EFFECT OF ORGANIC GROWTH PROMOTING SUBSTANCE (CHITOSAN) ON GROWTH AND YIELD OF BRRI dhan62

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CERTIFICATE

This is to certify that the thesis entitled as 'EFFECT OF ORGANIC GROWTH PROMOTING SUBSTANCE (CHITOSAN) ON GROWTH AND YIELD OF BRRI dhan62' submitted to the DEPARTMENT OF SOIL SCIENCE, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE (M.S.) in SOIL SCIENCE, embodies the results of a piece of bona fide research work carried out by HABIBUR RAHMAN, Registration. No. 09-03394, under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma in any other institution.

I further certify that any help or sources of information received during the course of this investigation has duly been acknowledged.

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CHAPTER 1

INTRODUCTION

Rice (*Oryza sativa* L.) belongs to the Poaceae family which is the staple food in Bangladesh. Rice is the staple food for more than three billion people that is over half of the world's total population (FAO, 2004). Rice is the most important source of the food energy for more than half of the human population. Rice is grown in 114 countries across the world on an area of about 150 million hectares with annual production of over 525 million tones, constituting nearly 11 per cent of the world's cultivated land (Rai, 2006). More than 90 per cent of the world's rice is produced and consumed in Asia where it is an integral part of culture and tradition. In Asia, it is the main item of the diet of 3.5 billion people. Therefore, increase in population will require 70 percent more rice in 2025 than is consumed today (Kim and Krishnan, 2002). According to the Food and Agriculture Organization (FAO) of the UN. 80% of the world rice production comes from 7 countries (UAE/FAO, 2012). However, if we talk about world rice production 2009-2010, the worldwide rice production by countries- in fact, the top ten countries of world counted for rice production viz. China: Mt: 166,417,000 (32.7%), India: Mt: 132,013,000 (26.0%), Indonesia: Mt: 52,078,832 (10.2%), Bangladesh: Mt: 38,060,000 (7.5%), Vietnam: Mt: 34,518,600 (6.8%), Thailand: Mt: 27,000,000 (5.3%), Myanmar: Mt: 24,640,000 (4.8%), Philippines: Mt: 14,031,000 (2.8%), Brazil: Mt: 10,198,900 (2.0%) and Japan: Mt: 9,740,000 (1.9%) (UAE-FAO, 2012). As a report of BBS (2011) for the year of 2009-2010, rice is cultivated in about 28056 thousand acres land and total annual production (all growing seasons) is 31975 thousand M. tons, with an average of 1168 kg acre^{-1}. Among the rice producing countries, Bangladesh ranks fourth, both in acreage and production (FAO, 2007).

In Bangladesh, over 40 per cent children under five are stunted while an estimated 44 per cent children of the same age group are at risk of zinc deficiency. But good news is that, Bangladesh Rice Research Institute (BRRI) released BRRI dhan62, a zinc-enriched paddy

variety. The newly innovated paddy variety has opened up a door of enormous prospects of mitigating zinc and protein deficiency besides fighting diarrhoea and pneumonia-induced childhood deaths and stunting. It's a short-duration high-yielding variety of rice which could be cultivated in Aman season. Each kilogram of rice of BRRI dhan62 contained 19 mg of zinc and 9 per cent of protein which will ensure high nutrition and will play a significant role in prevention of diseases; Zinc also played a vital role in prevention of liver-related diseases. The variety is the world's first-ever rice class developed in a bio-fortified system through breeding between local rice variety Zira Katari and BRRI dhan39. It is expected that consumption of the rice enriched with zinc will highly remove malnutrition. Particularly, this rice will protect child health. The yield of the variety is 3.5 to 4.5 ton/ha. To increase the production organic growth promoting substance may be used.

Chitosan is a natural biopolymer which stimulates growth and increases yield of plants as well as induces the immune system of plants (Boonlertnirun *et al*., 2008). Plant treated with chitosan showed significantly greater number of branches/plant than untreated control (Reddy *et al*., 2000). In agriculture, chitosan is used primarily as a natural seed treatment and plant growth enhancer and as an ecologically friendly biopesticide substance that boosts the innate ability of plants to defend themselves against fungal infections (Linden *et al*., 2000). The natural bio-control active ingredients, chitin/chitosan are found in the shells of crustaceans, such as lobsters, crabs and shrimps and many other organisms, including insects and fungi. It is one of the most abundant biodegradable materials in the world. Degraded molecules of chitin/chitosan exist in soil and water.

