ROLE OF SEEDLING NUMBER AND CHITOSAN RAW MATERIAL POWDER ON THE GROWTH AND YIELD OF BRRI dhan88

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DEDICATED TO
MY
BELOVED PARENTS & JERIN

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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 improvement of late sowing. Boro seedling characters and yield by using chitosan raw material powder in seedbed soil. The experiment was consisted of two factors and following Completely Randomized Block Design (RCBD) with four replications. 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 Number hill^{-1} (3) *viz;* S_1=Single seedling hill^{-1}. S_2 = Two seedling hill^{-1} and S_3 = Three seedling hill^{-1}. Experimental results revealed that among different levels of chitosan raw material powder, maximum average seedling height (21.93 cm) was obtained in T_5 (0.4 % chitosan raw material powder) treatment. Seedling treated with T_2 (0.1%) treatment perform well fresh weight seedling^{-1} (371.33 mg), oven dry weight seedling^{-1} (83.337 mg), maximum seedling strength (4.65 mgcm^{-1}), grain yield pot^{-1} (69.85 g), maximum harvest index (50.54 %). In case of different seedling number hill^{-1}, effective tillers pot^{-1} (22.67), first flowering (65.66), maximum grain yield pot^{-1} (65.168 g), the maximum harvest index (49.46%) was obtained in S_1 (Single seedling hill^{-1}). In case of combined effects, The maximum grain yield pot^{-1} (76.27 g) was obtained in T_3S_1 treatment combination. Chitosan raw material powder strongly improved the seedling characters at single seedling number hill^{-1}, yield and yield attributing characters of BRRI dhan88.Thus for cultivation of BRRI dhan88, it is suggested that optimum level (0.1%) of chitosan raw material powder could be applied in the seedbed soil along with transplanting single seedling hill $^{-1}$perform well for obtaining higher grain yield.

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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

Food security is a burning issue of the world at present. Increased rice production can play a vital role to address this issue successfully. Rice (*Oryza sativa L.*) is the most important food crop and a primary food source for more than one -third of world's population (Sarkar *et al*., 2017). Asia contributes more than 90% of the world's total rice production while using more than 90% of the total irrigation water (Jahan *et al*., 2017).

Ninety percent global rice production occurs in tropical and sub-tropical Asian countries (Mejia, 2006). In Bangladesh, the geographical, climatic and edaphic conditions are favorable for yearly rice cultivation. Rice is the staple food for about 156 million people of Bangladesh (Israt *et al*., 2016). In Bangladesh, rice covers about 28.49 million acres in which 34.5 million M tons of rice is produced while the average yield of rice is around 1.18 tons acre (BBS 2013). According to BBS, 2015, Bangladesh is the 5 th largest country of the world based on the rice cultivation. By the end of 2022, it is estimated that about 515 million tons of rice will be produced worldwide. Rice sector contributes half of the agricultural GDP and 1/6th of the national income in Bangladesh (BRRI, 2007).

There are three distinct growing seasons of rice in Bangladesh, according to change in seasonal conditions such as Aus, Aman and Boro. More than half of the total production (55.50%) is obtained in Boro season occurring in December-May,second largest production in Aman season (37.90%) occurring in July-November and little contribution from Aus season (6.60%) occurring in April-June (APCAS, 2016).

The lower yield of transplanted Boro rice has been attributed to several reasons. In such condition, increasing rice production can play a vital role. Therefore, attempts must be made to increase the yield per unit area by adopting modern rice cultivars, nutrient management practices and applying improved technology such age of seedling etc. (Rinaudo, 2006).

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. They are inherent to have specific properties of being environmentally friendly and easily degradable. Thailand is a world-

leading exporter of frozen shrimps. Therefore, there are abundant raw materials for chitosan production. Chitosan has a wide scope of application. With high affinity and non-toxicity, it does no harm human beings and livestock. Chitosan regulates the immune system of plants and induces the excretion of resistant enzymes. Moreover, chitosan not only activates the cells, but also improves its disease and insect resistant ability (Doares *et.al*., 1995)

Chitosan is produced commercially by deacetylation of chitin, which is the structural element in the exoskeleton of crustaceans (such as crabs and shrimp) and cell walls of fungi. Chitosan is considered an environmentally friendly product that has been widely used in agricultural applications mainly for enhancing soil characteristics which is suitable for plant growth and also stimulation of plant defense. It has been used in seed, leaf, fruit and vegetable coating, as well as a fertilizer and in controlled agrochemical release (Ibrahim *et al*., 2015). Chitosan may be used as an alternative source of N which increases efficiency of applied N (Saravanan *et al*., 1987). 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). Rice is the country's dominant crop and a key component of the population's diet. Three main paddy rice systems are farmed in the country i.e. Aman, Boro and Aus. Bangladesh is currently the 4th largest rice producing country in the world.

Chitosan is obtained from chitin which is considered as the second most abundant naturally occurring polysaccharides next to cellulose found in the planet (Rinaudo, 2006). Chitin is basically present in arthropods exoskeleton materials such as crab, shrimp and some fungi. Commercially, chitosan is prepared by demineralization of chitin using acids followed by a deproteinization with a base (Kaya *et al.*, 2015). Now, chitosan and its oligosaccharides have gained wide prospects in agricultural application, biomedicine and biotechnology due to their biocompatibility, biodegradability and bioactivity (Katiyar *et al*., 2014).

The induction of H_2O_2 by chitosan was reported to be the crucial com-ponent in the chitosan stimulation of rice growth during drought stress (Pongprayoon *et al*., 2013).

Tiller dynamic of the rice plant greatly depends on the age of seedlings at transplanting (pasuquin *et al*., 2008). Tillering and growth of rice proceed normally when optimum aged seedings are transplanted at the right time (Mobasser *et al*., 2007).

Number of seedlings hill^{-1} is an important factor for successful rice production because it affects plant population unit^{-1} area, availability of sunlight and nutrients, photosynthesis and respiration, which ultimately influence the yield contributing characters and yield (Chowdhury *et al.*, 1993). Nakano and Mizushima (1994) reported that grain yield is negatively correlated with increasing the number of seedling hill^{-1}. Alam (2006) reported that the highest number of total tillers and number of effective tillers were obtained from two seedlings hill^{-1}, Obulamma and Reddeppa (2002) reported that one seedling hill^{-1} gave the highest grain yield, crop growth rate and net assimilation rate while three seedlings hill^{-1} had the highest dry matter production, leaf area index and leaf area density.

In Bangladesh, there is limited information on the impact of organic growth promoters such chitosan on rice growth and yield.

By considering the above fact, the proposed research work was undertaken to achieve the following objectives:

Objectives

i. To improve Boro seedling by using chitosan raw material powder in seedbed.

ii. To examine Number of seedling hill^{-1} effects of chitosan raw material powder treated Boro seedlings on grain yield.

CHAPTER II

REVIEW OF LITERATURE

An attempt was made in this section to collect and study relevant information available regarding to impact of late planting with chitosan raw material powder treated seedlings on yield performance of BRRI dhan88, to gather knowledge helpful in conducting the present piece of work.

2. 1: Effect of chitosan raw material

Seedling height

Issak and Sultana (2017) conducted an experiment to determine the effect of chitosan powder on the development of high qualities rice seedlings of BRRI dhan29 and discovered that utilizing the chitosan powder in the seedbed increased the production of Boro rice seedlings.

Poor seedling quality could affect the growth of rice plants, leading to a decrease in tillering capacity per plant, effective panicle number, total spikelet's number, total dry matter accumulation, and ultimately a decrease in grain yield (Pan *et al.,* 2011). The yield losses of rice due to prolonged seedling age were related to the reductions in biomass accumulation, stem number, spikelet number, grain filling percentage (Sarwar *et al.,* 2011).

Ziani *et al.,* (2010) found that chitosan-treated seeds grew seedlings more successfully than untreated seeds (with longer, better-developed radicles and greener hypocotyls, for example) and had a decreased risk of fungus infection. The incorporation of nutrients (nitrogen) from chitosan could potentially be connected to the observed growth improvement by chitosan.

Boonlertnirun *et al*., (2008) discovered that chitosan is a real biopolymer that boosts plant growth and yield in addition to inducing the plant immune system.

Ouyang and Langlai (2003) who studied the Chinese cabbage (Brassica campestris) cv. Dwarf hybrid No. 1, they discovered that seed treatment with 0.4–0.6 mg^{-1} seed and leaf spraying with 20–40 micro gm-1 enhanced plant height and leaf area.

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.

Seedling fresh weight

Issak and Sultana (2017) carried out an experiment to observed the role of chitosan powder on the production of quality rice seedlings of BRRI dhan29 was in the field of Sher-e-Bangla Agricultural University, Dhaka and found that the maximum fresh weight (29.14 g) production of 100 seedlings was found in the treatment T_4 having 400 g CHT powder/m^2 and the lowest fresh weight production (12.6 g) was found in the treatment T_6 (control) which was significantly different from all other treatments. These results indicate that fresh weight productions of BRRI dhan29 rice seedlings were influenced by the chitosan powder treatments and this might be due its supplementation of plant nutrients and growth regulators.

Ouyang and Langlai (2003) reported that seeds of non-heading Chinese cabbage dressed with chitosan at the rate 0.4-0.6 mgg^{-1} seed and leaf spraying with 20-40 micro gm^{-1} increased fresh weight.

Saravanan *et al*., (1987) carried out an experiment to know the effect of combined application of bio-organic and chemical fertilizers on physical properties, nitrogen transformation and yield of rice in submerged soils and found that the organic manures viz. sludge and spray of CHT increases the efficiency of applied N.

Seedling dry weight

Issak and Sultana (2017) reported that oven dry weight productions of BRRI dhan29 rice seedlings were influenced by the chitosan powder applications and this might bedue its nutritional support to the seedlings, improvement of growth promoting hormonal activity and could improve the biological as well as physio-chemical properties of the seedbed soils.

Boonlertnirun *et al.,* (2008) conducted an experiment to investigate the effect of chitosan application in rice production and found that application of chitosan stimulates the seedling dry matter weight significantly.

Martinez et al., (2007) carried out an experiment to study the Influence of seed treatment with chitosan on tomato (*Lycopersicum esculentum* L.) plant growth and reported that in general, the best response was obtained when seeds were treated with

1 mgL^{-1} chitosan during four hours, as this concentration stimulated significantly plant dry weight, although the other indicators were not modified.

Seedling strength

Issak and Sultana (2017) carried out an experiment to 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 and maximum seedling strength (5.79 mg cm^{-1}) was obtained in the T_5 treatment having CHT powder @ 500 gm^{-2} whereas the minimum seedling strength (10.80 mg cm^{-1}) was obtained in the T_6 treatment (control).

Tillers $hill^{-1}$

Ahmed *et al.,* (2013) carried out an experiment at the field laboratory, Department of Crop Botany, Bangladesh Agricultural University, Mymensingh during the period from November 2011 to April 2012 to investigate the effect of Chitosan on growth, yield contributing characters and yield of BRRI dhan29 and reported that the foliar application of Chitosan had significant effect on the production of tillers $hill^{-1}$ in rice. The result revealed that Chitosan treated plants produced the higher number of tillers compare to control. The maximum number of tillers $hill^{-1}$ (9.33, 13.67 and 16.67) was observed in 50 mg L^{-1} followed by 75 mg L^{-1} Chitosan (8.33, 12.33 and 15.33) at 30, 60 and 90 DAT respectively. In contrast, the minimum number of tillers $hill^{-1}$ (7.33, 10.33 and 13.33 respectively) was found in control.

Effective tiller $hill^{-1}$

Ahmed *et al*., (2020) conducted a field experiment at the research field of Sher-e Bangla Agricultural University, Dhaka, Bangladesh, to examine the effect of chitosan-raw-materials on yield maximization of BRRI dhan 49. The chitosan raw- materials were applied in different doses and methods (Seedbed and main field applied methods). The treatment combinations were as follows: T_1: Seedbed applied @ 0 gm^{-2} + Main field applied @ 0 t/ha (Control); $T_{2:}$ Seedbed applied @ 0 g/m^2 + Main field applied @ 0.5 t/ha; T_3: Seedbed applied @ 250 g/m^2 + Main field applied @ 0 t/ha; T_4: Seedbed applied @ 250 g/m^2 + Main field applied @ 0.5 t/ha. Experiment result revealed that, different level of chitosan significantly effects on effective tillers $hill^{-1}$ and the highest

number of effective tiller hill^{-1} (14) was obtained in the T_3 whereas the lowest number of effective tillers hill^{-1} (11.67) was obtained in the T_1 (control) treatment. It was observed that the chitosan-raw-materials application in soil the increases the effective tillers hill^{-1}.

Grain yield

Ahmed *et al.,* (2013) carried out a study to investigate the effect of chitosan on growth and yield of rice cv. BRRI dhan29 observed significant effect of Chitosan on grain yield of rice. The result revealed that 50 mg L^{-1} of Chitosan treated plants produced the highest grain yield (7.05 t ha^{-1}) followed by 75 mgL^{-1} (6.77 t ha^{-1}) and 100 mgL^{-1} (6.14 tha^{-1}) of Chitosan where 75 and 100 mgL^{-1} Chitosan were statistically same. On the other hand, the lowest grain yield (5.83 t ha^{-1}) was observed at control treatment.

Nguyen and Tran (2013) carried out an experiment to know the effect of application of chitosan solutions for rice production in Vietnam and reported that, the chitosan produced from shrimp shells using dilute acetic acid proved effective in controlling plants infection by microbial agents leading to higher yields. The field study 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.

Abdel Mawgoud *et al.,* (2010) reported that application of chitosan at 2 mgL^{-1} improved yield components (number and weight) of strawberry chitosan application had a tendency to increase grain yield of rice plants over than unapplied seed.

Boonlertnirun *et al.,* 2006 reported that rice yield cultivar Suphan Buri 1 was significantly increased over the control (no chitosan) after application of polymeric chitosan at the concentration of 20 ppm.

Straw yield

Sultana *et al.,* (2015) conducted a field experiment to investigate the impact of foliar application of oligo chitosan improves morphological character and yield in rice. The experiment was done with randomized complete block with four replications. BINA Dhan-14 seeds were soaked with 100 ppm chitosan for 24 hours whereas the control seeds were soaked in distilled water. Four different concentrations were used in this experiment that is 0, 40, 80 and 100 ppm oligomeric chitosan and four times foliar spray

after germination (on day 3, 17, 55 and 70 at field stages) were carried out. In the control treatment only water was sprayed. Experiment result revealed that straw yield shows significant differences between control plants and foliar sprayed chitosan plants and highest straw yield (4.38 t/ha) was recorded under 100 ppm oligomeric chitosan and lowest straw yield (3.24 t/ha) was observed under 0 ppm oligomeric chitosan.

Kananont *et al.,* (2015) carried out an experiment to improving the rice performance by fermented chitin West with Fermented chitin waste (FCW). The experiment consisted with three levels of FCW (Fermented chitin waste) @ (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 experiment results revealed that FCW @ 1% the straw yield differ significantly from 0.5% FCW, 0.25% FCW and the rest of the treatment.

Biological yield

Ahmed (2015) carried out an experiment to know the Performance of BRRI dhan49 as influenced by modified chitosan in the seedbed and in the main field and found that chitosan application showed non-significant effect to biological yield, but slightly influenced biological yield comparable to control treatment.

Harvest index

Chibu *et al.,* (2000) carried out a study to observed the effects of chitosan application on growth and chitinase activity in several crops and reported that in Soybean harvest index was significant in chitosan application plants compare to control.

2.2 Effect number of seedling per hill

Grain yield

Faruk *et al.,* (2009) reported that the highest grain yield was obtained in two seedlings per hill. A field experiment was conducted at the Agronomy Research Field, Hajee Mohammad Danesh Science and Technology University, Dinajpur during June to December, 2007 to find out the effect of age of seedling and number of seedlings hill-^{1}on the yield of short duration transplant aman rice named BRRI Dhan 33. The treatments consisted of four seedling ages viz. 2, 3, 4 and 5 weeks old and three levels of number of seedling hill^{-1} viz. one, two and three. Various seedling ages, different levels of number of seedlings hill^{-1} and their interactions significantly influenced the

yield parameters. The highest effective tillers hill^{-1}, panicle length, grain, and straw yields were found in four weeks old seedling but the lowest results were found from the two weeks old seedling. Two seedlings hill^{-1} were the best performer in respect of yield and yield components. Effective tillers hill^{-1}, grains panicle^{-1}, grain and straw yields were higher than one or three seedlings hill^{-1}. The 1000 grain weight was unaffected by the seedling ages, number of seedlings hill^{-1} and their interactions. Finally, four weeks aged seedling demonstrated the best performance in respect of grain yield and this variety may preferably be cultivated with two seedlings hill^{-1} to obtain appreciably good yield in aman season.

Obulamma and Reddeppa (2002) reported that one seedling hill^{-1} gave the highest grain yield, crop growth rate and net assimilation rate while three seedlings hill^{-1} had the highest dry matter production, leaf area index and leaf area density.

T Islam and MA. Salam (2017) reported that grain yield was not significantly affected by the number of seedlings hill^{-1} but numerically the highest grain yield was recorded from single seedling hill^{-1}. From the interaction it is observed that grain yield was not significantly affected by the interaction of cultivar and number of seedlings hill^{-1} . But numerically the highest grain yield was recorded from the interaction of BRRI dhan56 × single seedling hill^{-1}.

Straw yield

Hossain *et al*., (2003) noticed that Seedling number per hill can cause competition between the plants is high in which sometimes results in gradual shading and lodging and thus increase production of straw instead of grain. It is, therefore, necessary to determine the optimum seedling number per hill for high yield.

Bagheri *et al.,* (2011) noticed that the highest (635.8 g m^{-2}) straw yield was obtained from 20 days old seedlings over 30 and 40 days.

Rajesh and Thanunathan (2003) reported that the seedling age had significant difference on straw yield. Planting of 40day old seedlings found to be optimum to get significantly higher (5.63 t ha^{-1}) straw yield compared to 30 (5.09 t ha^{-1}) and 50 (4.76 t ha^{-1}) days old seedlings.

Sharma and Ghosh (1998) stated that younger seedlings produced significantly higher straw (7.53 tha^{-1}) yields as compared to older seedlings from their studies on hybrids

rice.

Biological yield

Chakrabortty (2013) conducted a field experiment at the Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from December 2011 to May 2012 to study the growth and yield of Boro rice as affected by seedling age and planting geometry under System of Rice Intensification (SRI) and reported that seedling age varied biological yield of Boro rice and the maximum biological yield (9.84 tha^{-1}) was recorded in 16 days old seedling and the minimum biological yield (8.73 t ha^{-1}) was found in 30 days old seedling.

Chandrapala *et al.*, (2010) a field experiment conducted during the kharif season of 2007 and 2008 on sandy clay loam soil-having pH 7.65 at Hyderabad. That observed that the transplanting of 12day old seedling of rice (cv. Rassi) under SRI at as pacing of 25×25 cm, was recorded significantly higher biological yield over 25 days seedling under conventional transplanting at 20×15 cm and direct sowing of sprouted rice under unpuddled condition.

Harvest index

Islam *et al.*, (2021) carried out an experiment in the Agriculture Field Laboratory, Noakhali Science and Technology University (NSTU) to evaluate the effects of age of seedlings on the yield and growth performance of transplanted Aus. (T. Aus) rice variety from April 2019 to July 2019 and observed that the age of seedlings had significantly affected total tillers $hill^{-1}$, effective tillers $hill^{-1}$, panicle length in T. *Aus* rice variety. The highest harvest index (33.88%) was obtained from 22 days old seedlings. The lowest harvest index (30.467%) was obtained from 30 days old seedlings.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at Sher-e-Bangla Agricultural University, Dhaka to investigate the improvement of Transplanted seedling numbers per hill on *Boro* seedling characters by using chitosan raw material powder and their yield performance at different seedling Number per hill. 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 soil research field, Dhaka
AEZ	AEZ-28, Modhupur Tract
General Soil Type	Shallow Red Brown Terrace Soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

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

Physical characteristics	
Constituents	Percent (%)
Sand	26
Silt	45
Clay	29
Textural class	Silty clay
Chemical characteristics	Value
pH	5.8
Organic carbon (%)	0.5

Organic matter (%)	0.87
Total nitrogen (%)	0.04
Available P (ppm)	20.54
Exchangeable K (meq/100 g soil)	0.10

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- II.

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 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 from 15th Dec-30th December. This variety attains a height of 100 cm. The life cycle of this variety is 140-143 days. Grain yield is around 7 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.

3.4 Chitosan raw materials

The composition of chitosan raw materials is given in the table 3

Table 3. Composition of chitosan raw materials which was used in research work.

Name of the nutrients	Nutrient content
Nitrogen (N)	7.03%
Phosphorus (P)	0.643%
Potassium (K)	0.28%
Sulphur (S)	0.092%
Calcium (Ca)	2.43%
Magnesium (Mg)	0.36%
Zinc (Zn)	92.03 ppm
Boron(B)	152 ppm
Organic Carbon (OC)	7.52%
Organic Matter (OM)	12.96%

3.5 Seed collection and sprouting

BRRI dhan88 was collected from BRRI (Bangladesh Rice Research Institute), Joydebpur, Gazipur. Healthy and disease frees 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.

3.6 Experimental treatment

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

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

T_1= 0%

T_2= 0.1%

T_3= 0.2%

T_4= 0.3%

T_5= 0.4%

T_6= 0.5%

Factor B: Seedling number per hill (3) *viz;*

S_1= single seedling hill^{-1},

S_2= Double seedling hill^{-1} and

S_3= Three seedling hill^{-1}.

