similarly fresh weight, dry weight and seedling strength of optimum sowing time of control was identical with S_8T_2 in 25 day age seedlings, S_7T_2 in 30 day age seedlings and S_8T_2 in 35 day age seedlings. As the combined treated seedbed of S_8T_2 and S_7T_2 which are sown 14 to 16 days later then control seedbed and 8-10 days after BRRI recommended optimum sowing time identical with the control. S_8T_2 and S_7T_2 combined treatment may help in producing same quality

seedling of optimum time control at cold temperature along with production of 8-10 days late sowing seedling then optimum time. Again the yield production of optimum sowing time seedling may impacted by application of chitosan raw material powder at $35DT_4$. Thus for cultivation of BRRI dhan88, it is suggested that optimum level (0.3%) of chitosan raw material powder could be applied in the seedbed soil along with transplanting young (35 days old) seedling perform well for obtaining higher grain yield. On the other hand, the maximum level of organic carbon, organic matter and soil pH was recorded in the treatment T_6 and the minimum level in the treatment T_1 (control). Chitosan powder increased the level of organic matter in a dose dependent manner. Quality of the Boro rice seedlings were improved due to the application of chitosan powder and the seedlings strength were increased in a dose dependent manner. Taken together, the research findings indicated that chitosan raw materials significantly influenced the seedling strength and that was allow to influenced the maximum effective tiller production resulting higher grain yield. The results suggested that the chitosan raw materials could be an effective yield boosting tool for rice cultivation under Climate Smart Agriculture in Bangladesh.

Conclusion

Based on the above results of the present study, the following conclusions may be drawn Chitosan raw material powder improved the seedling characters (seedling height, fresh weight, oven dry weight and seedling strength), yield and yield attributing characters of BRRI dhan88. Late seed sowing decreases seedling production especially seedling height, fresh weight, dry weight and seedling strength up to 21% compared to optimum sowing time due to cold injury & other environmental factors. Late sowing farmers may overcome this yield gap by using optimum doses of chitosan raw material powder in seedbed soil. Farmer may delay 8-10 days in seed sowing by using optimum dose of chitosan raw material where they may get same quality seedling by applying CHT powder. All the treatments using chitosan raw material powder showed better performance by the following sequence $T_4>T_5>T_6>T_3>T_2>T_1$. Among the treatments, T_4 showed the superior performance. Among the treatment combinations, $35DT_4$ showed the best performance. Chitosan raw material powder improves chemical properties of soil for sustainable agriculture.

Recommendations

From the above experimental findings, it is apparent that the application of chitosan raw material powder @ 0.2% in seedbed soil improved seedling characters, yield and yield parameters of BRRI dhan88. So, it is suggested to the late sowing farmers to apply 0.2% chitosan raw material powder in seedbed soil for better performance. In order to recommend the practices for the rice growers, the following aspects would be considered in future:

i. Similar experiments need to be conducted in field condition in different locations and seasons of Bangladesh especially north region where presenting higher cold stress and hilling injuries to draw a final conclusion regarding to the effect of chitosan raw material powder application in the seedbed in seedling production along with different ages seedling for obtaining better grain yield of BRRI dhan

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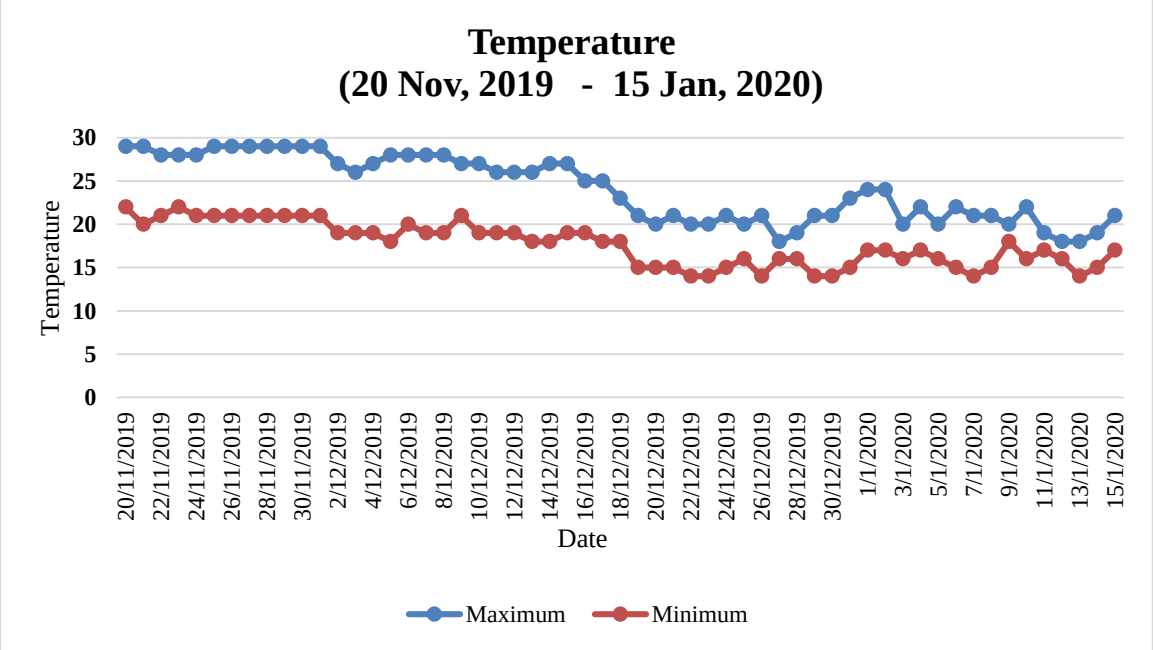
APPENDIX

Appendix I. Monthly meteorological information during the period from November, 2019 to April 2020

Year	Month	Air temperature (^{0}C)		Relative humidity (%)	Total rainfall (mm)
		Maximum	Minimum		
2019	November	29.6	20.1	53	00
	December	28.4	14.1	47	00
2020	January	24.5	14.1	41	00
	February	25.5	14	34	7.7
	March	31.7	20.2	60	73
	April	32.7	23.8	74	168

(Source: Metrological Centre, Agargaon, Dhaka (Climate Division)

Appendix II. Daily meteorological information during the period from 20 November, 2019 to 15 January 2020



Appendix III. Analysis of variance of the data of pH, percentage of total nitrogen, percentage of organic carbon and percentage of organic matter

Mean square of					
Source	**df**	**pH**	**% total nitrogen**	**Organic carbon (%)**	**Organic matter (%)**
Treatment	5	0.43200**	5.71E-03**	0.04172**	0.09719**
Error	18	0.01444	3.222E-06	0.00028	0.00054
Total	23				

^{Ns}; Non significant

**: Significant at 0.01 level of probability