Chitosan has a wide scope of application on various plants. With high affinity and non-toxicity, it does no harm to 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 has strong effects on agriculture such as acting as the carbon source

for microbes in the soil, accelerating the transformation process of organic matter into inorganic matter and assisting the root system of plants to absorb more nutrients from the soil. Chitosan is absorbed to the root after being decomposed by bacteria in the soil. Application of chitosan in agriculture, even without chemical fertilizer can increase the microbial population by large numbers and transforms organic nutrient into inorganic nutrient which is easily absorbed by the plant roots (Bolto *et al*., 2004).In Bangladesh limited information is available on the effect of organic growth promoting substance like chitosan on the growth and yield of rice.With a view to generate information a field experiment was conducted to investigate the effect of chitosan ongrowth and yield of BRRI Dhan62 in the location of AEZ-28.Keeping these facts in mind the following objectives are undertaken:

- To study the effect of chitosan on the growth and development of BRRI dhan62
- To evaluate the effect of chitosan on yield of BRRI dhan62

CHAPTER 2

REVIEW OF LITERATURE

Plant growth regulators are the substances that standardize the growth in an incredible form. Many scientists are now studying the pattern of growth and development of plant treated with different plant growth regulators. Chitosan is a natural biopolymer which stimulates growth and increases yield whose functions are very nearer to Gibbrelic acid (GA_3). Extensive studies of the regulatory effects of chitosan on various crops have been carried out worldwide by different workers. Some of the related reports are reviewed below.

2.1. Effect of PGRs on morphological and growth characters

2.1.1. Plant height

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

Tiwari *et al.* (2011) conducted an experiment to identify a suitable and cost efficient substitute of Gibbrelic acid to enhance hybrid rice seed production**.** The results indicated that the analysis of variance was significant for all the characters except plant height.

Supachitra *et al*. (2011) conducted an experiment to determine the plant growth stimulating effects of chitosan on Thai indica rice (*Oryza sativa* L.) cv. Leung Pra Tew 123. Rice seedlings were treated with oligomeric chitosan with 80% degree of deacetylation at the concentration of 40 mg L^{-1} by seed soaking overnight before sowing, followed by spraying on 2-week and 4-week old seedlings, respectively. The oligomeric chitosan stimulated plant height.

Application of oligo-chitosan increased mineral uptake of coffee and stimulated the growth of coffee seedlings. Spraying oligo-chitosan with concentration of 60 ppm increased the height of the coffee seedlings up to 33.51% (Nguyen *et al*., 2011).

A positive effect of Chitosan was observed on the growth of roots, shoots and leaves of several crop plants (Chibu and Shibayama, 2001). Chitosan under low temperature increased shoot height and root length in maize plants compared to that of the control (Guan *et al.*, 2009).

Boonlertnirun *et al*. (2008) revealed that application of Chitosan on rice plants did not influence the plant height significantly. Sultana (2007) applied Miyobi on rice and reported that plant height increased in Miyobi applied plant than control.

A greenhouse experiment was conducted by Boonlertnirun *et al*. (2006) to determine the most effective Chitosan type and appropriate application method for increasing rice yield and found that the application of Chitosan with different molecular weights and different application methods did not affect plant height.

The application of Chitosan via seed soaking and spraying 4 times created variation in number of tillers/plant and dry matter accumulation, but did not affect plant height, 1000-grain weight and number of seeds/head of rice (Boonlertnirun *et al.*, 2005).

Sekh (2002) carried out an experiment to find out the effect of PGRs on rice and found that GABA @ 0.33 mgL^{-1} produced the highest shoot height.

Hoque (2002) conducted field experiment on a high yielding variety (Shatabdi) of wheat to evaluate the effect of CI-IAA, GABA and TNZ-303 by soaking seeds in 0.16 mlL^{-1}, 0.33 mlL^{-1} and 0.66 mlL^{-1} aqueous solutions and revealed that the GABA at 0.33 mlL^{-1}

produced the tallest shoot at 60 and 90 DAS. Shoot height was significantly higher over that produced in control.

2.1.2. Number of tillers hill^{-1}

Limpanavech et al. (2008) conducted an experiment with six types of Chitosan molecules, P-70, O-70, P-80, O-80, P-90, and O-90, to determine the effects on Dendrobium 'Eiskul' floral production. Chitosan O-80 at all concentrations tested, 1, 10, 50, and 100 mg L-1 could induce early flowering and increase the accumulative inflorescence number during the 68 weeks of the experimental period, when compared to the non-Chitosan treated controls.