3.7 Sowing and transplanting time

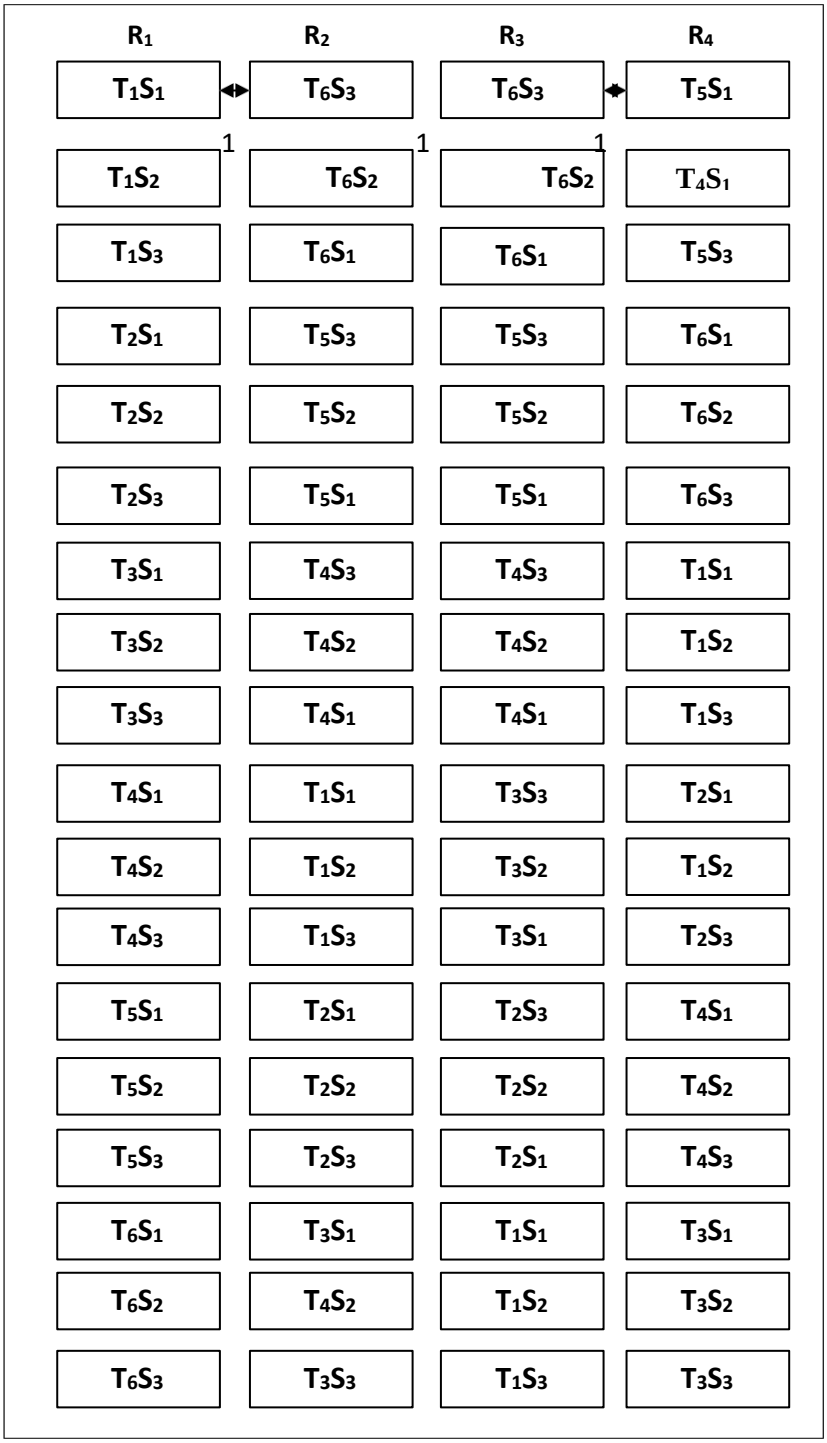
In this experiment prepared seedbed and sown seed in the seedbed last week of November and transplant seedling in the main field 5th January.

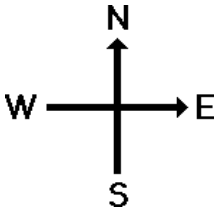
3.8 Seed pot preparation and application of chitosan raw material powder

2-inch plastic pots were used for raising seedling. Field moist soil was collected from Sher-e-Bangla Agricultural University farm then mixed with different level of Chitosan raw material powder according with par treatment requirement. Then the pot was filled with 1 kg chitosan raw material treated soil. After that 100 seeds were sown in the pot for raising seedlings.

3.9 Experimental design

The experiment was laid out in Randomized completely block design (RCBD) with 2 factor and four replications. Total 72 units pots will be made for the experiment with 6 treatments. Required pot size were used. The layout of the experiment is given below





LEGEND

Chitosan level viz;

T_1= 0% Chitosan,

T_2= 0.1% Chitosan,

T_3= 0.2% Chitosan,

T_4= 0.3%Chitosan,

T_5= 0.4% Chitosan and

T_6= 0.5% Chitosan

Different number of seedling hill^{-1}

S_1= Single seedling hill^{-1}

S_2= Double seedling hill $^{-1}$and S_3=Three seedling.hill^{-1}

Figure 1: Layout of the Experiment

3.10 Detail of experimental Site-

3.10.1 Selection and preparation of the pot

Earthen pots of having 12 inches' diameter, 12 inches' height with a hole at the center of the bottom were used. Silty clay 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 cm 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 30 cm and the area of the upper soil surface was (πr^2 = 3.14x 0.015x 0.015=0.07 m2). The preparation of the pot was done in 16 January 2020.

3.10.2 Fertilizer management

The following doses of fertilizer were applied for cultivation of T. *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 of the fertilizers except urea were applied as basal dose at the time of filling pot with soil. Urea (300 kg ha^{-1}) was applied in equal three splits. The first dose of urea was applied at 12 days after transplanting (DAT). The second dose of urea was added as top dressing at 27 days after transplanting and third dose was applied at 42 days after transplanting recommended by BRRI.

3.10.3 Seedling transplanting in the pot

The seedling of rice was transplanted to the pot according to treatment requirement. Seedling transplanting was done at 18 January, 2020.

3.11 Intercultural operations

3.11.1 Application of irrigation water

Irrigation water was done to each pot according to the critical stage. It was given by using water pipe.

3.11.2 Weeding

The crop was infested with some common weeds, which were controlled by uprooting and removed them three times from the pot during the period of experiment. Weeding was done After 20, 30 and 45 days after transplanting.

3.11.3 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 Lha^{-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.

3.12. General observations of the experimental field

Regular observations were made to observe the growth and visual different of the crops, due to application of different doses of chitosan materials and number of seedlings per hill. In general, the plant looked healthy with normal green plants. Incidence of stem borer, green leaf hopper, leaf roller was observed during tillering stage and there was also some rice bugs were present in the experimental pot. But no bacterial and fungal disease was not observed. Uniform flowering was observed.

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 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 were also sun dried properly. Finally grain and straw yields pot^{-1} were recorded.

3.14 Field operation

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

Table 4. List of schedules of field operations done during the course of experimentation

Operations	Working Dates
Collection of field moist soil	28th November, 2019
Different level of chitosan raw material powder was mixed with field moist soil	30th November, 2019
Filling the pot with chitosan raw material powder mixed soil	3rd December, 2019
Seed sowing	5th December, 2019
Collection and preparation of the main pot	10th January, 2020

Application of fertilizers (1/3rd Urea, TSP, MOP, Gypsum)	11th January, 2020
Transplanting of seedlings	14th January, 2020
Intercultural Operations	**Working Dates**
1st Weeding	25th January, 2020
2nd Weeding	5th February, 2020
3rd Weeding	20th February, 2020
1st split application of urea	17th January, 2020
2nd split application of urea	2nd February, 2020
3rd split application of urea	17th February, 2020
Insecticide application	3rd February, 2020
Harvesting and threshing	24th April and 27th April , 2020

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 (mgcm^{-1})

v. Number of tillers pot^{-1}

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

vii. Days to first flowering

viii. Days to 100% flowering

ix. Unfilled grain weight (g)

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

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

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

xiii. Harvest index

3.16 Procedure od data collection

i. Average seedling height (cm)

The height of 25 seedlings during transplanting were measured with a meter scale from the ground level to tip of seedlings and the mean heights were expressed in cm.

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

Fresh weight of 25 seedlings were collected during transplanting time from each treatment and then weighted by using a digital electric balance and the mean weight were expressed in gram.

iii. Oven dry weight seedling (mg)

Different treated 25 seedlings were collected from seedbed and then sun dried. The sun dried seedling again dried in oven and weighted by using a digital electric balance & their mean was expressed in mg.

iv. Seedling Strength ($mgcm^{-1}$)

$$\text{Seedling strength } (mgcm^{-1}) = \frac{Oven\ dry\ weight\ per\ seedling}{average\ seedling\ \ height} \quad (mgcm^{-1})$$

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.

vii. Days to first flowering

The date of flower blooming was recorded from the number of days of 1st the date of flower blooming after transplanting.

viii. Days to 100% flowering

After completion of 100% flowering data was recorded from the number of days of 100% flowering after transplanting.

ix. Unfilled grain weight (g)

Unfilled grain weight was measuring by using a digital electric balance and the mean weight were expressed in gram.

x. 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.

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

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

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

The summation of grain yield and above ground straw yield was the biological yield. Biological yield pot^{-1} (g) = (Grain yield pot^{-1}+ straw yield pot^{-1}) g.

xiii. Harvest index (%)

Harvest index was calculated on dry weight basis with the help of following formula.

Harvest index (%) = $\frac{Grain\ yield}{Biological\ yield} \times 100$

Biological yield = Grain yield + straw yield

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 Walkley and Black (1934) Wet Oxidation Method. 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. To obtain the organic matter content, the amount of organic carbon was multiplied by the Van Bemmelen factor, 1.73. The result was expressed as percentage.

3.17.4 Total nitrogen

Total N content of soil were determined followed by the Micro Kjeldahl method. One gram of oven dry ground soil sample was taken into micro jeldahl flask to which 1.1 gm catalyst mixture (K_2SO_4: $CuSO_4.5H_2O$: Se in the ratio of 100:10:1), and 6 ml H_2SO_4 were added. The flasks were swirled and heated 200^0C and added 3 ml H_2O_2 and then heating at 360^0C was continued until the digest was clear and colorless. After cooling, the content was taken into 100 ml volumetric flask and the volume was made up to the mark with distilled water. A reagent blank was prepared in a similar manner. These digests were used for nitrogen determination. Then 20 ml digest solution was transferred into the distillation flask, then 10 ml of H_3BO_3 indicator solution was taken into a 250 ml conical flask which is marked to indicate a volume of 50 ml and placed the flask under the condenser outlet of the distillation apparatus so that the delivery end dipped in the acid. Add sufficient amount of 10N-NaOH

solutions in the container connecting with distillation apparatus. Water runs through the condenser of distillation apparatus was checked. Operating switch of the distillation apparatus collected the distillate. The conical flask was removed by washing the delivery outlet of the distillation apparatus with distilled water. Finally, the distillates were titrated with standard 0.01 N, H_2SO_4 until the color changes from green to pink. The amount of N was calculated using the following formula:% N = (T-B) × N × 0.014 × 100/S. Where, T = Sample titration (ml) value of standard H_2SO_4, B = Blank titration (ml) value of standard H_2SO_4, N = Strength of H_2SO_4 and S = Sample weight in gram.

3.17.5 Available phosphorus

Available P was extracted from the soil with 0.5 M Na HCO_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 STAT-10. 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

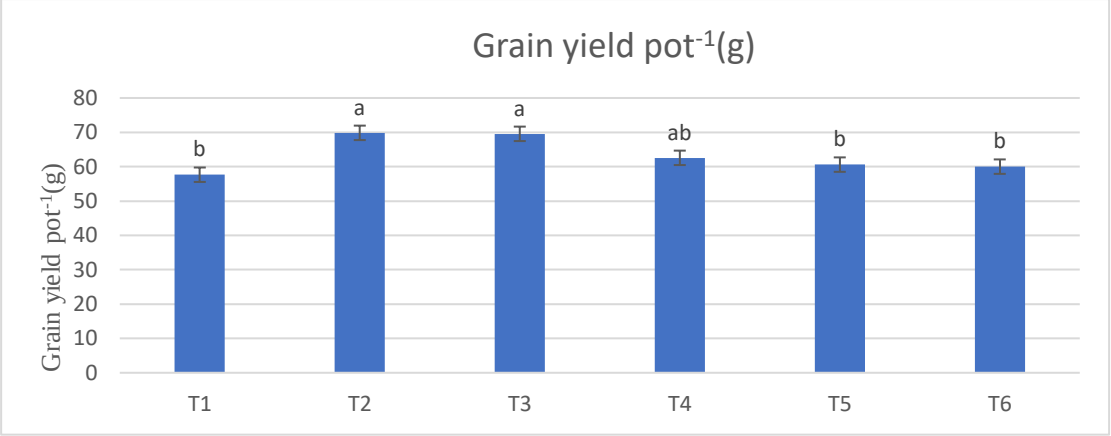
RESULT AND DISCUSSION

Results obtained from the present study have been presented and discussed in this chapter with a view to study the suitable seedling number for trans planting Boro seedling 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. Grain yield pot^{-1} (g)

Effect of chitosan raw material powder on grain yield pot^{-1} (g) of BRRI dhan88

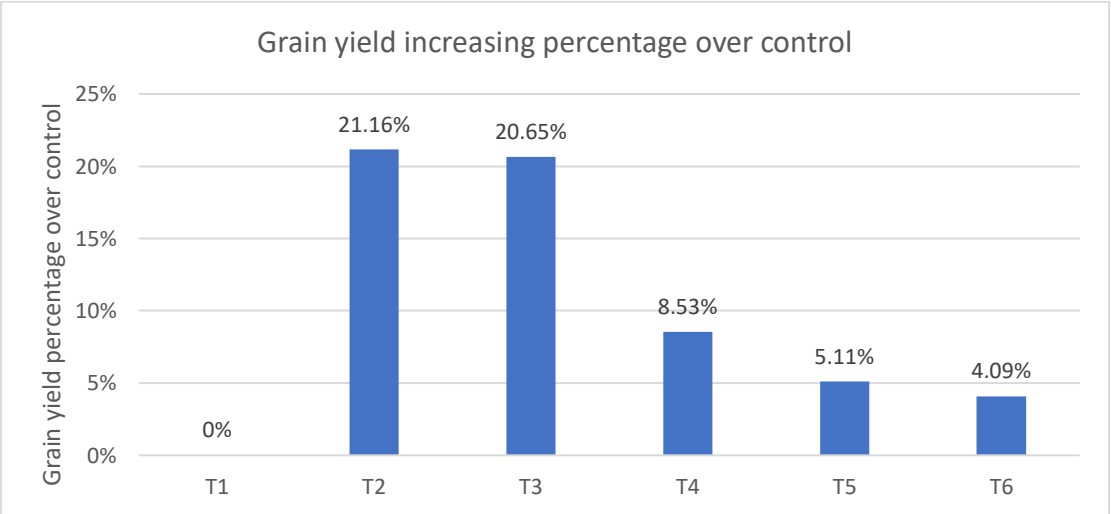
Seedlings treated with different level of chitosan raw material powder significantly effect on grain yield pot^{-1} (g) of BRRI dhan88 (Fig. 26). Experimental result showed that, maximum grain yield pot^{-1} (69.85g) was obtained in T_2 (0.1% chitosan raw material powder) treatment, whereas the minimum grain yield pot^{-1} (57.65g) was obtained in T_1(0% chitosan raw material powder) treatment. It was observed from the experimental result that, chitosan raw material powder treated seedling in the seedbed influenced grain yield of BRRI dhan88 of this sequence (T_2>T_3>T_4>T_5>T_6>T_1). The increase in grain yield pot^{-1} might be due to the effect of chitosan raw materials in order of (T_2>T_3>T_4>T_5>T_6>T_1). Raw material powder application enhancing tillering number and effective tillers pot^{-1} which influence the grain yield of rice. The result obtained from the present study was similar with the findings of Behboudi *et al.,* (2018) and they reported that chitosan uses significantly improved the number of grains per spike and grain yield as compared to that with control. Ahmed *et al,*. (2013) reported that 50 mg L^{-1} of Chitosan treated plants produced the highest grain yield (7.05 t ha^{-1}) followed by 75 mgL^{-1} (6.77 t ha^{-1}) and 100 mgL^{-1} (6.14 t ha^{-1}) of Chitosan where 75 and 100 mg L^{-1} Chitosan were statistically same. On the other hand, the lowest grain yield (5.83 t ha^{-1}) was observed control treatment.



Here level of chitosan raw materials powder, T_1= 0%, T_2= 0.1%, T_3= 0.2%, T_4= 0.3%, T_5= 0.4%, T_6= 0.5%

Fig 2. Effect of chitosan raw material powder on grain yield pot^{-1} (g) of BRRI dhan88. Bars with different letters are significantly different at p ≤ 0.05 applying DMRT.

From the figure 1 it was noticed that due to chitosan raw material powder application grain yield increased over control treatment. The maximum grain yield increased over control treatment (21.16%) was obtained in T_2 (0.1% chitosan raw material powder) treatment, whereas minimum grain yield increased over control treatment (4.09%) was obtained in T_6 (0.5% chitosan raw material powder). The result obtained from the present study was similar with the findings of Nguyen and Tran (2013) and 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 significant

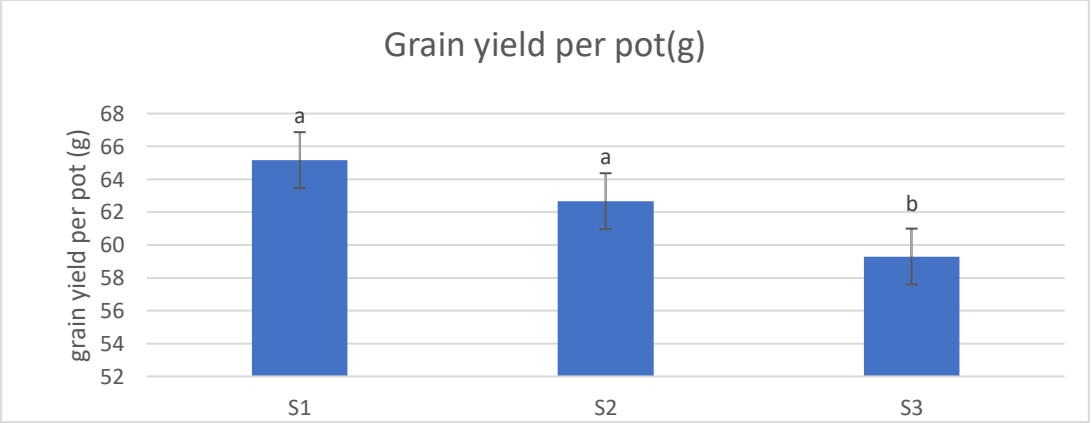


Here level of chitosan raw materials powder, T_1= 0%, T_2= 0.1%, T_3= 0.2%, T_4= 0.3%, T_5= 0.4%, T_6= 0.5%

Fig 3. Effect of chitosan raw material powder on grain yield pot^{-1} (g) of BRRI dhan88. Bars with different letters are significantly different at p ≤ 0.05 applying DMRT.

Effect of seedling number on grain yield pot^{-1} (g) of BRRI dhan88

Seedling number significantly effects on grain yield pot^{-1} (g) of BRRI dhan88 (Fig. 2). Experimental result revealed that, the maximum grain yield pot^{-1} (65.168 g) was obtained in S_1 (Single seedling) treatment. Whereas the minimum grain yield pot^{-1} (59.298 g) was obtained in S_3 (Three seedling) treatment. Seedling number per hill can cause competition between the plants is high in which sometimes results in gradual shading and lodging and thus increase production of straw instead of grain. It is, therefore, necessary to determine the optimum seedling number per hill for high yield (Hossain *et al.*, 2003).



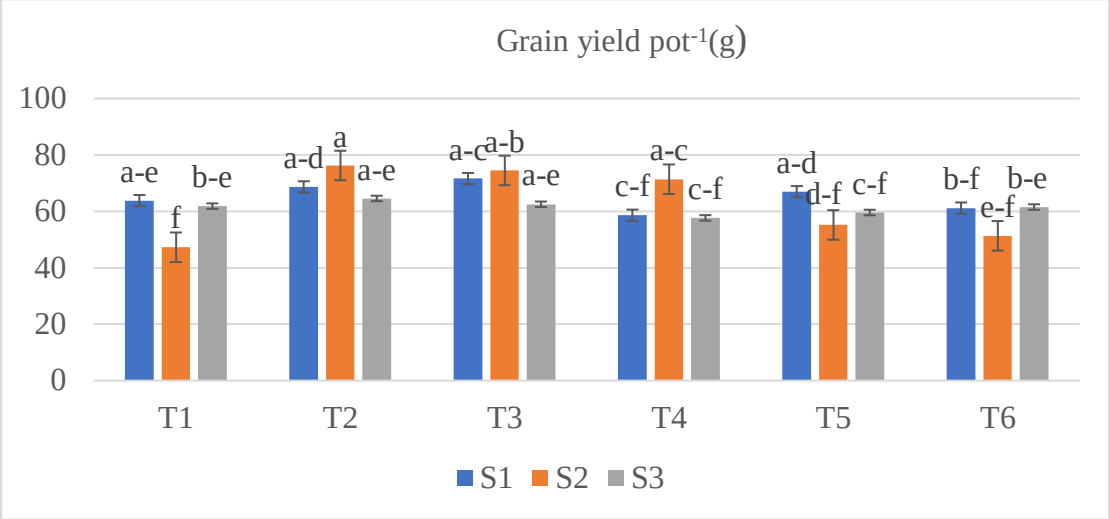
S_1= Single seedling hill $^{-1}$, S_2= Two seedling hill^{-1}, S_3= Three seedling hill^{-1}

Fig 4. Effect of different seedling number per hill on grain yield per pot (g) BRRI dhan88. Bars with different letters are significantly different at p ≤ 0.05 applying DMRT

Combined effect of chitosan raw material powder and number of seedling hill^{-1} on grain yield pot^{-1} (g) of BRRI dhan88.

Seedling treated with different level of chitosan raw material powder along with number of seedling hill^{-1} significantly effect on grain yield pot^{-1}(g) of BRRI

dhan88.Experimental result revealed that, the maximum grain yield pot^{-1} (76.27g) was obtained in T_3S_1 treatment combination. Whereas the minimum grain yield hill^{-1} (47.283 g) was obtained in T_2S_2 treatment combination**.**



Here level of chitosan raw materials powder, T_1= 0%, T_2= 0.1%, T_3= 0.2%, T_4= 0.3%, T_5= 0.4%, T_6= 0.5%

S_1= Single seedling hill $^{-1}$, S_2= Two seedling hill^{-1}, S_3= Three seedling hill^{-1}

Fig 5 Effect of chitosan raw material powder and effect of number of seedling hill^{-1} on grain yield pot^{-1} (g) BRRI dhan88. Bars with different letters are significantly different at p ≤ 0.05 applying DMRT.

4.2 Tiller Number pot^{-1}

Effect of chitosan raw material powder on tiller number pot^{-1} of BRRI dhan88

Different levels of chitosan raw material powder significantly effect on tiller number pot^{-1}at different days after transplanting of BRRI dhan88 (Fig. 6). Experimental result showed that, the maximum tiller number pot^{-1} (6.83, 14.5, 32.5 and 40) at 30, 40, 50 and 60 DAT were obtained in T_3 (0.2% chitosan raw material powder) treatment which was statistically similar with (6.50) at T_2 treatment (0.1% chitosan raw material powder) and (6.5) T_4 treatment (0.3% chitosan raw material powder) at 30 DAT. Whereas the minimum tiller number pot^{-1} (4) at 30 DAT was obtained in T_1 (0% chitosan raw material powder) treatment. At 40 DAT the minimum tiller number pot^{-1} (7.92) was obtained in T_1 (0% chitosan raw material powder) treatment. At 50 and 60 DAT the minimum tiller number pot^{-1} (22.67 and 30.5) was obtained in T_1(0% chitosan raw

material powder) treatment. The result obtained from the present study was similar with the findings of Ahmed *et al.*, (2013) and they reported that Chitosan treated plants produced the higher number of tillers compare to control.

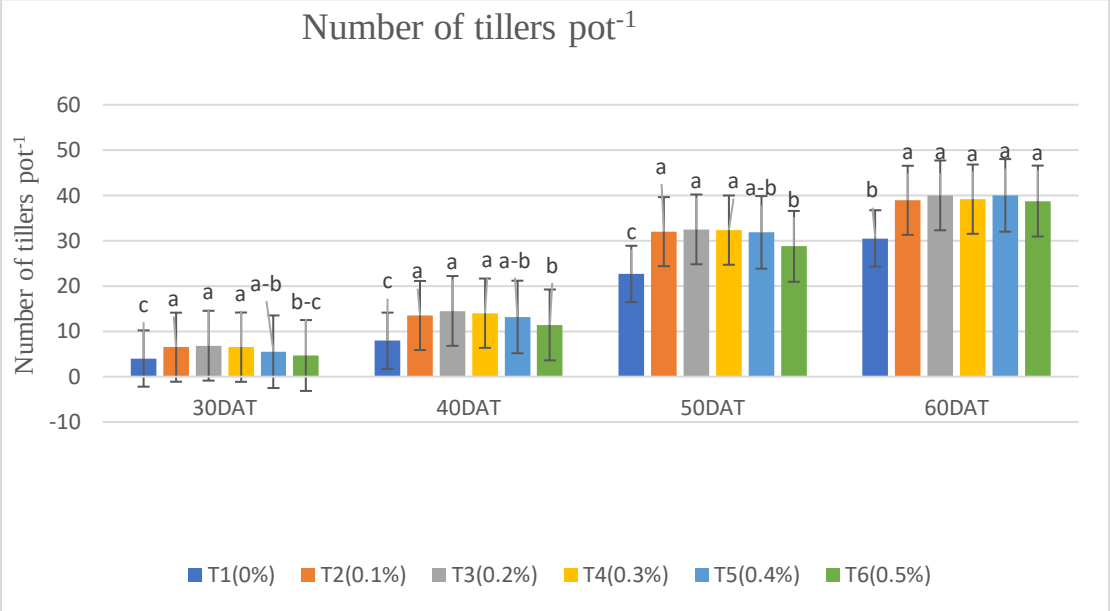


Fig 6. Effect of chitosan raw material powder on tiller number pot^{-1} of BRRI dhan88. Bars with different letters are significantly different at p ≤ 0.05 applying DMRT.

Effect of chitosan raw material powder on tillering patterns of BRRI dhan88 at different DAT

From the Fig.7 it was observed that, application of different level of chitosan raw material powder influenced tillering patterns of BRRI dhan88. Application of chitosan raw material powder reducing the day requirement for maximum tillering occurrence comparatively to control treatment. In this experiment, result showed that application of different level of chitosan raw material powder influence maximum tillers occurrence and it was maximum at 40-50 DAT, whereas in control treatment it was 50-60 DAT. Chitosan enhances the ability of plants to uptake its required nutrients. It increases the ability of plants to accelerate its growth and germination, improve the quality of yield contributing characters comparable to control treatment.

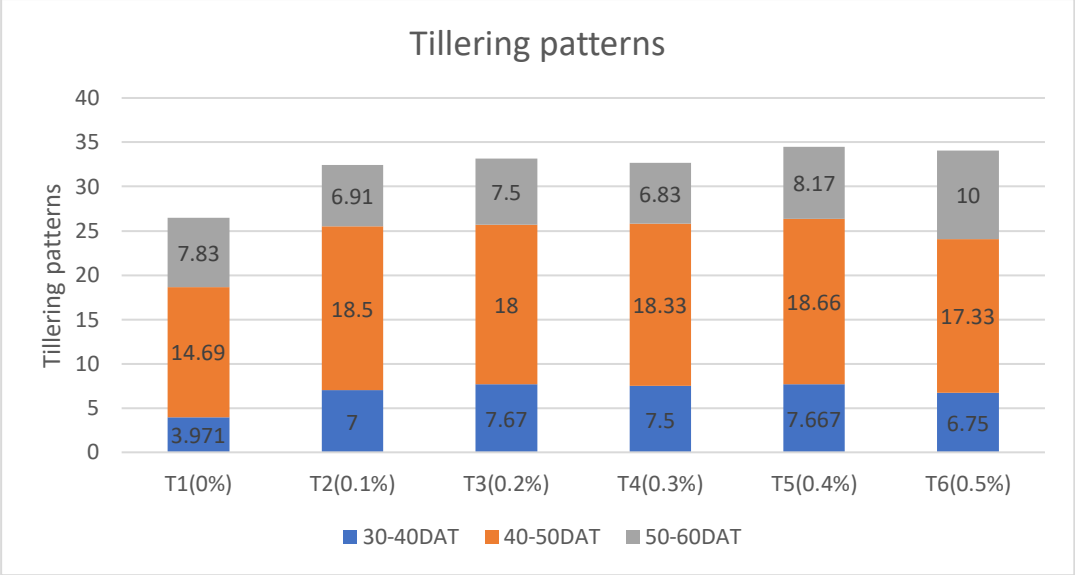
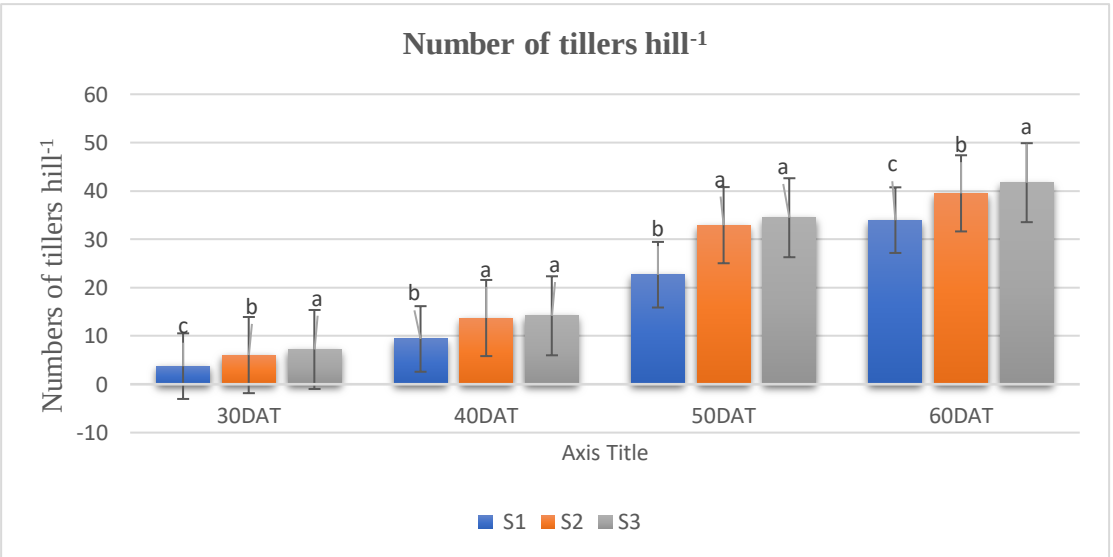


Fig 7. Effect of chitosan raw material powder on tillering patterns pot^{-1} of BRRI dhan88. Bars with different letters are significantly different at $p \leq 0.05$ applying DMRT.

Effect of seedling number hill^{-1} on tillers pot^{-1} of BRRI dhan88 at different DAT

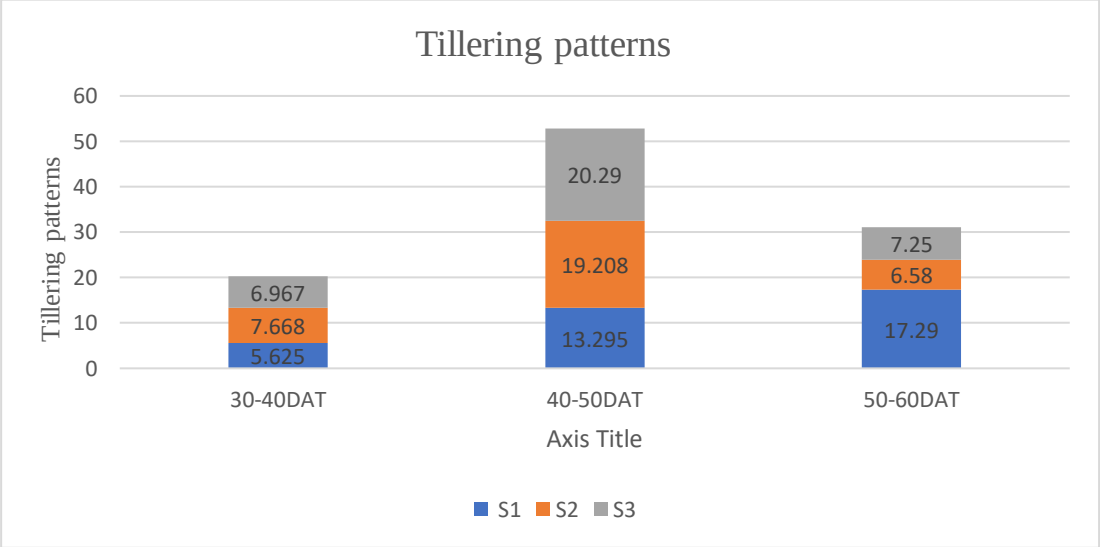
Seedling number significantly effects on tiller number hill^{-1} at different days after transplanting of BRRI dhan88 (Fig. 8). Experimental result showed that, the maximum number of tillers pot^{1} (7.2 ,14.17, 34.46 and 41.71) at 30, 40, 50 and 60 DAT was obtained in S_3 (Three seedling) treatment whereas the minimum number of tillers hill^{-1} (3.75, 9.375, 22.67 and 33.96) at 30, 40, 50 and 60 DAT was obtained in S_1 (Single seedling) treatment.



S_1= Single seedling hill $^{-1}$, S_2= Two seedling hill^{-1}, S_3= Three seedling hill^{-1}

Fig 8. Effect of seedling number hill^{-1} on tiller number pot^{-1} of BRRI dhan88. Bars with different letters are significantly different at p ≤ 0.05 applying DMRT

From the Fig. 9. it was observed that, different Number of seedling influenced tillering patterns of BRRI dhan88. In this experiment, result showed that (S_1) single seedling number hill^{-1} for maximum tillers occurrence comparable to others different seedling number hill^{-1} and it was maximum at 40-50 DAT, whereas increasing transplanting days may be decreasing tillering patterns and its was minimum in Two seedling number hill^{-1} (S_2) needed more time for maximum tillering occurrence and its was at 50-60 DAT.



S_1= Single seedling per hill, S_2= Two seedling per hill, S_3 = Three seedling per hill

Fig 9. Effect of seedling number hill^{-1} on tillering patterns of BRRI dhan88 Bars with different letters are significantly different at p ≤ 0.05 applying DMRT

Combined effect of chitosan raw material powder and different seedling number hill^{-1} on tiller number pot^{-1} of BRRI dhan88

Combined effect of chitosan and seedling age significantly effect on number of tillers hill^{-1} of BRRI dhan88 at different days after transplanting (Table 5). Experiment result revealed that, the maximum tiller number hill^{-1} (5, 15.75, 36.50 and 44.25) at 30, 40, 50 and 60 DAT was obtained in T_5S_3 treatment combination. Whereas the minimum tiller number hill^{-1} (2.50, 5.25, 16.5 and 28) at 30, 40, 50 and 60 DAT was obtained in T_1S_1 treatment combination.

4.3 Number of effective tillers pot^{-1}

Effect of chitosan raw material powder on number of effective tillers pot^{-1} of BRRI dhan88

Seedling treated with different level of chitosan raw material powder significantly effect on effective tillers pot^{-1} of BRRI dhan88 (Fig. 10). Experimental result showed that, maximum effective tillers hill^{-1} (28.25) was obtained in T_4 (0.3 % chitosan raw material powder) treatment, whereas the minimum effective tillers hill^{-1} (20.25) was obtained in T_1 (0% chitosan raw material powder) treatment. Ahmed *et al.*, (2020) reported that different level of chitosan significantly effects on effective tillers hill^{-1} and the highest number of effective tillers hill^{-1} (14) was obtained in the T_3 (Seedbed applied @ 250 g/m^2 + Main field applied @ 0 t/ha) treatment whereas the lowest number of effective tillershill^{-1} (11.67) was obtained in the T_1 control treatment. It was observed that the application of chitosan raw-material powder in soil increased the effective tillers hill^{-1}. Boonlertnirun *et al.*, (2012) also showed that application methods of chitosan significantly affected tiller number per plant.

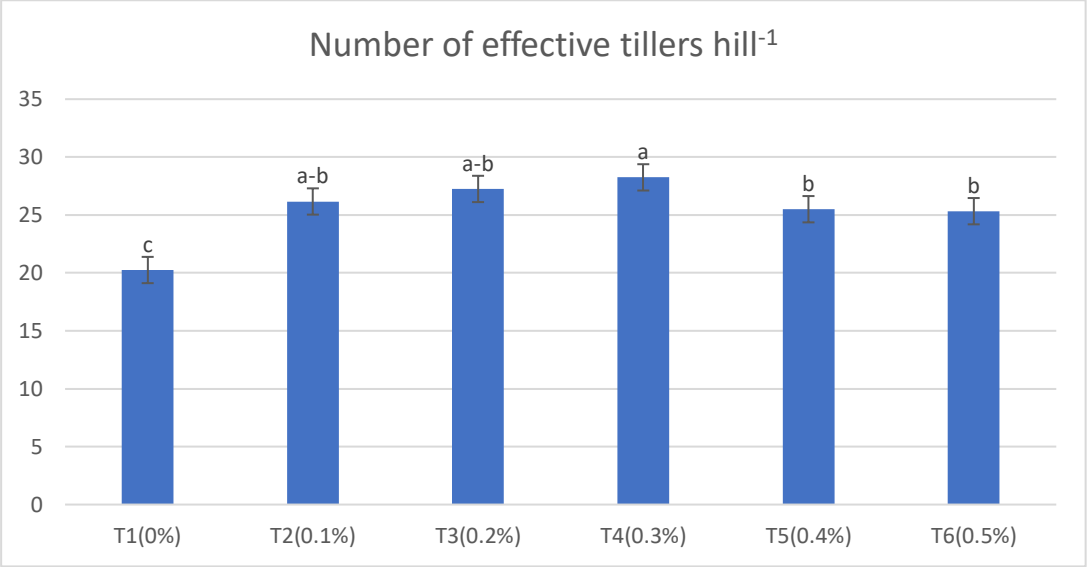


Fig 10. Effect of chitosan raw material powder on effective tiller number pot^{-1} of BRRI dhan88. Bars with different letters are significantly different at $p \leq 0.05$ applying DMRT

From the Fig.11 it was noticed that, application of chitosan raw material powder increased the effective tiller number percentage over control treatment. Chitosan

application in the seedbed influenced the seedling growth which ultimately helped proper root and shoot development of the seedlings as it consumed more nutrients. As a result, effective tiller number increased comparable to control treatment. Maximum effective tiller number percentage (39.45%) was found in T_4 (0.3% chitosan raw material powder) treatment.

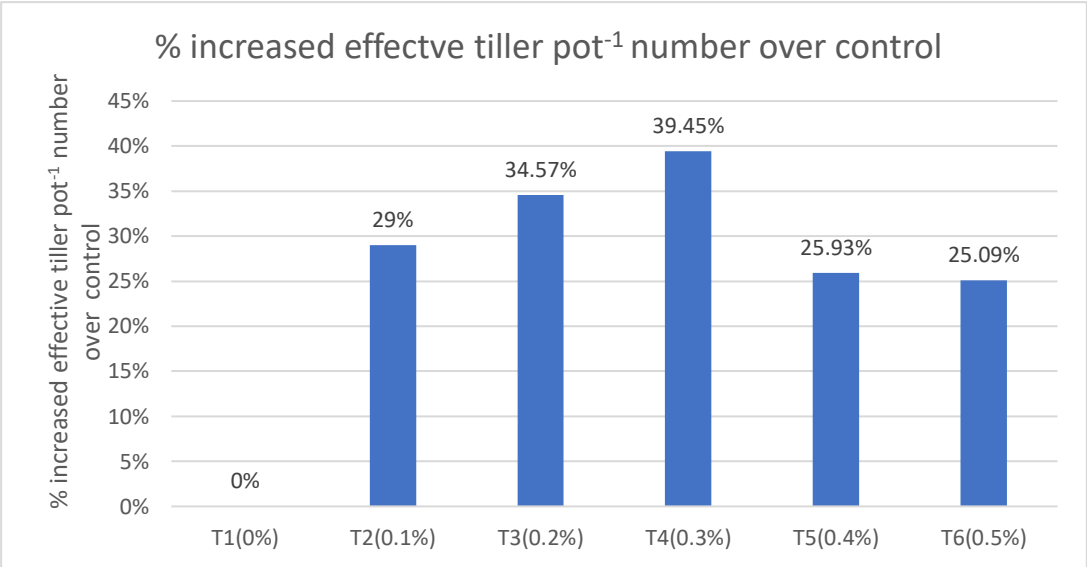
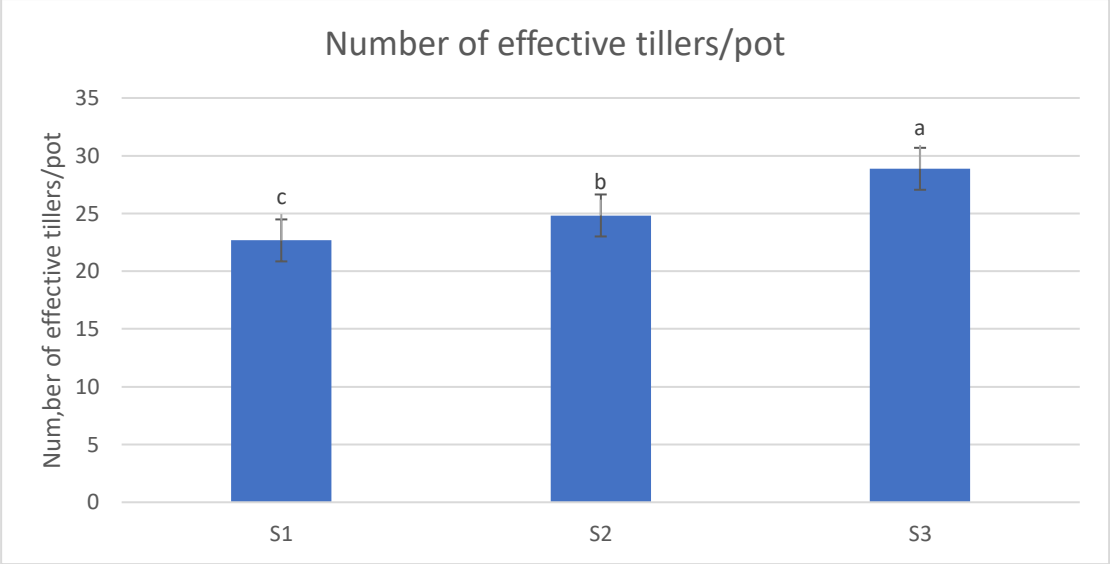


Fig 11. Effect of chitosan raw material powder % increased effective tiller pot^{-1} number over control BRRI dhan88. Bars with different letters are significantly different at $p \leq 0.05$ applying DMRT

Effect of number of seedlings hill^{-1} on number of effective tillers pot^{-1} of BRRI dhan88

Seedling age significantly effect on effective tillers pot^{-1} of BRRI dhan88 (Fig. 12). Experimental result showed that, the maximum effective tillers pot^{-1} (28.87) was obtained in S_3 (Three seedling pot^{-1}) treatment whereas the minimum effective tillers pot^{-1} (22.67) was obtained in S_1 (Single seedling pot^{-1}) treatment.