The application of polymeric Chitosan by seed soaking before planting followed by four foliar sprayings throughout cropping season significantly increased the number of tillers per plant (Boonlertnirun et al., 2006).

Hoque (2002) carried out an experiment on seed germination and seedling growth by seed soaking of different wheat cultivars with 0.16 mlL^{-1}, 0.33 mlL^{-1} and 0.66 mlL^{-1} of CI-IAA, GABA and TNZ-303. The number of tiller enhanced significantly at 0.33 mlL^{-1} of PGR compared to that of control.

2.1.3 Total dry matter (TDM)

Lu Chang-min *et al*. (2009) reported that the tomato seed were soaked in different concentration of Chitosan solution which were impact on tomato seed germination and the growth of seedlings. The results showed that the tomato main root length and root activity were higher than the control that treated with water. Chitosan under low temperature increased shoot and root dry weight in maize plants compared to that of the control (Guan *et al.*, 2009).

Siddique (2007) sprayed Myobi @1, 2 and 3 mg L^{-1} on boro rice. Myobi increased total dry matter production with the increased concentration of Myobi. In general, that 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 (Martinez *et al*., 2007).

Boonlertnirun *et al*. (2006) indicated that applicaiton of polymeric Chitosan by seed soaking before planting followed by four foliar sprayings throughout cropping season significantly increased ($P<0.05$) the dry matter accumulation in the rice grain.

Afzal *et al*. (2005) were investigated that the effects of seed soaking with plant growth regulators (IAA, GA_3, kinetin or prostart) on wheat (*Triticum aestivum* cv. Auqab-2000). Results revealed that the root and shoot length, fresh and dry weight of seedlings were significantly increased by 25 mg L^{-1} kinetin followed by 1% prostart for 2 h treatments under both normal and saline conditions.

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

Jahan (2001) reported that the increased fresh weight of rice (cv. BR-14, Gazi) shoot by KNap as seed soaking and foliar spray on the crop. Weights of dry matter in rice also increased due to application of KNap and nitrogen. Application of more concentration of KNap than appropriate concentration decreased the dry matter production of different crops.

Chibu and Shibayama (1999) studied Chitosan application on four crops: soybean, lettuce, tomato and rice. The results showed that Chitosan at 0.1 or 0.5% leaf dry weight of soybean, lettuce and rice whereas Chitosan at 0.1% showed positive effects on dry weight

of tomato. Chibu and Shibayama (1999) found that dry weight of dry-land rice cv. Misatohatamochi grown with both 0.1 and 0.5% of Chitosan were increased over the control. Gulnaz *et al.* (1999) reported that seeds of wheat treated with 10 mg L^{-1} GA_3 resulted in 36-43% increase in dry matter at 13, 11 ds/m.

Ali *et al*. (1997) also revealed that dry matter accumulation of soybean cv. Akishirome increased 42 days after sowing with soils supplemented with 0.1% Chitosan. The results of Hidalgo *et al*. (1996) showed that tomato plants grown from seed coated with Chitosan increased dry weight and stem thickness more than the untreated plants.

2.2 Effect of Plant growth regulators on yield contributing characters

2.2.1 Effective tiller hill^{-1} and length of panicle

Islam (2007) applied Miyobi on rice at the rate of 1.0, 2.0, 3.0 and 4.0 mgL^{-1} and reported that panicle length increased with increasing hormone concentration and the highest panicle length was recorded in 4.0 mgL^{-1} Miyobi. Similar result was also reported by Sultana (2007) in rice. Lu *et al.* (2002) found that the panicle numbers of rice were increased after watering with Chitosan at the rate of 0.4 g /50 cm^3 (Chitosan: water). Hoque (2002) was conducted the field experiment and observed that the wheat cv. Treated with GABA (0.33 mlL^{-1}) produced the tallest spike (9.00 cm) followed by TNZ-303 (8.10 cm) and CL-IAA (7.95 cm). The length of spike in GABA treated plant was significantly higher than the other treatments.

Ohta *et al.* (2001) also reported that the application of a soil mix of Chitosan 1% w/w at sowing remarkably increased flower numbers of *Eustoma grandiflorum.* Zhu *et al.* (1998) reported that application of GA_3 increased panicle length, number of effective panicles, grain number panicle and 1000-grain weight, in wheat, length of spike was influenced significantly by PGRs.