S_1= Single seedling hill $^{-1}$, S_2= Two seedling hill^{-1}, S_3= Three seedling hill^{-1}

Fig. 12. Effect of different seedling number hill^{-1}of effective tillers pot^{-1} BRRI dhan88. Bars with different letters are significantly different at p ≤ 0.05 applying DMRT.

Combined effect of chitosan raw material powder and seedling age on number of effective tillers pot^{-1} of BRRI dhan88.

Combined effect of chitosan raw material powder and seedling number pot $^{-1}$ significantly effect on effective tillers pot^{1} of BRRI dhan88 (Table 5). Experimental result revealed that, the maximum effective tillers pot^{-1} (32 a) was obtained in T_4S_3 treatment combination. Whereas the minimum tiller number pot^{-1} (16.5i) was obtained in T_1S_1 treatment combination

Table -5 Combined effect of chitosan raw material and of tillers pot^{-1} at different DAT and number of effective tillers pot^{-1} of BRRI dhan88

Treatment combinations	Number of tillers pot^{-1}				Effective tillers pot^{-1}
	30 DAT	40 DAT	50 DAT	60 DAT	
T_1S_1	2.5g	5.25h	16.5g	28h	16.5i

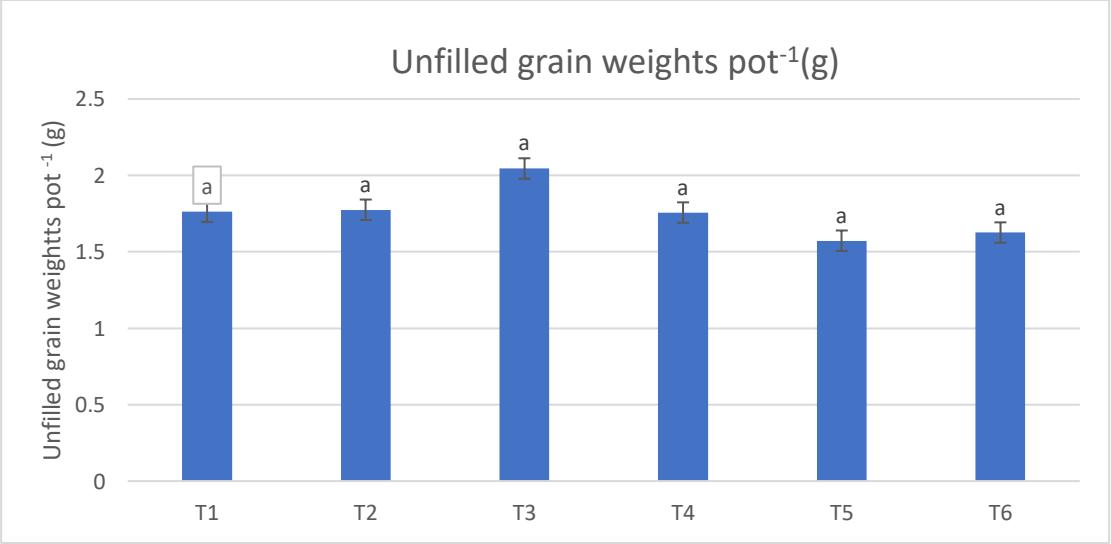
T_1S_2	4,25ef	7.750gh	23.5ef	35fg	19.75hi
T_1S_3	5.25de	10.750efg	28.00cde	37.250defg	24.5defg
T_2S_1	4.25ef	9.50fg	22.50ef	35.75fg	22.5fgh
T_2S_2	6.50bcd	15.50ab	34.50ab	39.50bcdef	24.75defg
T_2S_3	8.75a	15.50ab	39.00a	41.50abcd	31.25ab
T_3S_1	4.50ef	11.50def	26.750def	35.750fg	26.75cde
T_3S_2	7.75ab	17.00a	37.25a	42.75abc	26cdef
T_3S_3	8.25a	15abc	33.50abc	41.50abcd	29abc
T_4S_1	4.50ef	11efg	24.75ef	32.75gh	24.75defg
T_4S_2	7.50ab	16.50ab	36ab	41abcde	28bcd
T_4S_3	7.50ab	14.50abcd	36.25ab	43.75ab	32a
T_5S_1	3.50fg	10fg	24.25ef	35.25fg	24.25defg
T_5S_2	5.75cde	13.75abcde	34.75ab	40.50abcde	23.5efg
T_5S_3	5abc	15.75ab	36.50ab	44.25a	28.75abc
T_6S_1	3.25fg	13.50bcde	33.500abc	42abc	21.26gh
T_6S_2	4.50ef	11.75cdef	31.50bcd	38.25cdef	27cde
T_6S_3	6.25bcd	13.50bcde	33.500abc	42abc	27.5bcd
LSD (0.05)	1.6479	3.376	5.5480	4.7061	3.9325
CV(%)	20.48	19.16	13.2	8.64	10.88

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= Single seedling per pot, S_2= Two seedling per pot, S_3=Three seedling per pot , T_1= 0% Chitosan, T_2= 0.1% Chitosan, T_3= 0.2% Chitosan, T_4= 0.3% Chitosan, T_5= 0.4% Chitosan and T_6= 0.5% Chitosan

4.4 Unfilled grains weight pot^{-1} (g)

Effect of chitosan raw material powder on unfilled grains weight pot^{-1} (g)

Different level of chitosan raw material powder treated seedlings significantly effect on unfilled grains weight pot^{-1} (g) of BRRI dhan88 (Fig.13). Experimental result showed that, the maximum unfilled grains weight pot^{-1} (2.045g) was obtained in T_3 (0.2%) chitosan raw material powder) treatment, whereas the minimum unfilled grains weight pot^{-1} (1.5725 g) was obtained in T_5 (0.4 % chitosan raw material powder) treatment. Optimum application of chitosan influence fresh weight, oven dry weight of the seedling, increasing seedling strength and influence root development in early seedbed stage which ultimately impact on proper nutrient uptake, result in vigor growth, development and lower unfilled grains weight pot^{-1} comparable to higher level of chitosan application or control treatment.



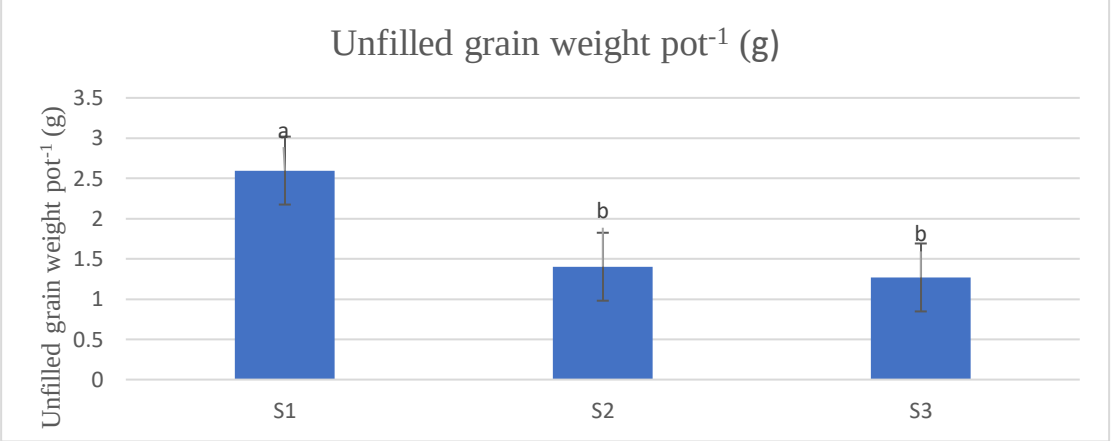
Here level of chitosan raw materials powder, T_1= 0%, T_2= 0.1%, T_3= 0.2%, T_4= 0.3%, T_5= 0.4%, T_6= 0.5%.

Fig 13. Effect of chitosan raw material powder on unfilled grains weight pot^{-1} (g) of BRRI dhan88. Bars with different letters are significantly different at p ≤ 0.05

applying DMRT.

Effect of seedling number hill^{-1} on unfilled grains weight pot^{-1} (g) of BRRI dhan88

Unfilled grains weight pot^{-1} (g) of BRRI dhan88 was significantly differ due to different age of seedling (Fig.14). Experimental result revealed that the maximum unfilled grains weight pot^{-1} (2.5967 g) was obtained in S_1 (Single seedling) treatment, whereas the minimum unfilled grains weight pot^{-1} (1.2692 g) was obtained in S_3 (Three seedling) treatment. The variation of unfilled grains weight pot^{-1} (g) at different seedling number might be due to the reason that, transplanting seedling at early age into the field easily handle the transplanting shock and comparative little or no root damage was occurred during this time, whereas late transplanting result in poor growth, heavy transplanting shock, root damage, less solar radiation absorption and nutrient uptake occurred which ultimately impact on growth yield and yield contributing characters of rice.



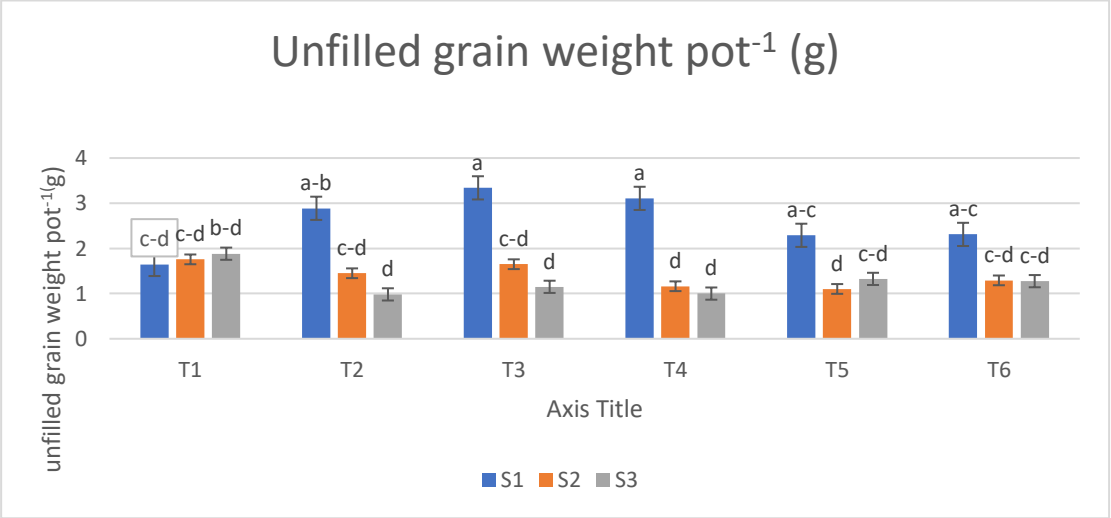
S_1= Single seedling hill $^{-1}$, S_2= Two seedling hill^{-1}, S_3= Three seedling hill^{-1}

Fig 14. Effect of seedling number on unfilled grains weight pot^{-1} (g) of BRRI dhan88. Bars with different letters are significantly different at p ≤0.05 applying DMRT.

Combined effect of chitosan raw material powder and seedling number on unfilled grains weight of BRRI dhan88

Seedling treated with different level of chitosan raw material powder along with different Number of seedlings significantly effect on unfilled grains weight pot^{-1} (g) of BRRI dhan88 (Fig 15). Experimental result revealed that, the maximum unfilled grains weight pot^{-1} (3.34 g) was obtained in T_3S_1 treatment combination. Whereas the

minimum unfilled grains weight pot^{-1} (0.9825 g) was obtained in T_2S_3 treatment combination.



Here level of chitosan raw materials powder, T_1= 0%, T_2= 0.1%, T_3= 0.2%, T_4= 0.3%, T_5= 0.4%, T_6= 0.5%. S_1= Single seedling hill $^{-1}$, S_2= Two seedling hill^{-1}, S_3 = Three seedling hill^{-1}.

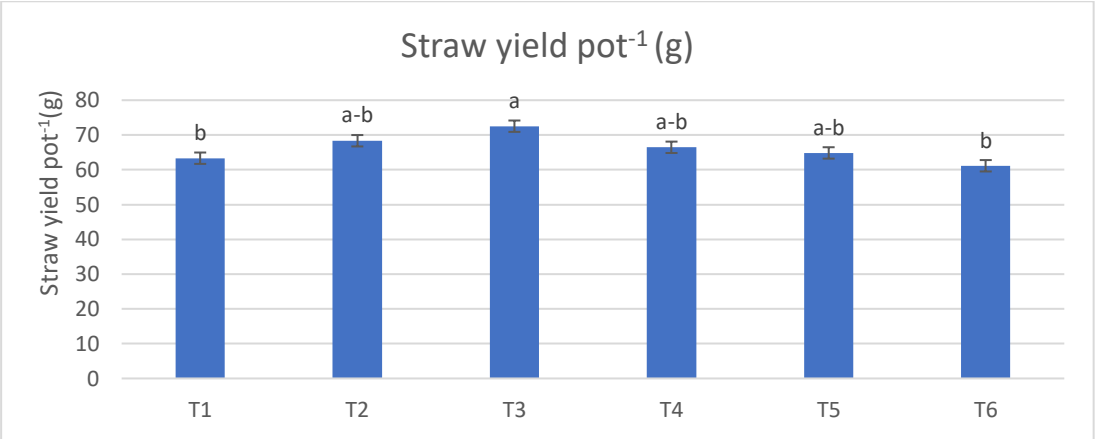
Fig 15. Effect of chitosan raw material powder and effect of number of seedling hill^{-1} on unfilled grains weight pot^{-1} (g) at BRRI dhan88. Bars with different letters are significantly different at p ≤ 0.05 applying DMRT.

4.5 Straw yield pot^{-1}(g)

Effect of chitosan raw material powder on straw yield pot^{-1} (g) of BRRI dhan88

Straw yield pot^{-1} (g) of BRRI dhan88 was significantly varied due to the effect of different level of chitosan raw material powder application (Fig. 16). Experimental result showed that the maximum straw yield pot^{-1} (72.58g) was obtained in T_3 (0.2% chitosan) treatment which was statistically similar with (68.345g) T_2(0.1% chitosan raw material powder). Whereas the minimum straw yield pot^{-1}(61.15g) was obtained in T_6 (0.5% chitosan raw material powder) treatment. Sultana *et al.*, (2015) also found similar result which supported the present finding and reported that straw yield shows significant differences between control plants and foliar sprayed chitosan plants and highest straw yield (4.38 t/ha) was recorded under 100 ppm oligomeric chitosan and lowest straw yield (3.24 t/ha) was observed under 0 ppm oligomeric chitosan. Kananont *et al.*, (2015) also reported that (Fermented chitin waste) FCW @ 1% the straw yield

different significantly from 0.5% FCW, 0.25% FCW and the rest of the treatment.

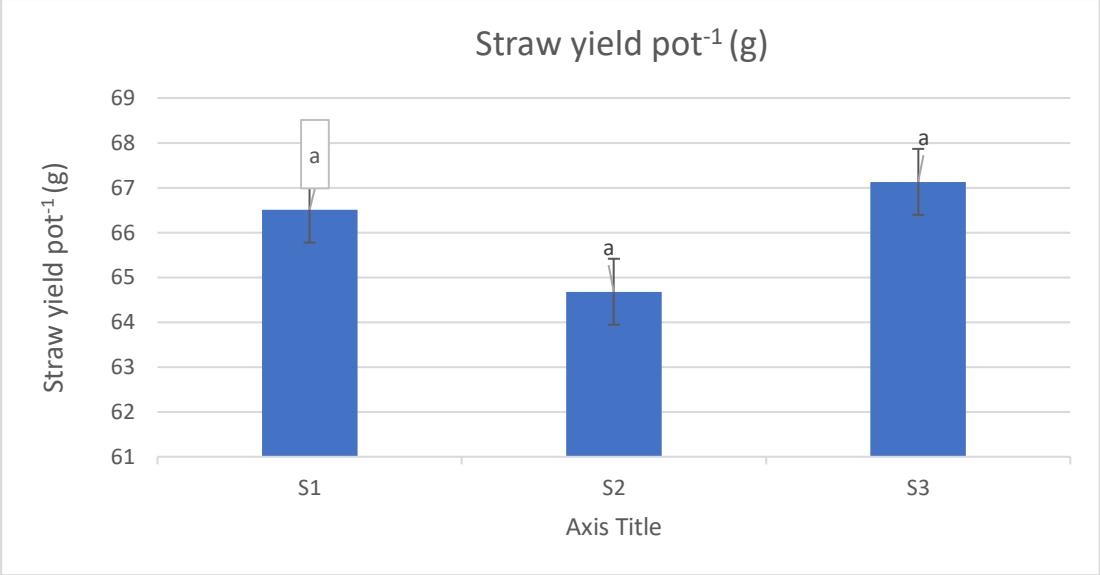


Here level of chitosan raw materials powder, T_1=0%, T_2=0.1%, T_3=0.2%, T_4=0.3%, T_5=0.4%, T_6=0.5%

Fig 16. Effect of chitosan raw material powder on straw yield pot^{-1} (g) and of BRRI dhan88. Bars with different letters are significantly different at p ≤ 0.05 applying DMRT.

Effect of number of seedling hill $^{-1}$ on straw yield (g) pot^{-1} of BRRI dhan88

Seedling age significantly effect on straw yield pot^{-1} (g) of BRRI dhan88 (Fig. 17). Experimental result revealed that the maximum straw yield pot^{-1} (67.13 g) was obtained in S_3 (Three seedling) treatment. Whereas the minimum straw yield pot^{-1} (64.68 g) was obtained in S_2 (Two S seedling) treatment. Panigrahi*et al.*, (2014) also found similar result which supported the present finding and reported that growth, yield and economics of basmati rice did not vary much between the crops planted with 10 and 15 day old seedlings. Bagheri *et al.*, (2011) noticed that the highest (635.8 gm^{-2}) straw yield was obtained from 20 days old seedlings over 30 and 40 days. Rajesh and Thanunathan (2003) reported that the seedling age had significant difference on straw yield. Planting of 40 old seedlings found to be optimum to get significantly higher (5.63 t ha^{-1}) straw yield compared to 30 (5.09 t ha^{-1}) and 50 (4.76 t ha^{-1}) days old seedlings. Sharma and Ghosh (1998) stated that younger seedlings produced significantly higher straw (7.53 t ha^{-1}) yields as compared to older seedlings from their studies on hybrids rice.

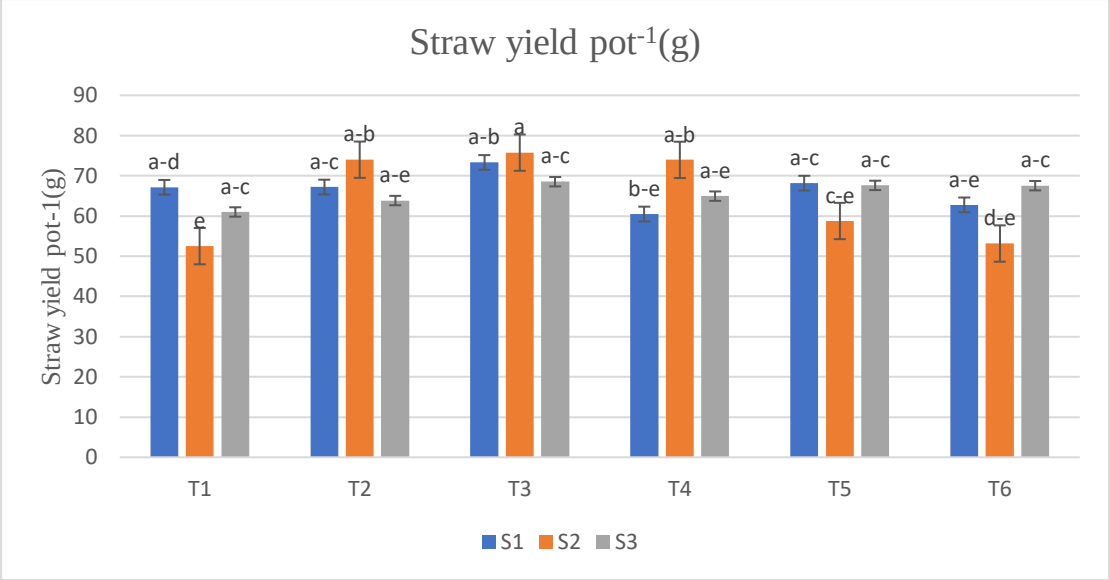


S_1= Single seedling hill $^{-1}$, S_2= Two seedling hill^{-1}, S_3= Three seedling hill^{-1}

Fig 17. Effect of number of seedlings per hill on straw yield pot^{-1} (g) at BRRI dhan88. Bars with different letters are significantly different at p ≤ 0.05 applying DMRT.

Combined effect of chitosan raw material powder and seedling age on straw yield (g) pot^{-1}

Seedling treated with different level of chitosan raw material powder along with different ages of seedling significantly effect on straw yield pot^{-1} (g) of BRRI dhan88. Experimental result revealed that, the maximum straw yield pot^{-1} (75.5 g) was obtained in T_3S_2 treatment combination which was statistically similar with T_2S_2 (74 g). Whereas the minimum straw yield pot^{-1} (52 g) was obtained in T_1S_2 treatment combination which was statistically similar with T_6S_2 (53.15 g) treatment combination.



Here level of chitosan raw materials powder, T_1= 0%, T_2= 0.1%, T_3= 0.2%, T_4= 0.3%, T_5= 0.4%, T_6= 0.5%

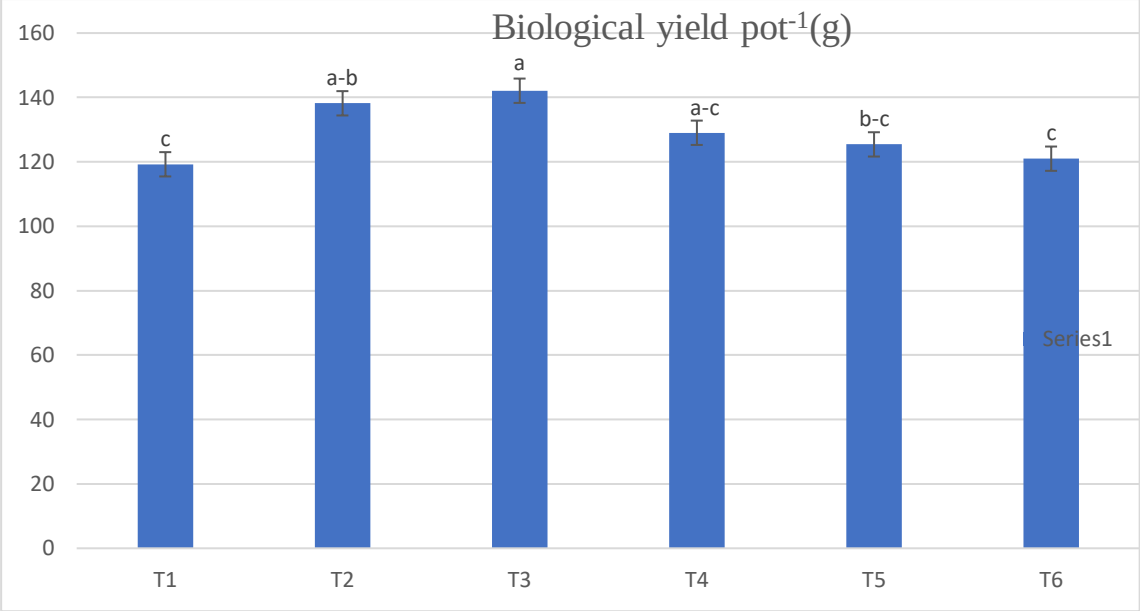
S_1= Single seedling hill^{-1}, S_2= Two seedling hill^{-1}, S_3= Three seedling hill^{-1}

Fig 18. Effect of chitosan raw material powder and effect of number of seedling hill^{-1} at Straw yield pot^{-1} (g) BRRI dhan88. Bars with different letters are significantly different at p ≤ 0.05 applying DMRT.

4.6 Biological yield pot^{-1} (g)

Effect of chitosan raw material powder on biological yield pot^{-1} (g) of BRRI dhan88

Biological yield pot^{-1} (g) of BRRI dhan88 was significantly varied due to the effect of different level of chitosan raw material powder application (Fig. 19). Experimental result showed that, the maximum biological yield pot^{-1} (142.09 g) was obtained in T_3(0.2% chitosan raw material powder) treatment. Whereas the minimum biological yield pot^{-1}(119.25 g) was obtained in T_1 (0 % chitosan raw material powder) treatment. The result obtained from the present study was similar with the findings of Ahmed (2015) who reported that chitosan application showed non-significant effect tobiological yield, but slightly influenced biological yield comparable to control treatment.

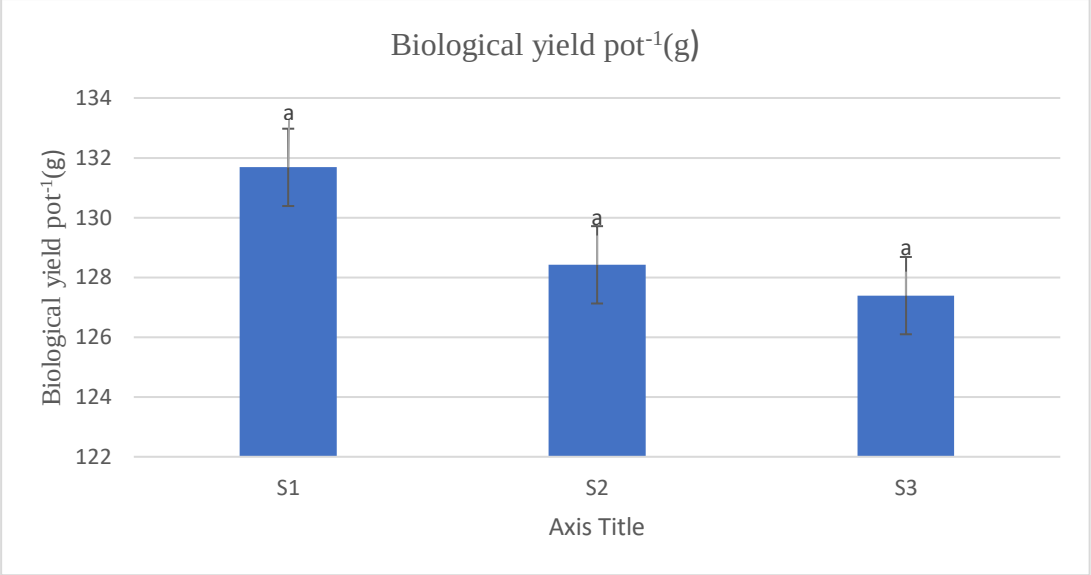


Here level of chitosan raw materials powder, T_1= 0%, T_2= 0.1%, T_3= 0.2%, T_4= 0.3%, T_5= 0.4%, T_6= 0.5%.

Fig 19. Effect of chitosan raw material powder on biological yield pot^{-1} BRRI dhan88. Bars with different letters are significantly different at p ≤ 0.05 applying DMRT.

Effect of number of seedling hill^{-1} on biological yield pot^{-1} (g) of BRRI dhan88

Seedling age significantly effect on biological yield pot^{-1} (g) of BRRI dhan88 (Fig. 20). Experimental result revealed that the maximum biological yield pot^{-1} (108.8 g) was obtained in S_2 (Two seedling hill^{-1}) treatment. Whereas the minimum biological yield pot^{-1} (106.5) was obtained in S_1 (Single seedling hill^{-1}) treatment.

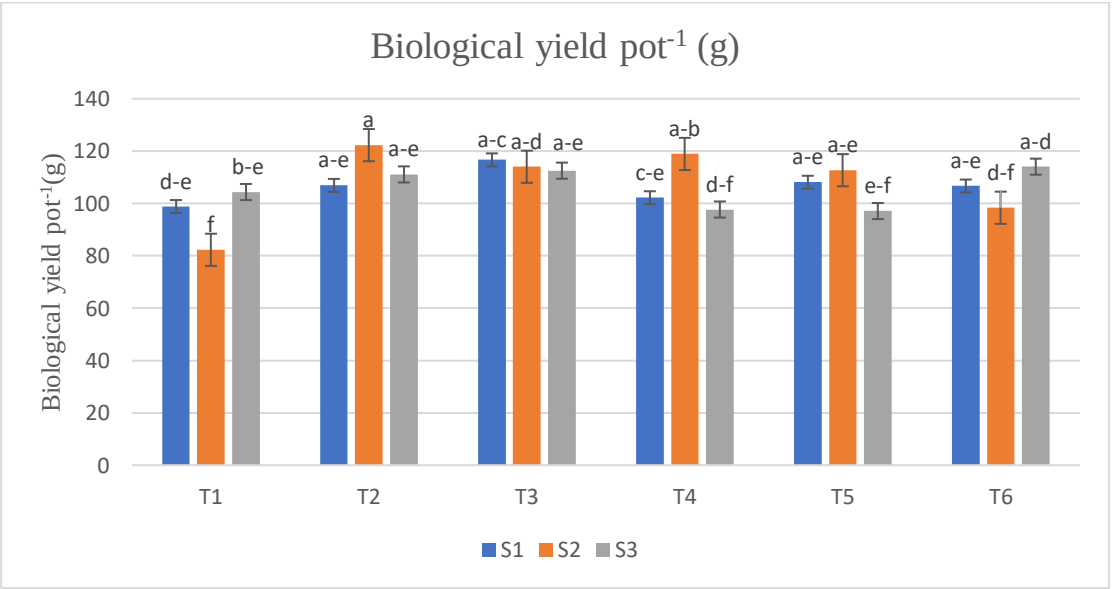


S_1= Single seedling hill^{-1}, S_2= Two seedling hill^{-1}, S_3= Three seedling hill^{-1}

Fig 20. Effect of seedling number hill $^{-1}$ on biological yield pot^{-1} BRRI dhan88. Bars with different letters are significantly different at p ≤ 0.05 applying DMRT.

Combined effect of chitosan and seedling number hill^{-1} on biological yield pot^{-1} (g) of BRRI dhan88.

Combined effect of chitosan raw material powder and seedling number hill^{-1}significantly effect on biological yield pot^{-1}(g) of BRRI dhan88 (Fig 21). Experiment result revealed that, the maximum biological yield pot^{-1} (122.27 g) was obtained in T_2S_2 treatment combination. Whereas the minimum biological yield hill^{-1}(82.28 g) was obtained in T_1S_1 treatment combination.



Here level of chitosan raw materials powder, T_1= 0%, T_2= 0.1%, T_3= 0.2%, T_4= 0.3%, T_5= 0.4%, T_6= 0.5%

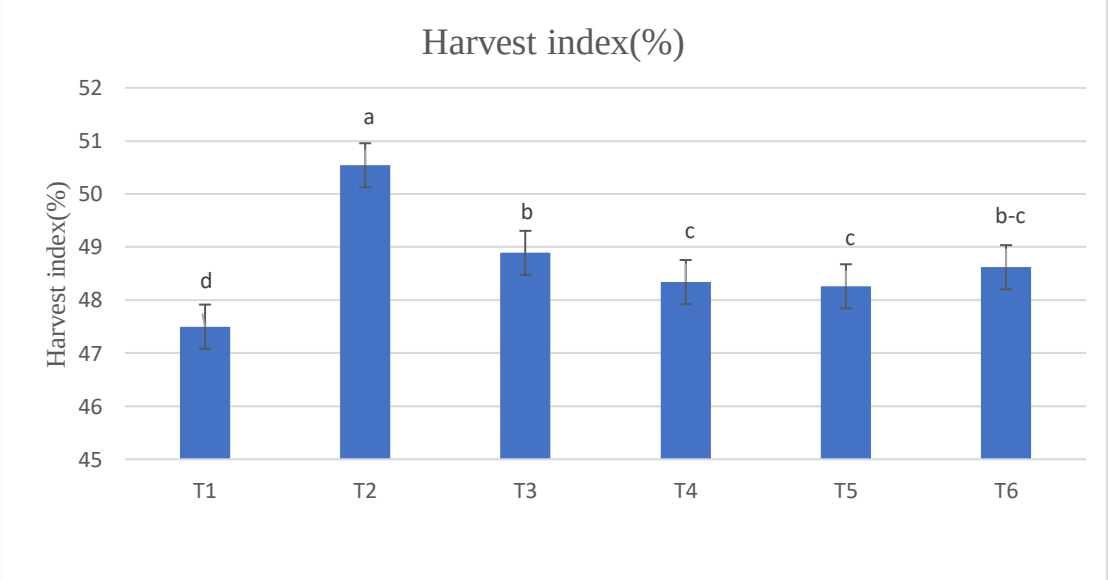
S_1= Single seedling hill^{-1}, S_2= Two seedling hill^{-1}, S_3= Three seedling hill^{-1}

Fig 21. Effect of chitosan raw material powder and effect of number of seedling hill^{-1}on Biological yield pot^{-1} (g) at BRRI dhan88. Bars with different letters are significantly different at p ≤ 0.05 applying DMRT.

4.7 Harvest index (%)

Effect of chitosan raw material powder on harvest index (%) of BRRI dhan88

Different chitosan raw material powder treated seedling significantly effect on harvest index of BRRI dhan88 (Fig. 22). Experimental result showed that, the maximum harvest index (50.54%) was obtained in T_2 (0.1% chitosan) treatment Whereas the minimum harvest index (47.5 %) was obtained in T_1 (0% raw material powder) treatment. The result obtained from the present study was similar with the findings of Chibu *et al*,. (2000) and they found that in soybean, harvest index was in chitosan application plants compare to control.

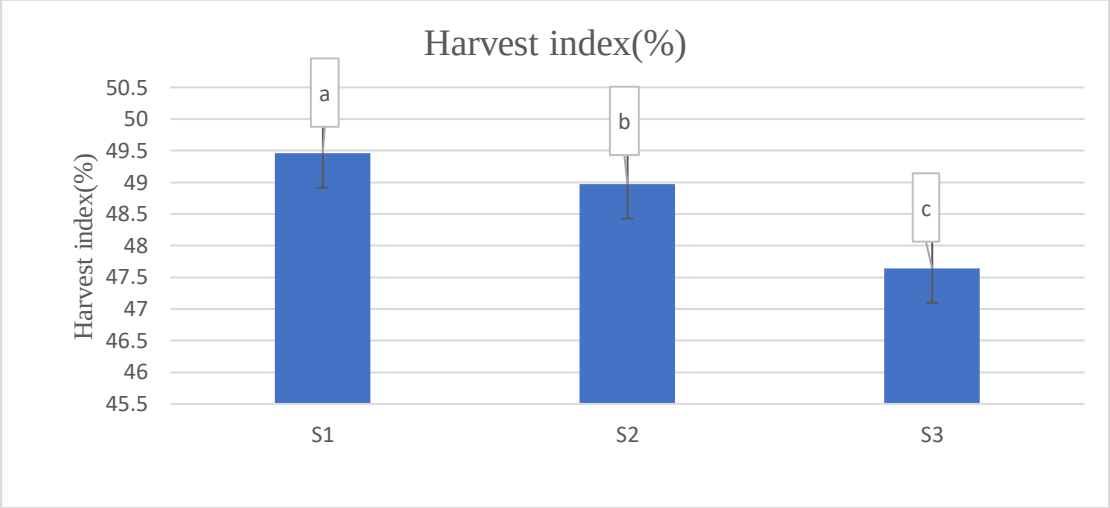


Here level of chitosan raw materials powder, T_1= 0%, T_2= 0.1%, T_3= 0.2%, T_4= 0.3%, T_5= 0.4%, T_6= 0.5%.

Fig.22.Effect of chitosan raw material powder on Harvest index (%) BRRI dhan88. Bars with different letters are significantly different at p ≤ 0.05 applying DMRT.

Effect of seedling number hill^{-1} on harvest index (%) of BRRI dhan88

Seedling number hill^{-1} showed significantly effect on harvest index of BRRI dhan88. Experiment result revealed that the maximum harvest index (49.46%) was obtained in S_1(single seedling) treatment. Whereas the minimum harvest index (47.64%) was obtained in S_3 (Three seedling) treatment

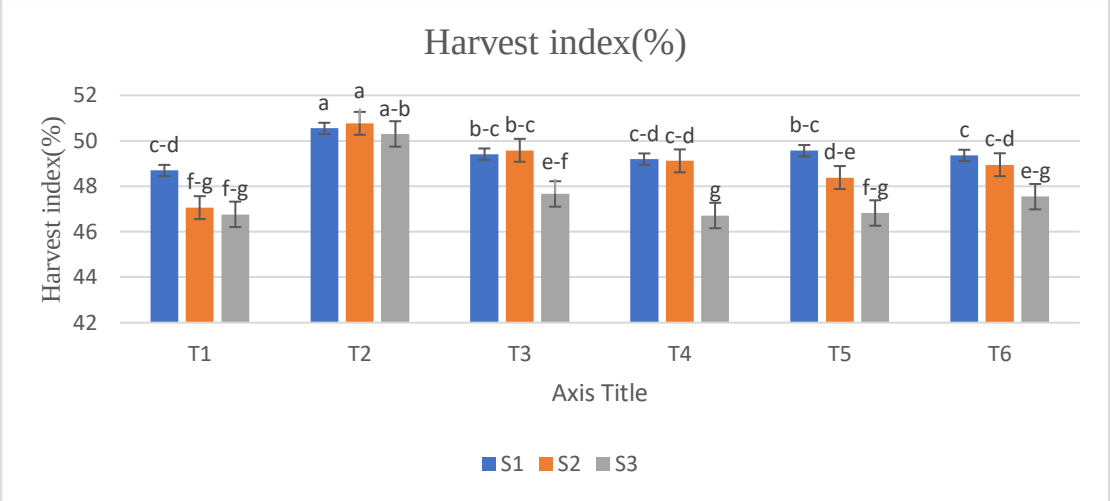


S_1= Single seedling hill^{-1}, S_2= Two seedling hill^{-1}, S_3= Three seedling hill^{-1}

Fig 23. Effect of seedling number per hill on harvest index (%) BRRI dhan88. Bars with different letters are significantly different at p ≤ 0.05 applying DMRT.

Combined effect of chitosan raw material powder and seedling number hill $^{-1}$ on harvest index (%) of BRRI dhan88.

Different level of chitosan raw material powder along with seedling number hill^{-1} showed significant effect on harvest index of BRRI dhan88. Experimental result revealed that, the maximum harvest index (50.76%) was obtained in T_2S_2 treatment combination statistically similar with (50.54%) was obtained in T_2S_1 treatment combination. Whereas the minimum harvest index (46.71%) was obtained in T_4S_3 treatment combination.



Here level of chitosan raw materials powder, T_1= 0%, T_2= 0.1%, T_3= 0.2%, T_4= 0.3%, T_5= 0.4%, T_6= 0.5%

S_1= Single seedling hill^{-1}, S_2= Two seedling hill^{-1}, S_3= Three seedling hill^{-1}

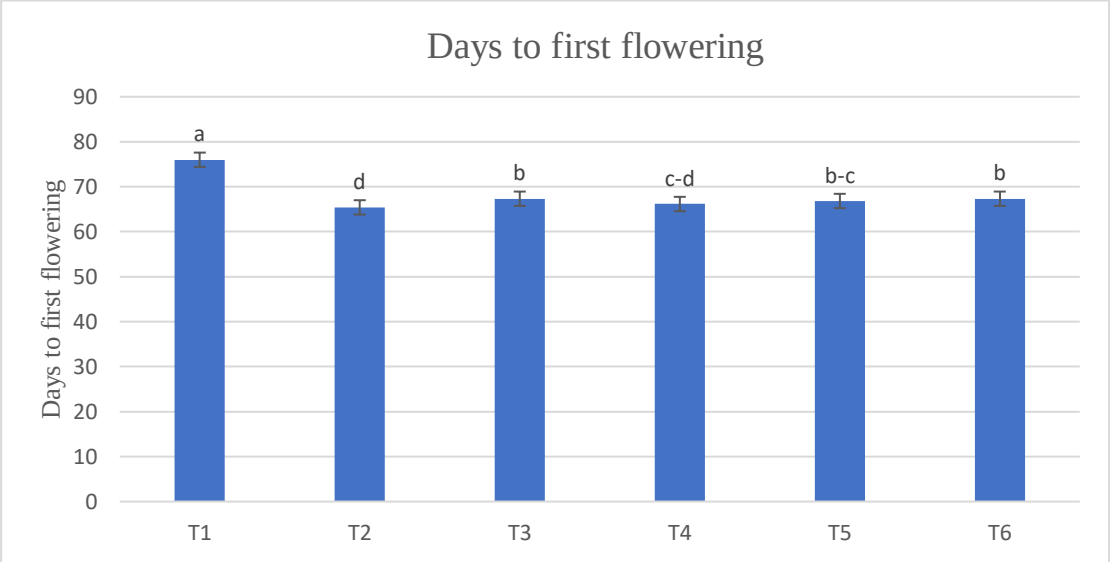
Fig 24. Effect of chitosan raw material powder and effect of number of seedlings on harvest index (%) at BRRI dhan88. Bars with different letters are significantly different at p ≤ 0.05 applying DMRT

4.8 Days to first flowering

Effect of chitosan raw material powder on days to first flowering of *Boro* Rice

Different level of chitosan raw material powder treated seedlings significantly effect on first flowering day of BRRI dhan88 (Fig. 25). Experimental result showed that, the maximum days for first flowering (76) was obtained in T_1(0% chitosan raw material powder) treatment, whereas the minimum days for first flowering (65.42) was obtained in T_2(0.1% chitosan raw material powder) treatment, which was statistically similar with (66.167) T_4(0.3% chitosan raw material powder) treatment. Different level of chitosan influenced florigen gene expression which ultimately impact on early flowering comparable to control treatment. In plants, flowering time is elaborately controlled by various environment factors. Rice has two florigens molecules Hd3a and Rice Flowering Locus T_1 (RFT_1), that are induced flowering. In rice (*Oryza sativa*), early heading date 1 (Ehd1) is a major inducer of florigen gene expression. Ehd1 (EH Domain Containing 1) is a Protein Coding gene. Several transcription factors activate or repress the expression of Ehd1, a gene that is a critical convergence point for various flowering signals in rice. It is possible to bring one week before the flowering stage

by application of chitosan raw material powder at optimum dose compare to control treatment.

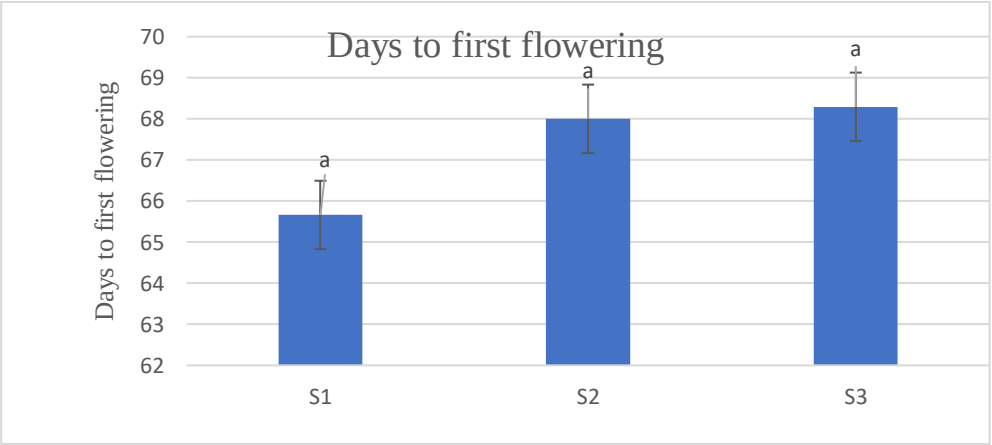


Here level of chitosan raw materials powder, T_1= 0%, T_2= 0.1%, T_3= 0.2%, T_4= 0.3%, T_5= 0.4%, T_6= 0.5%.

Fig 25. Effect of chitosan raw material powder on days to first flowering BRRI dhan88. Bars with different letters are significantly different at p ≤ 0.05 applying DMRT.

Effect of number of seedling hill $^{-1}$ on days to first flowering of BRRI dhan88

Different seedling age significantly effect on first flowering day of BRRI dhan88 (Fig. 26). Experimental result showed that, the maximum days for first flowering (68 29 was obtained in S_3(Three seedling) treatment whereas the minimum days for first flowering (65.66) was obtained in S_1 (Single seedling) treatment.

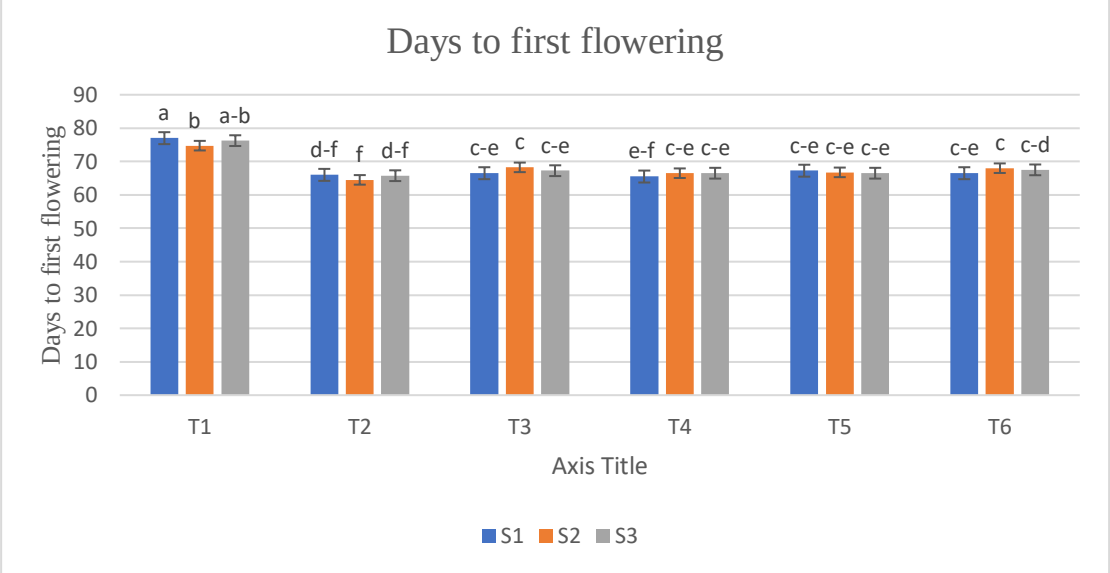


S_1= Single seedling hill^{-1}, S_2= Two seedling hill^{-1}, S_3= Three seedling hill^{-1}.

Fig 26. Effect of different seedling number hill^{-1} days to first flowering BRRI dhan88. Bars with different letters are significantly different at p ≤ 0.05 applying DMRT.

Combined effect of chitosan and seedling hill $^{-1}$ on days to first flowering

Combined effect of chitosan raw material powder and seedling age significantly effect on days to first flowering of BRRI dhan88 (Fig 27). Experimental result revealed that, the maximum days for first flowering (77.00) was obtained in T_1S_1 treatment combination which was statistically similar with T_1S_3 (76.25) treatment combination. Whereas the minimum days for first flowering (64.5) was obtained in T_2S_2 treatment combination, which was statistically similar with T_2S_3(65.75) treatment combination.



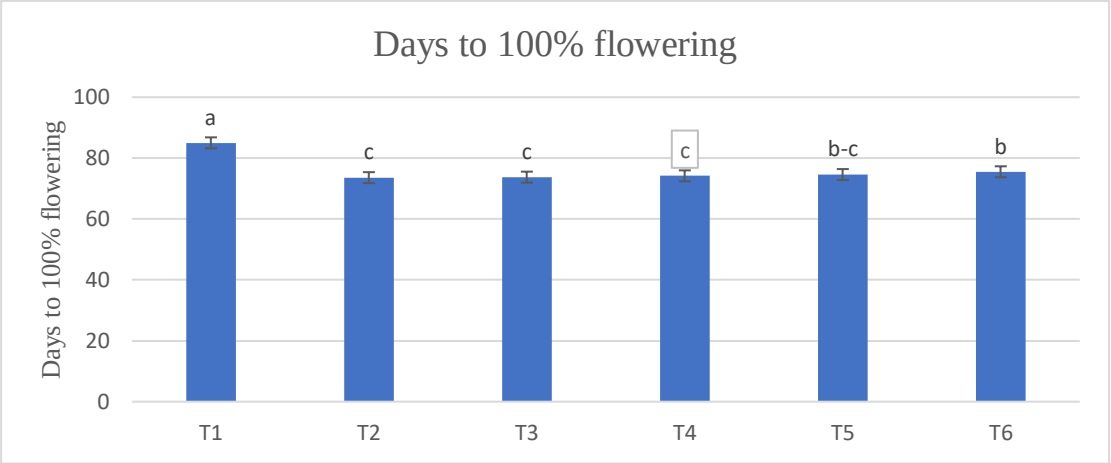
Here level of chitosan raw materials powder, T_1= 0%, T_2= 0.1%, T_3= 0.2%, T_4= 0.3%, T_5= 0.4%, T_6= 0.5%. S_1= Single seedling hill $^{-1}$, S_2= Two seedling hill^{-1}, S_3= Three seedling hill^{-1}.

Fig 27. Effect of chitosan raw material powder and different seedling number hill^{-1}days to first flowering at BRRI dhan88. Bars with different letters are significantly different at p ≤ 0.05 applying DMRT.

4.9 Days to 100% flowering

Effect of chitosan raw material powder on days to 100% flowering of *Boro* Rice

Seedlings treated with different level of chitosan raw material powder significantly effect on 100% flowering day of BRRI dhan88 (Fig. 28). Experimental result showed that, the maximum days for 100% flowering (85) was obtained in T_1 (0% chitosan) treatment, whereas the minimum days for 100 % flowering (73.583) was obtained in T_2 (0.1% chitosan) treatment

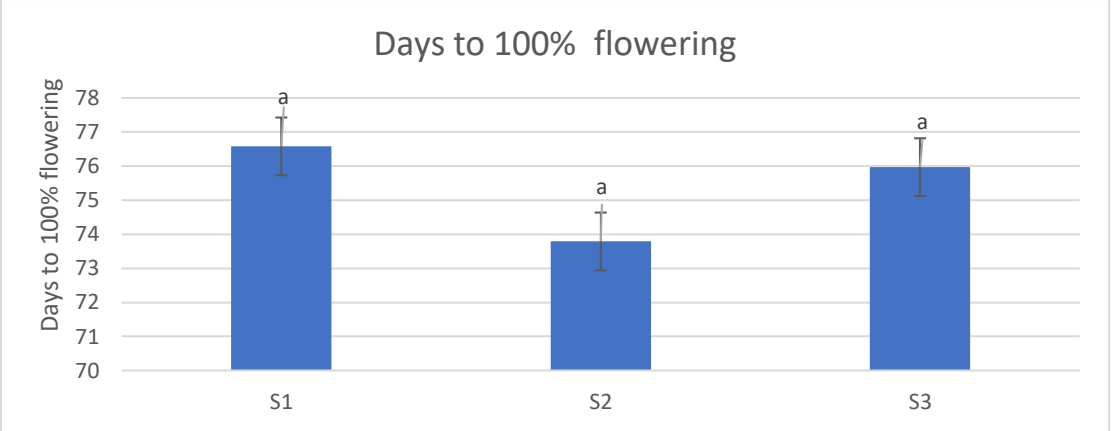


Here level of chitosan raw materials powder, T_1= 0%, T_2= 0.1%, T_3= 0.2%, T_4= 0.3%, T_5= 0.4%, T_6= 0.5%.

Fig 28. Effect of chitosan raw material powder on days to 100 % flowering BRRI dhan88. Bars with different letters are significantly different at $p \leq 0.05$ applying DMRT.

Effect of number of seedling hill^{-1} on days to 100% flowering of BRRI dhan88

Different seedling number hill^{-1} significantly effect on 100% flowering day of BRRI dhan88 (Fig. 29). Experimental result showed that, the maximum days for 100% flowering (76.58) was obtained in S_1(Single seedling) treatment whereas the minimum days for 100% flowering (73.79) was obtained in S_2 (two seedling) treatment.

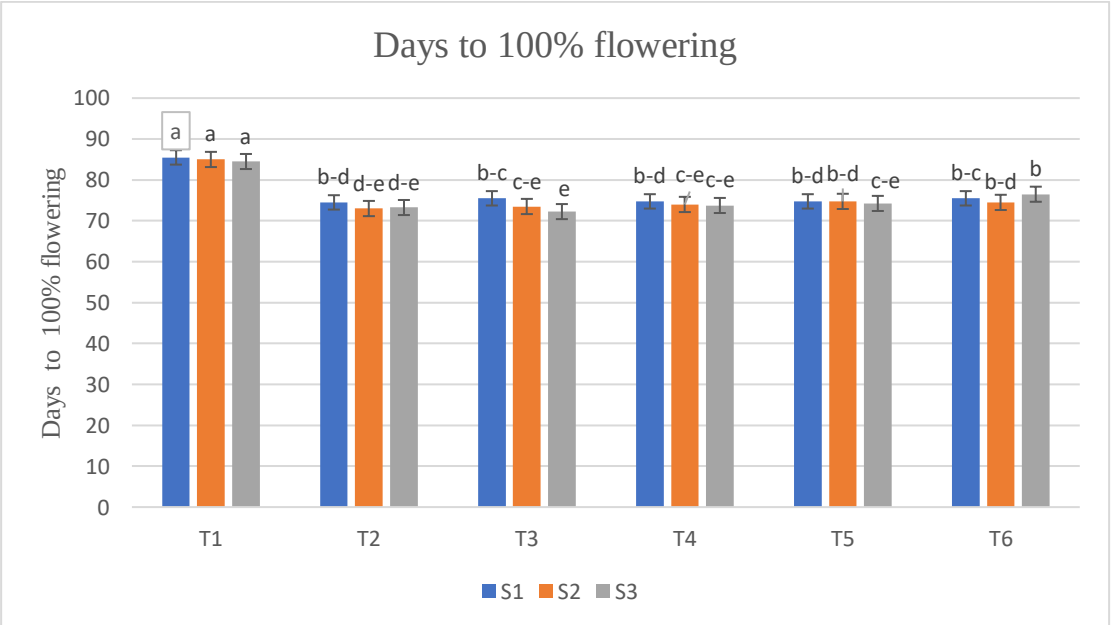


S_1= Single seedling hill^{-1}, S_2= Two seedling hill^{-1}, S_3= Three seedling hill^{-1}

Fig 29. Effect of Number of seedling hill^{-1} BRRI dhan88 at Days to 100% flowering. Bars with different letters are significantly different at p ≤ 0.05 applying DMRT.

Combined effect of chitosan raw material powder and number of seedling hill^{-1} on days to 100% flowering of BRRI dhan88.

Combined effect of chitosan and seedling age significantly effect on 100% flowering day of BRRI dhan88 (fig 30). Experiment result revealed that, the maximum days for 100% flowering (85.5) was obtained in T_1S_1 treatment combination which was statistically similar with T_1S_2 (85.00) and T_1S_3 (84.5) treatment combination. Whereas the minimum days for 100% flowering (72.25) was obtained in T_3S_3 treatment combination.



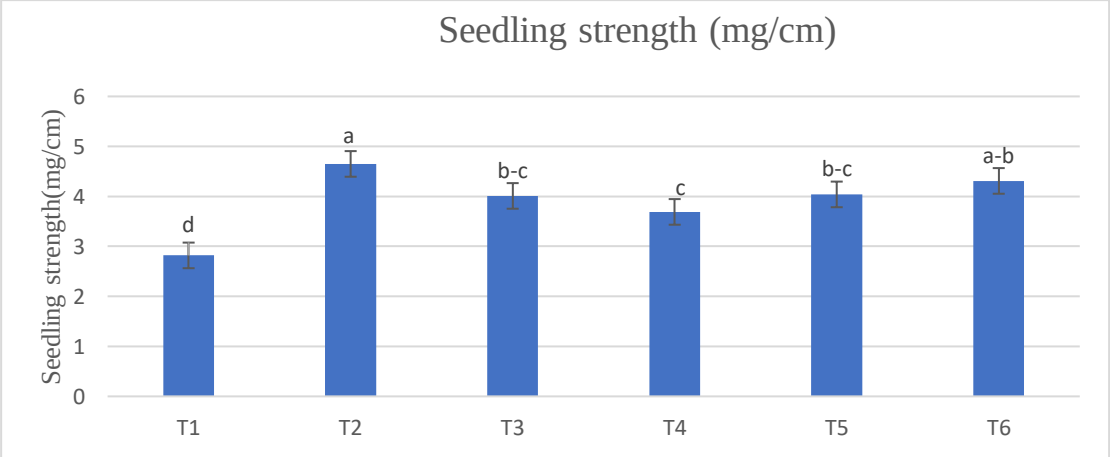
Here level of chitosan raw materials powder, T_1= 0%, T_2= 0.1%, T_3= 0.2%, T_4= 0.3%, T_5= 0.4%, T_6= 0.5%. S_1= Single seedling hill^{-1}, S_2= Two seedling hill^{-1}, S_3= Three seedling hill^{-1}.

Fig. 30. Effect of chitosan raw material powder and different seedling number hil$^{l\ -1}$ BRRI dhan88 at Days to 100% flowering. Bars with different letters are significantly different at p ≤ 0.05 applying DMRT.

4.10. Seedling strength (mg/cm)

Effect of chitosan raw material powder on seedling strength of BRRI dhan88

Seedling treated with different level of chitosan raw material powder significantly effect on seedling strength (mgcm^{-1}) of BRRI dhan88 (Fig. 31). Experimental result showed that, maximum seedling strength (4.65 mgcm^{-1}) was obtained in T_2 (0.1 % chitosan) treatment, whereas the minimum seedling strength (2.82 mgcm^{-1}) was obtained in T_1 (0 % chitosan raw material powder) treatment. Ahmed *et al*. (2020) reported that seedling strength was increased with the application of chitosan-raw-materials in the seedbed. Boonlertnirun *et al.,* (2008) found that application of chitosan stimulates the seedling strength significantly.

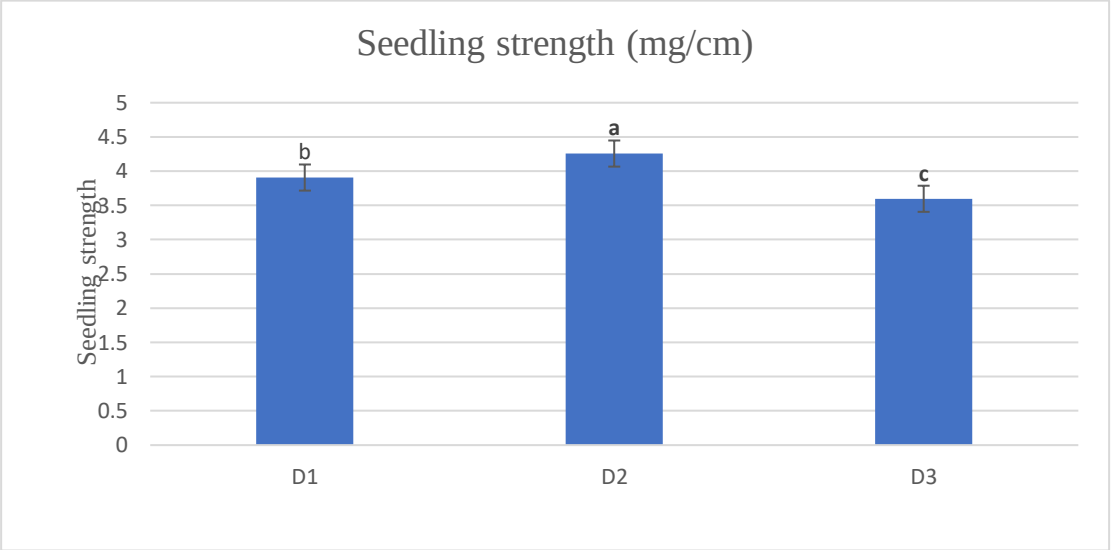


Here level of chitosan raw materials powder, T_1= 0%, T_2= 0.1%, T_3= 0.2%, T_4= 0.3%, T_5= 0.4%, T_6= 0.5%

FIG.31. Effect of chitosan raw material powder level on oven dry weight seedling^{-1} of BRRI dhan88.Bars with different letters are significantly different at p ≤0.05 applying DMRT.

Effect of seedling age on seedling strength of BRRI dhan88

Seedling age significantly effects on seedling strength of BRRI dhan88 (Fig. 32). Experimental result showed that, the maximum seedling strength (4.2572 $mgcm^{-1}$) was obtained in D_2 (45 days old seedling) treatment whereas the minimum seedling strength (3.5972 $mgcm^{-1}$) was obtained in D_3 (50 days old seedling) treatment. Seedling stays in longer period in the seeded increasing seedling strength due to reason that comparatively older seedling has mature root, uptake more nutrient from the seedbed which influence height and dry matter accumulation to younger seedlings.

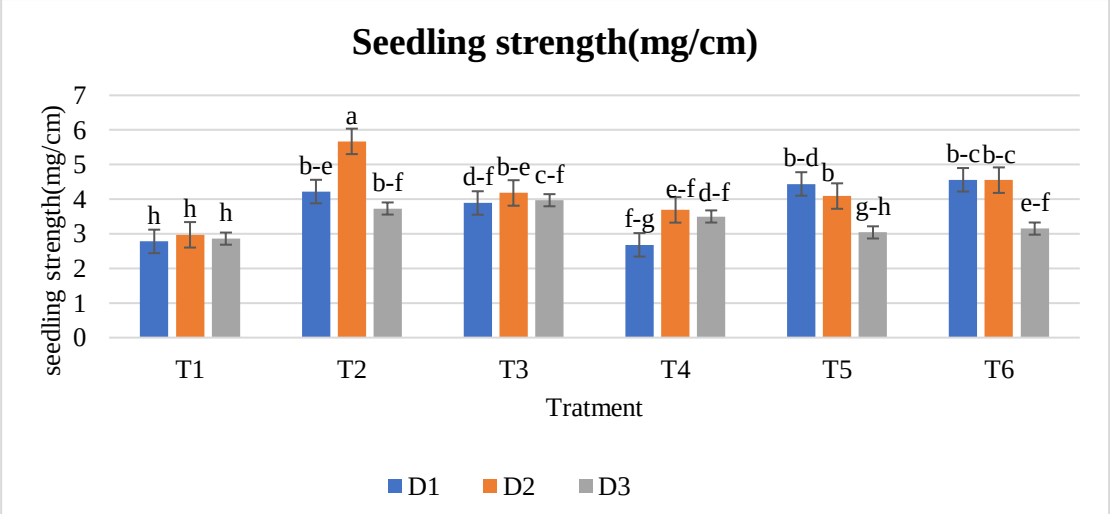


D_1= 40 days, D_2= 45 days, D_3= 50 days

FIG.32. Effect of seedling age on seedling strength (mg/cm) of BRRI dhan88.Bars with different letters are significantly different at p ≤0.05 applying DMRT.

Combined effect of chitosan raw material powder and seedling age on seedling strength of *Boro* Rice

Combined effect of chitosan raw material powder and seedling age significantly effect on seedling strength of BRRI dhan88 (Fig. 33). Experimental result showed that, the maximum seedling strength (5.67 $mgcm^{-1}$) was obtained in T_2D_2 treatment combination whereas the minimum seedling strength (2.78 mg/cm) was obtained in T_1D_1 treatment combination.



Here level of chitosan raw materials powder, T_1= 0%, T_2= 0.1%, T_3= 0.2%, T_4= 0.3%, T_5= 0.4%, T_6= 0.5%. D_1= 40 days, D_2= 45 days, D_3= 50 days

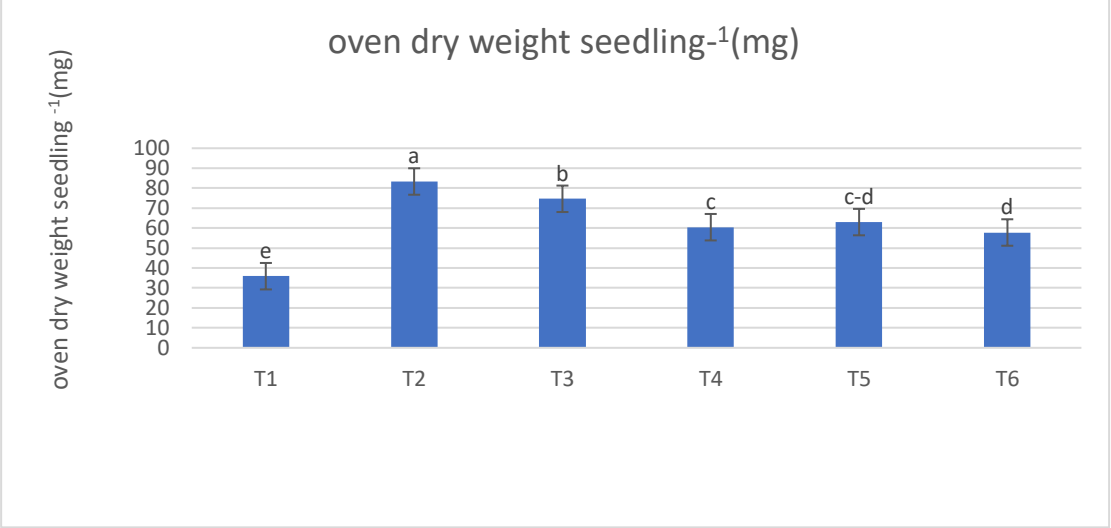
FIG.33. Effect of chitosan raw material powder and seedling age on oven dry weight seedling^{-1} of BRRI dhan88. Bars with different letters are significantly different at p ≤0.05 applying DMRT.

4.11 Oven dry weight seedling^{-1} (mg)

Effect of chitosan raw material powder on oven dry weight seedling^{-1} of BRRI

Application of different level of chitosan raw material powder significantly effects on oven dry weight seedling^{-1} of BRRI dhan88 (Fig. 34). Experimental result showed that, the maximum oven dry weight seedling^{-1} (83.337 mg) was obtained in T_2 (0.1% chitosan raw material powder) treatment, whereas the minimum oven dry weight seedling^{-1} (35.887 mg) was obtained in T_1 (0% chitosan raw material powder) Application of chitosan raw material powder influences the nutrient uptake capacity of plant which improve the growth and development of the plant. As a result, increasing dry weight seedling^{-1}comparable to control treatment were noticeable. Ahmed *et al*. (2020) reported that seedling oven dry weight was increased with the application of chitosan-raw-materials in the seedbed. Issak and Sultana (2017) also reported that oven dry weight productions of BRRI dhan29 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 physio-chemical properties of the seedbed soils. Boonlertnirun *et al.*, (2008) found that application of chitosan stimulates the seedling dry matter weight

significantly.

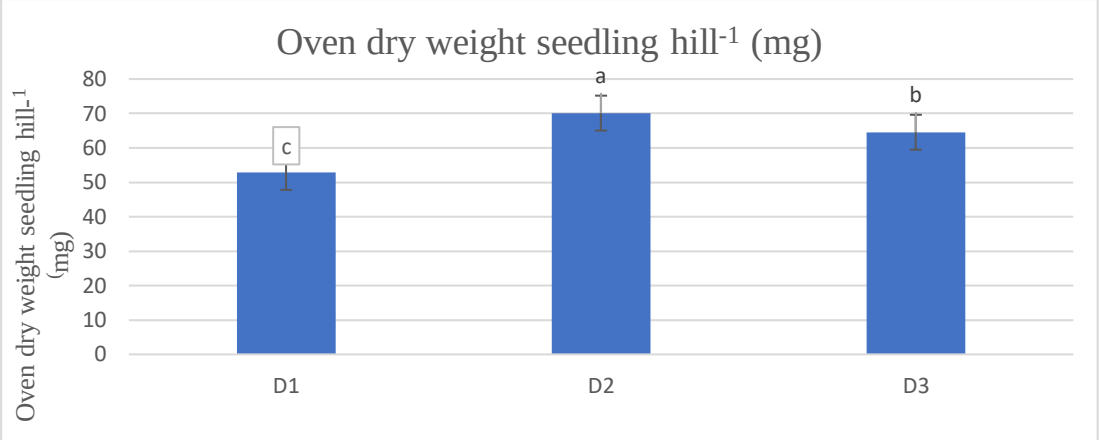


Here level of chitosan raw materials powder, T_1= 0%, T_2= 0.1%, T_3= 0.2%, T_4= 0.3%, T_5= 0.4%, T_6= 0.5%.

FIG.34. Effect of chitosan raw material powder level on oven dry weight seedling^{-1} of BRRI dhan88.Bars with different letters are significantly different at p ≤0.05 applying DMRT

Effect of seedling age on oven dry weight seedling^{-1} of BRRI dhan88

Different ages of seedling significantly effect on oven dry weight seedling^{-1} of BRRI dhan88 (Fig. 35). Experimental result showed that, the maximum oven dry weight seedling^{-1} (70.11 mg) was obtained in D_2 (45 days old seedling) treatment whereas the minimum oven dry weight seedling^{-1} (52.88 mg) was obtained in D_1 (40 days old seedling) treatment. Seedling stay in longer period in the seeded increasing oven dry weight seedling^{-1} due to reason that comparatively old seedling has mature root, uptake more nutrient from the seedbed which influence growth comparable to young seedlings

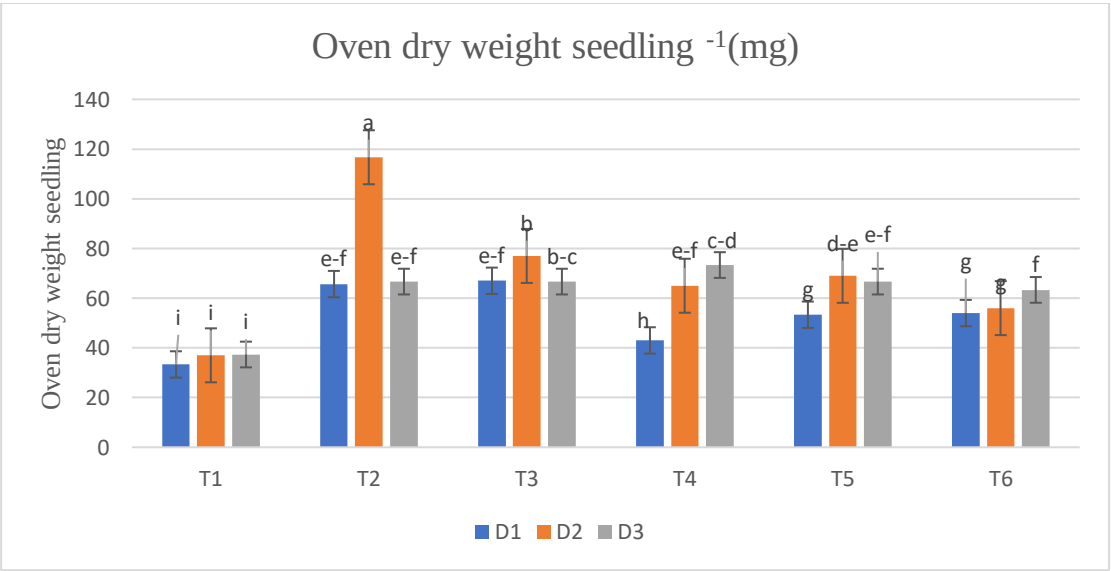


D_1= 40 days, D_2= 45 days, D_3= 50 days

FIG.35. Effect of seedling age on oven dry weight seedling^{-1} of BRRI dhan88. Bars with different letters are significantly different at p ≤0.05 applying DMRT.

Combined effect of chitosan raw material powder and seedling age

Seedling treated with different level of chitosan along with different ages of seedling significantly effect on oven dry weight seedling^{-1}of BRRI dhan88 (Figure 36). Experimental result showed that, the maximum oven dry weight seedling^{-1} (116.7 mg) was obtained in T_2D_2 treatment combination whereas the minimum oven dry weight seedling^{-1} (33.33 mg) was obtained in T_1D_1 treatment combination which was statistically similar with T_1D_2 (37 mg) and T_1D_3 (37.33 mg) treatment combination.



Here level of chitosan raw materials powder, T_1= 0%, T_2= 0.1%, T_3= 0.2%, T_4= 0.3%, T_5= 0.4%, T_6= 0.5%. D_1= 40 days, D_2= 45 days, D_3= 50 days

FIG.36 Effect of chitosan raw material powder and seedling age on oven dry weight seedling^{-1} of BRRI dhan88. Bars with different letters are significantly different at p ≤0.05 applying DMRT.

4.12 Fresh weight seedling^{-1} (mg)

Effect of chitosan raw material powder on fresh weight seedling^{-1} of BRRI

Application of different level of chitosan raw material powder significantly effect on fresh weight seedling^{-1} of BRRI dhan88 (Fig. 37). Experimental result showed that, the maximum fresh weight seedling^{-1} (371.33 mg) was obtained in T_2 (0.1% chitosan raw material powder) treatment, whereas the minimum fresh weight seedling^{-1}(190.33 mg) was obtained in T_1 (0% chitosan raw material powder) treatment. Optimum dose of chitosan raw material powder influences the nutrient uptake which improve the growth and development of the plant result in increasing fresh weight seedling^{-1} comparable to higher level of chitosan application. Ahmed *et al*., (2020) reported that seedling fresh weight was increased with the application of chitosan-raw-material powder in the seedbed. Issak and Sultana (2017) also reported that, fresh weight productions of BRRI dhan29 rice seedlings were influenced by the chitosan powder treatments and this might be due its supplementation of plant nutrients and growth regulators.

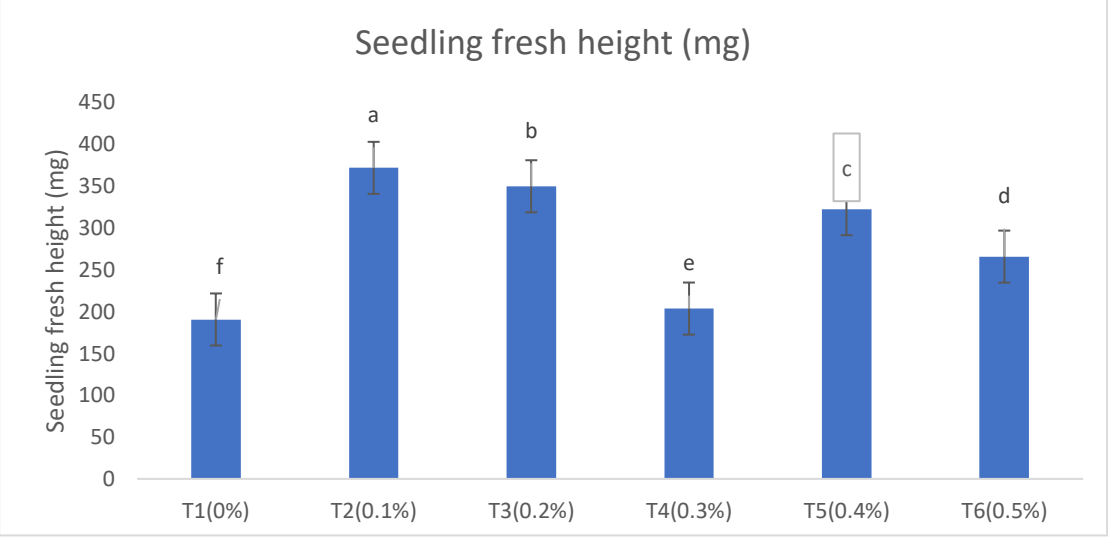
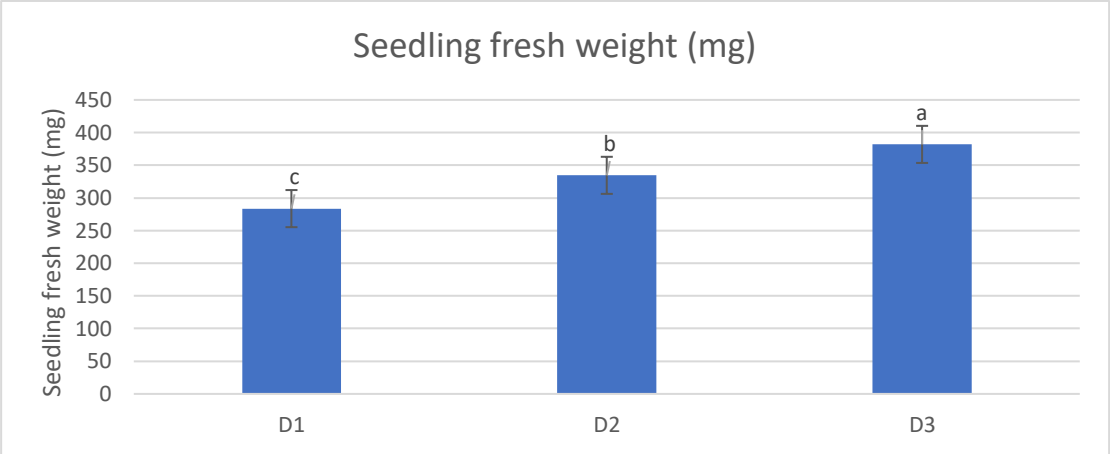


FIG.37. Effect of chitosan raw material powder level on fresh weight seedling^{-1} of BRRI dhan88.Bars with different letters are significantly different at p ≤0.05 applying DMRT.

Effect of seedling age on fresh weight seedling^{-1} of BRRI dhan88

Seedling age significantly effects on fresh weight seedling^{-1} of BRRI dhan88 (Fig. 38). Experimental result showed that, the maximum fresh weight seedling^{-1} (381.9 mg) was obtained in (50 days old seedling) treatment whereas the minimum fresh weight seedling^{-1} (283.61mg) was obtained in D_1 (40 days old seedling) treatment. In this experiment, old seedling had higher fresh weight seedling^{-1} due to reason that, comparatively old seedling stays in longer period in the seedbed, developed root formation, uptake comparatively more water and nutrients which influence fresh weight comparatively young seedling.

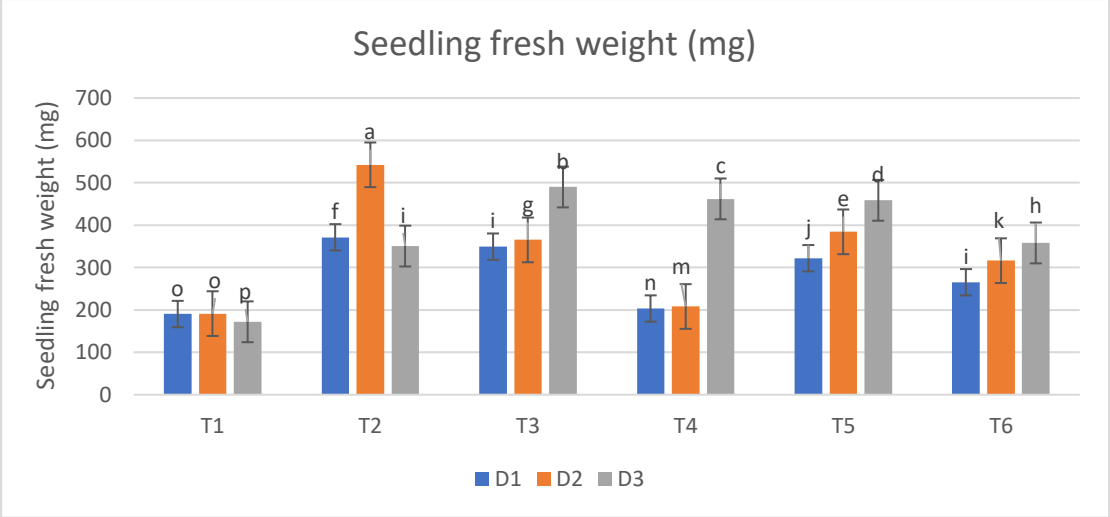


D_1= 40 days, D_2= 45 days, D_3= 50 days

FIG.38. Effect of seedling age on fresh weight seedling^{-1} of BRRI dhan88.Bars with different letters are significantly different at p ≤0.05 applying DMRT.

Combined effect of chitosan raw material powder and seedling age on fresh weight seedling^{-1} of BRRI dhan88

Seedling treated with different level of chitosan raw material powder along with different ages of seedling significantly effect on fresh weight seedling^{-1} of BRRI dhan88. Experimental result showed that, the maximum fresh weight seedling^{-1}(542.33 mg) was obtained in T_2D_2 treatment combination whereas the minimum fresh weight seedling^{-1}(190.33 mg) was obtained in T_1D_1 treatment combination, which was statistically similar with T_1D_2 (191.53 mg) treatment combination.



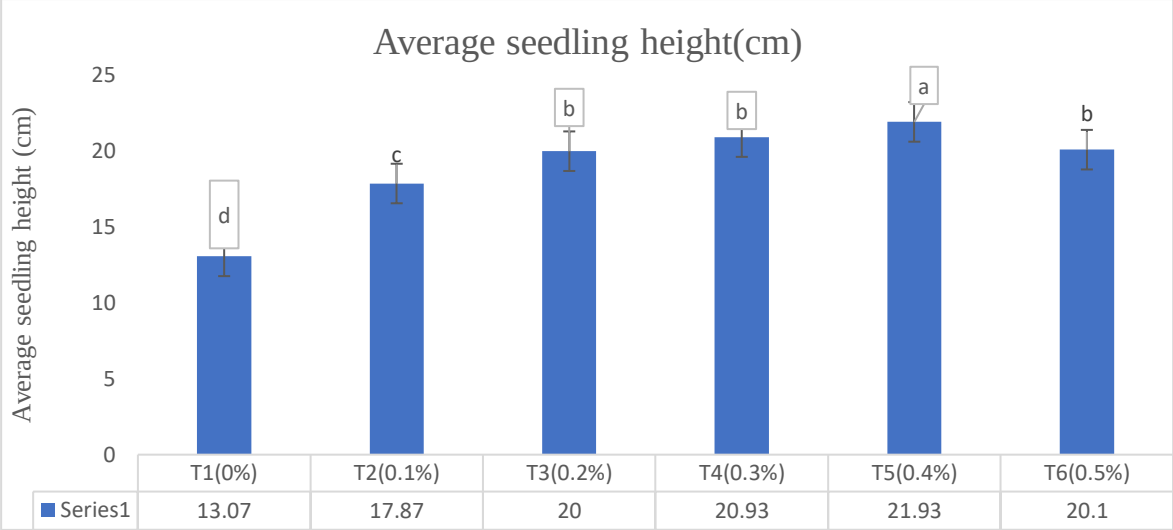
D_1= 40 days, D_2= 45 days, D_3= 50 days

FIG.39. Effect of chitosan raw material powder and seedling age on fresh weight seedling^{-1} of BRRI dhan88.Bars with different letters are significantly different at p ≤0.05 applying DMRT.

4.13. Average seedling height (cm)

Effect of chitosan raw material powder on seedling height of BRRI dhan88

Seedling treated with different level of chitosan raw material powder significantly influenced average seedling height of BRRI dhan88 (Fig.40). Experimental result revealed that the maximum average seedling height (21.93.cm) was obtained in T_5 (0.4 % chitosan raw material powder) treatment whereas the minimum average seedling height (13.07 cm) was obtained in T_0 (0% chitosan raw material powder) treatment. Seedling treated with chitosan raw material powder resulted in a better growth of the seedlings and lower chance of being infected by fungi in comparison with the untreated seedling. The observed growth improvement by chitosan raw material powder could also be related to the incorporation of nutrients from this powder. The result obtained from the present study was similar with the findings of Ahmed *et al*., (2020) and they reported that seedling height was increased with the application of chitosan-raw-materials in the seedbed. Issak and Sultana (2017) found that *Boro* rice seedlings production were improved by using the chitosan raw material powder in the seedbed. Boonlertnirun *et al.*, (2008) also reported that, chitosan is a natural biopolymer which stimulates growth and increases yield of plants as well as induces the immune system of plants.

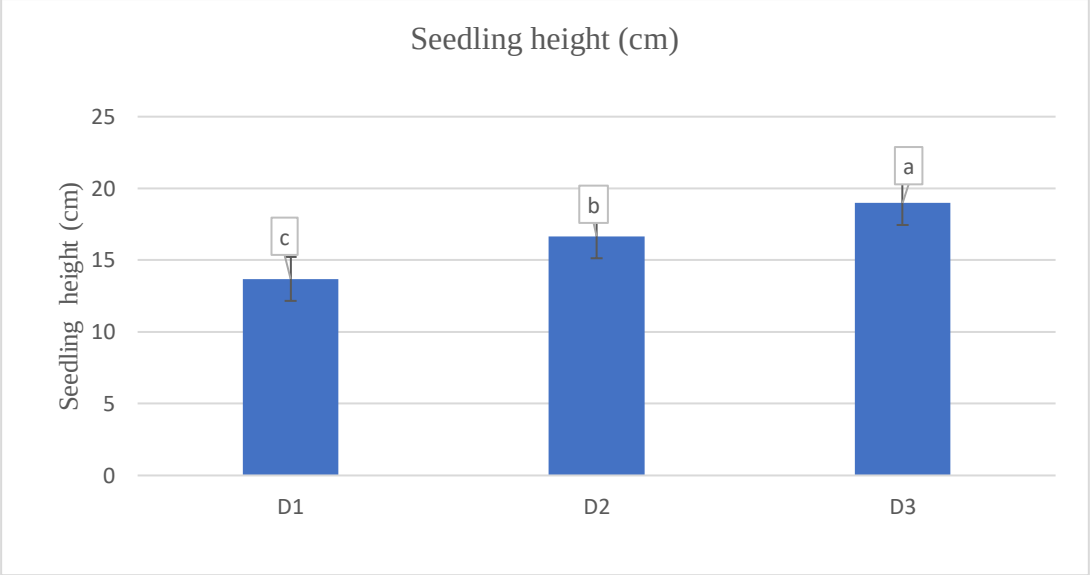


Here level of chitosan raw materials powder, T_1= 0%, T_2= 0.1%, T_3= 0.2%, T_4= 0.3%, T_5= 0.4%, T_6= 0.5%

Fig.40. Effect of chitosan raw materials powder level on average seedling height of BRRI dhan 88. Bars with different letters are significantly different at $p \leq 0.05$ applying DMRT.

Effect of seedling age (40, 45 & 50 Days) on average seedling height of BRRI dhan88 as influenced by chitosan raw material powder

Different ages of seedling significantly effect on average seedling height of BRRI dhan88 (Fig.3). Experimental result showed that, the maximum average seedling height (18.98 cm) was obtained in D_3 (50 days old seedling) treatment whereas the minimum average seedling height (13.69 cm) was obtained in D_1 (40 days old seedling) treatment. In general, the seedling height increased gradually with the advancement of time. Seedling stay in longer period in the seedbed increasing average seedling height due to reason that comparatively old seedling has mature root, uptake more nutrient from the seedbed which influence growth comparable to young seedlings.

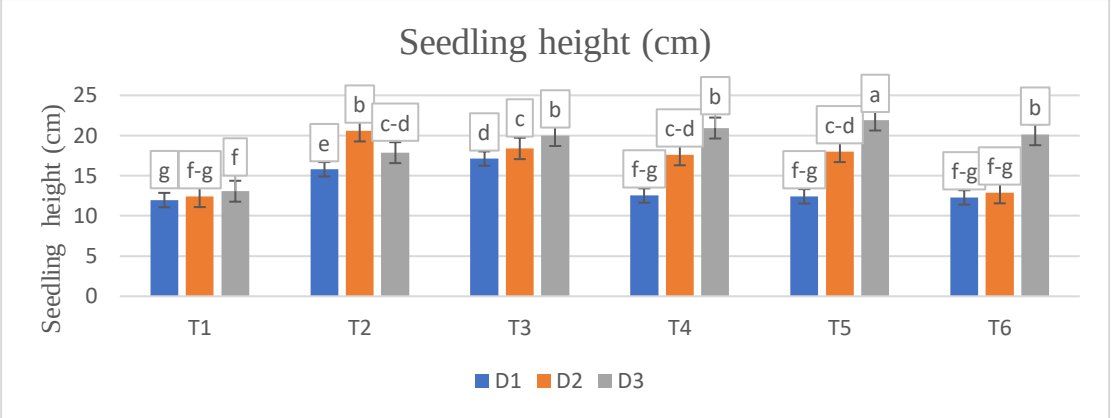


D_1= 40 days, D_2= 45 days, D_3= 50 days

Fig.41. Effect of seedling age on average seedling height of BRRI dhan 88. Bars with different letters are significantly different at p ≤ 0.05 applying DMRT.

Combined effect of chitosan raw material powder and seedling age on average seedling height of BRRI dhan88

Seedling treated with different level of chitosan raw material powder along with different ages of seedling significantly effect on average seedling height of BRRI dhan88. Experimental result showed that, the maximum average seedling height (21.93 cm) was obtained in T_5D_3 treatment combination whereas the minimum seedling height (11.97) was obtained in T_1D_1 treatment combination, which was statistically similar with T_1D_2 (12.43 cm), T_4D_1 (12.53 cm), T_5D_1 (12.43 cm), T_6D_1 (12.297 cm) and T_6D_2 (12.9 cm) treatment combination.



Here level of chitosan raw materials powder, T_1= 0%, T_2= 0.1%, T_3= 0.2%, T_4= 0.3%, T_5= 0.4%, T_6= 0.5%

D_1= 40 days, D_2= 45 days, D_3= 50 days

Fig.42. Effect of chitosan raw materials powder and seedling age on average seedling height of BRRI dhan 88. Bars with different letters are significantly different at p ≤ 0.05 applying DMRT.

4.14 Chemical Properties of seedbed soils after transplant

4.14.1 pH and percent total nitrogen

Form the table 6 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_5 treatment (0.05 % chitosan raw material powder) increasing seedbed soil pH (6.5) and T_4 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 6 Effect of different chitosan raw material powder treatments on pH and % total nitrogen of seedbed soil after transplant seedling

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)	0	0.18	0	0.003
CV(%)	0	1.97	0	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%

4.14.2 Percent organic carbon and organic matter

Chitosan raw material powder contents 7.52 % organic carbon and 12.96 % organic matter. From the table 7 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_5 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 7. 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)	0	0.02	0	0.03
CV(%)	0	2.62	0	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 CONCLUSION

A pot experiment was conducted at Sher-e-Bangla Agricultural University, Dhaka during November-2019 to April-2020, to investigate the seedling number hill^{-1} of *Boro* seedling characters by using chitosan raw material powder and their yield performance at different seedling Number hill^{-1}. The experiment was consisted of two factors, and followed Randomized complete block design (RCBD) with four replications. Factor A: chitosan raw material powder level (6) *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 chitosan raw material powder and Factor B: Different Number of seedling hill^{-1}(3) *viz;* S_1= Single seedling hill $^{-1}$, S_2= Two seedling hill $^{-1}$ and S_3= Three seedling hill^{-1}. Data on different parameters were collected for assessing results for this experiment and showed significant variation in respect of different characteristics of BRRI dhan88 due to the effect of different chitosan raw material powder level, seedling number hill^{-1} and their combinations.

In case of different chitosan raw material powder level, experimental result showed that, maximum average seedling height (21.93.cm) was obtained in T_5 (0.4 % chitosan raw material powder) treatment,fresh weight seedling^{-1} (371.33 mg, oven dry weight seedling^{-1} (83.337mg) ,maximum seedling strength (4.65 mgcm^{-1}) was obtained in T_2 (0.1% chitosan) treatment, maximum tiller number pot^{-1} (6.83, 14.5, 32.5 and 40) at 30, 40, 50 and 60 DAT were obtained in T_3 (0.2% chitosan raw material powder) treatment. maximum effective tillers hill^{-1} (28.25) was obtained in T_4 (0.3 % chitosan raw material powder) treatment. The maximum days for first flowering (76), 100 % flowering (85) was obtained in T_1 (0 % chitosan) treatment. maximum unfilled grains weight pot^{-1} (2.045g) was obtained in T_3 (0.2% chitosan raw material powder) treatment, grain yield pot^{-1} (69.85g) was obtained in T_2(0.1%) treatment straw yield pot^{-1} (72.58g), maximum biological yield pot^{-1} (1142.09g) was obtained in T_3(0.2% chitosan raw material powder) treatment,). Experimental result showed that, the maximum harvest index (50.54%) was obtained in T_2 (0.1% chitosan).

Whereas the minimum average seedling height (13.07 cm), fresh weight seedling^{-1}(190.33 mg, oven dry weight seedling^{-1} (35.887 mg), seedling strength (2.82 mgcm^{-1}) ,tiller number pot^{-1} (4) at 30 DAT was obtained in T_1 (0 % chitosan raw material

powder) treatment. At 40 DAT the minimum tiller number pot^{-1} (7.92) was obtained in T_1 (0 % chitosan raw material powder) treatment. At 50 and 60 DAT the minimum tiller number pot^{-1} (22.67 and 30.5) was obtained in T_1(0 % chitosan raw material powder) treatment. minimum effective tillers hill^{-1} (20.25) was obtained in T_1 (0 % chitosan raw material powder) treatment

The minimum days for first flowering (65.42) for 100 % flowering (73.583) was obtained in T_2 (0.1 % chitosan) treatment. minimum unfilled grains weight pot^{-1} (1.5725 g) was obtained in T_5 (0.4% chitosan raw material powder) treatment. the minimum grain yield pot^{-1} (57.65g) was obtained in T_1(0% chitosan raw material powder) treatment. the minimum straw yield pot^{-1}(61.15g) was obtained in T_6 (0 .5% chitosan raw material powder) treatment.the minimum biological yield pot^{-1}(119.25g) was obtained in T_1 (0% chitosan raw material powder) treatment, Whereas the minimum harvest index (47.5%) was obtained in T_1 (0% chitosan raw material powder) treatment.

In respect of different seedling number hill^{-1}, the maximum number of tillers pot^{1} (7.2 ,14.17, 34.46 and 41.71) at 30, 40, 50 and 60 DAT was obtained in S_3 (Three seedling hill^{-1}) , the maximum effective tillers pot^{-1} (28.87) was obtained in S_3 (Three seedling hill^{-1}) the maximum days for first flowering (68 29 was obtained in S_3(Three seedling hill^{-1}) the maximum days for 100% flowering (76.58) was obtained in S_1(Single seedling hill^{-1}),The maximum unfilled grains weight pot^{-1}(2.5967 g) was obtained in S_1 (Single seedling) treatment, the maximum grain yield pot^{-1} (65.168 g) was obtained in S_1(Single seedling per hill) treatment. maximum straw yield pot^{-1} (67.13 g) was obtained in S_3 (Three seedling per hill), the maximum biological yield pot^{-1} (108.8 g) was obtained in S_2(Two seedling hill $^{-1}$), the maximum harvest index (49.46%) was obtained in S_1 (single seedling hill^{-1}). The minimum number of tillers hill^{-1} (3.75, 9.375, 22.67 and 33.96) at 30, 40, 50 and 60 DAT was obtained in S_1(Single seedling) treatment. The minimum effective tillers pot^{-1} (22.67) was obtained in S_1 (Single seedling pot^{-1}) treatment .The minimum days for first flowering (65.66) was obtained in S_1 (Single seedling) treatment. The minimum days for 100% flowering (73.79) was obtained in S_2 (two seedling) treatment. The minimum unfilled grains weight pot^{-1}(1.2692 g) was obtained in S_3 (Three seedling) treatment. The minimum grain yield pot^{-1} (59.298 g) was obtained in S_3(Three seedling hill^{-1}) treatment. The minimum straw

yield pot^{-1} (64.68 g) was obtained in S_2 (Two seedling hill^{-1}) treatment. The minimum biological yield pot^{-1} (106.5) was obtained in S_1 (Single seedling hill $^{-1}$) treatment. The minimum harvest index (47.64%) was obtained in S_3 (Three seedling hill^{-1}) treatment.

In case of combined effect, experimental result showed that, the maximum tiller number hill^{-1} (5, 15.75, 36.50 and 44.25) at 30, 40, 50 and 60 DAT was obtained in T_5S_3 treatment combination. Experimental result revealed that, the maximum effective tillers pot^{-1} (32 a) was obtained in T_4S_3 treatment combination. Experimental result revealed that, the maximum days for first flowering (77.00) was obtained in T_1S_1 treatment combination. The maximum days for 100% flowering (85.5) was obtained in T_1S_1 treatment combination. The maximum unfilled grains weight pot^{-1} (3.34 g) was obtained in T_3S_1treatment combination. , The maximum grain yield pot^{-1} (76.27 g) was obtained in T_3S_1 treatment combination. The maximum straw yield pot^{-1} (75.5 g) was obtained in T_3S_2 treatment. The maximum biological yield pot^{-1} (122.27 g) was obtained in T_2S_2 treatment combination. The maximum harvest index (50.54 %) was obtained in T_2S_1treatment combination.

Whereas the minimum tiller number hill^{-1} (2.50, 5.25, 16.5 and 28) at 30, 40, 50 and 60 DAT was obtained in T_1S_1 treatment combination. The minimum tiller number pot^{-1} (16.5i) was obtained in T_1S_1 treatment combination. The minimum days for first flowering (64.5) was obtained in T_2S_2 treatment. The minimum days for 100% flowering (72.25 day) was obtained in T_3S3 treatment combination.

The minimum unfilled grains weight pot^{-1} (0.9825 g) was obtained in T_2S_3 treatment combination. The minimum grain yield hill^{-1} (47.283 g) was obtained in T_1S_2 treatment combination. The minimum straw yield pot^{-1} (52 g) was obtained in T_1S_2 treatment. The minimum biological yield hill^{-1}(82.28 g) was obtained in T_1S_1 treatment combination. The minimum harvest index (46.71%) was obtained in T_4S_3 treatment combination.

Conclusion

Based on the above results of the present study, the following conclusions may be drawn

i. 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.

ii. All the treatments using chitosan raw material powder showed better performance by the following sequence $T_2>T_3>T_4>T_5>T_6>T_1$. Among the treatments, T2 showed the superior performance. Among the treatment combinations, T_3S_1 showed the best performance.

iii. Single seedling number hill $^{-1}$ increase the production percentage other seedling number hill $^{-1}$. Single seedling number hill $^{-1}$ cost effective.

iv. 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 @ 0.1% in seedbed soil improved seedling characters, yield and yield parameters of BRRI dhan88. So, it is suggested to the late sowing farmers to apply 0.1% chitosan raw material powder in seedbed soil for better performance and cost effective. In order to recommend the practices for the rice growers, the following aspects would be considered in future:

Similar experiments need to be conducted in field condition in different locations of Bangladesh to draw a final conclusion regarding to the effect of chitosan raw material powder application in the seedbed along with different number of seedling hill^{-1} for obtaining better grain yield of BRRI dhan 88.

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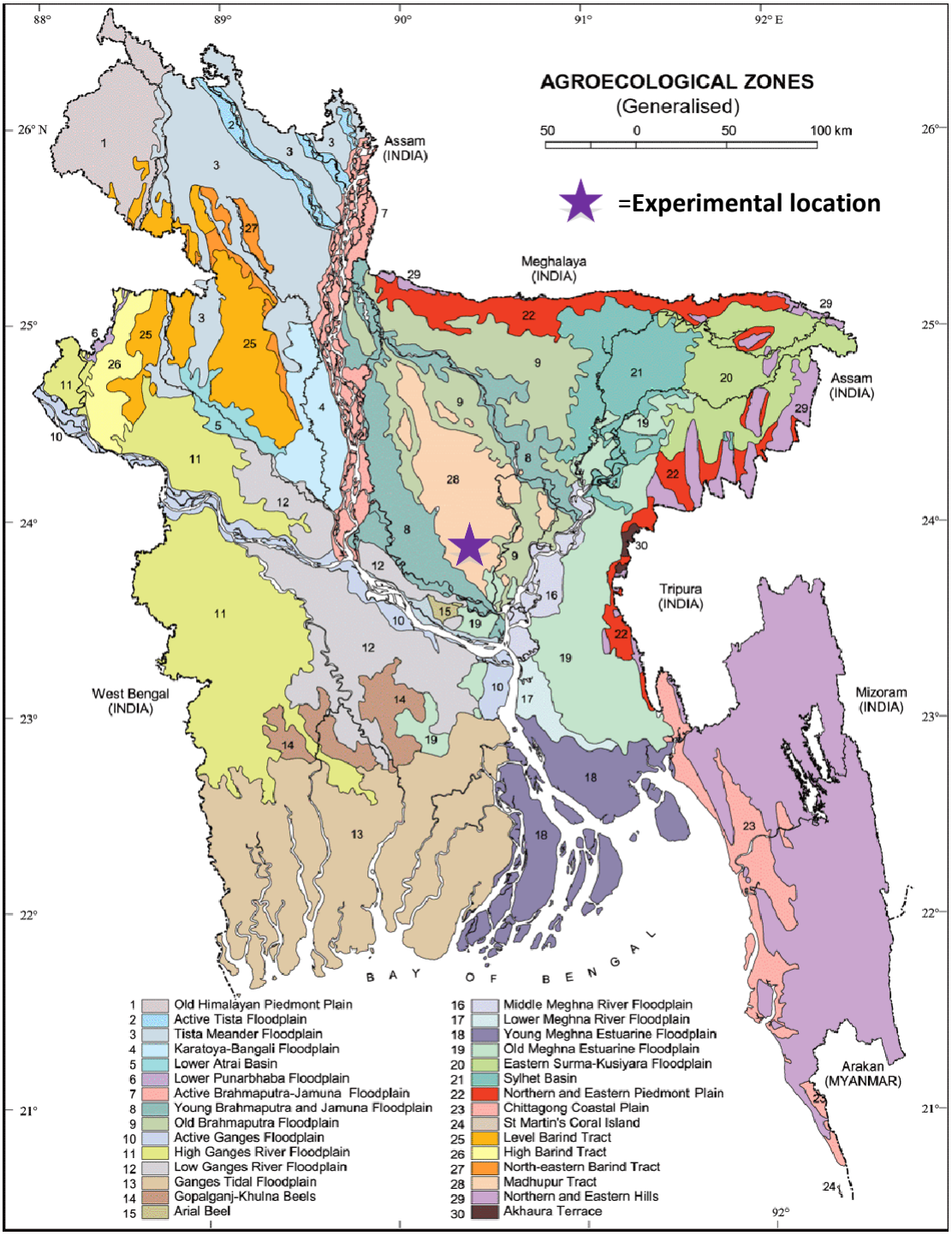
Appendix I. Map showing the experimental location under study

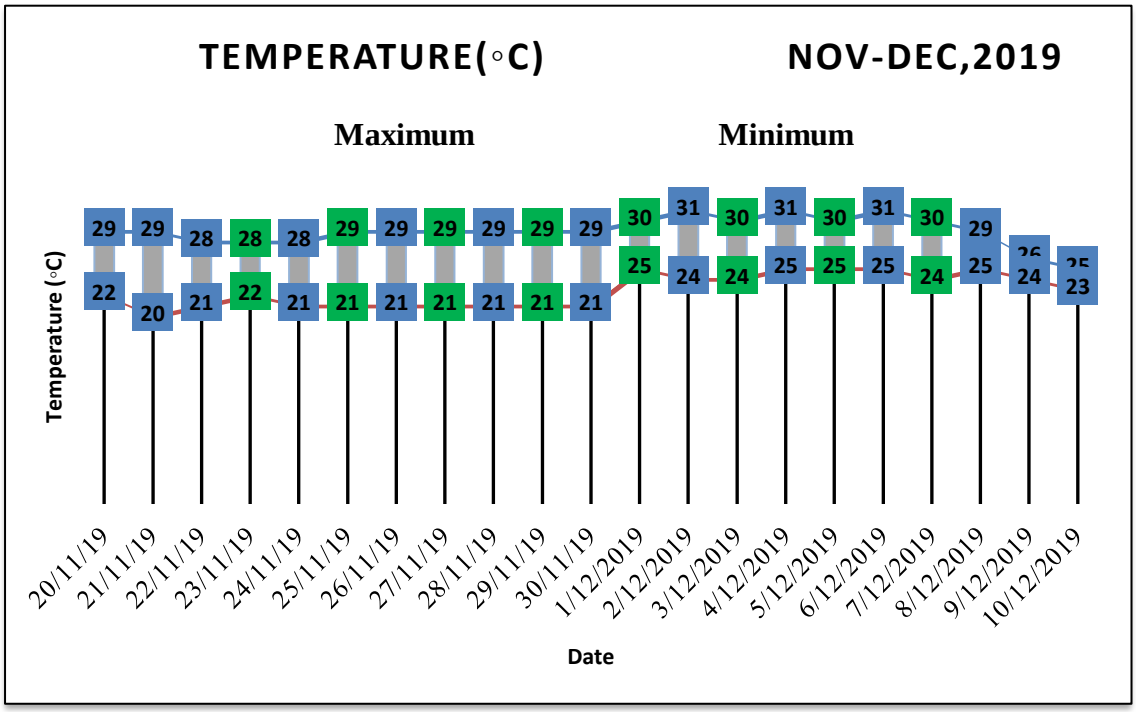


Appendix II. Monthly meteorological information during the period from November, 2019 to April 2020

Year	Month	Air temperature (^{0}C)		Relative humidity (%)	Total rainfall (mm)
		Maximum	Minimum		
2019	November	29.6	19.8	53	00
	December	28.8	19.1	47	00
2020	January	25.5	13.1	41	00
	February	25.9	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 I11. Daily meteorological information during the period from 20 November, 2019 to 10 December, 2019



Appendix IV. 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