2.2.2 Number of filled and unfilled grains panicle-1

Boonlertnirun et al. (2005) indicated that seed numbers per panicle of rice plant cv. Suphan Buri-1 were not affected by various Chitosan concentrations.

Hoque (2002) observed that concentration 0.33 ml /L of GABA has produced the highest filled grain per spike (41.4) significantly higher over other treatments of TNZ-303 in wheat. Ohta et al. (2001) also reported that the application of a soil mix of Chitosan 1% w/w at sowing remarkably increased flower numbers of *Eustoma grandiflorum.*

2.2.3 Thousand grain weight

An experimental trial was carried out by Ghoname *et al*., 2010 in the two successive seasons of 2008 and 2009 to investigate and compare the enhancing effects of three different biostimulation compounds on growth and production of sweet pepper plants. Three weeks after transplanting, plants were sprayed with any of the individual Chitosan (2, 4 and 6 cm /l). Data showed that individual fruit weight and number of fruits were also improved (Ghoname *et al*., 2010).

Islam (2007) conducted a field experiment on rice. He sprayed Myobi@2, 3 and 4 mg L^{-1} and GABA at 2, 3 and 4 mgL^{-1} as foliar application. He observed highest 1000-seed weight for 2 mgL^{-1} GABA followed by 2 mgL^{-1} Myobi.

A greenhouse experiments were conducted to determine the effect of Chitosan on drought recovery and grain yield of rice under drought conditions. Results revealed that the Chitosan applied before drought treatment gave the highest 1000-seed yield and also showed good recovery on yield (Boonlertnirun *et al*., 2007).

Yadav and Christopher (2006) reported that panchagavya spray recorded significantly higher rice seed length (8.05 cm) and breadth (2.49 cm) as well as 1000 seed weight

(16.55 g) as compared to without panchagavya spray (7.98 cm, 2.45 cm and 15.59 g, respectively).

Liupeng (1997) observed in a pot trial that rice plant sprayed with GA_3 at 5% panicle emergence and 2 and 3 days after to give total doses of 90, 120, 150 or 180 g GA_3 ha^{-1} had increased 1000-grain weight in all doses of GA_3. Increased in seed weight was found in wheat (Gurdev and Saxena, 1991).

Krivtsov *et al*. (1996) which found that thousand-grain weight and spike weight of wheat plants increased in treatment with low concentrations of polymeric Chitosan. In contrast, the work of Kuznia *et al*. (1993) found that seeds of white lupine treated with Chitosan did not consistently increased yields.

2.2.4 Grain yield

Sultana (2010) from BAEC, Bangladesh reported that the Oligo-Chitosan was applied for its potential use as plant growth promoter on growth and productivity of Maize (*Zea mays* L) plants. The foliar spraying of oligo-Chitosan (molecular weight 7,000 Da) with the concentration of 25, 50 and 75 mg L^{-1} was applied. The results showed that the application of oligo-Chitosan, at the concentration of 75 mg L^{-1}, plays a significant role in terms of plant height, weight of cob and weight of seeds per Maize.

Chitosan application proved to stimulate early growth stages of lettuce, soybean and upland rice. More recently, Abdel-Mawgoud *et al*., (2010) found an improvement effects on strawberry production or yield as a result of Chitosan application. Uddin *et al*. (2009) studied the effect of four different plant growth regulators viz. Control (No application of

PGR), NAA (30 mg L^{-1}), GA (30 mg L^{-1}) and 2, 4-D (30 mg L^{-1}) on tomato. The maximum fruits $plant^{-1}$ (42.66), average weight of individual fruit (92.06 g), yield $plant^{-1}$ (2.49 kg) and yield ha^{-1} (93.23 t ha^{-1}) were found in PGR and the minimum for all parameters were found in control (PGR) treatment.

Aziz and Miah (2009) conducted an experiment to determine the performance of "Flora" as PGR on the growth and yield of wetland rice under the treatment of T_1= Control (No-fertilizer), T_2= "Flora" @3ml/lit. of water, T_3= Soil Test Based (STB) dose and T_4= T_3 + "Flora" @3ml/lit. of water. BRRI dhan31 was used as test crop. The treatment T_4 where chemical fertilizer was applied on STB in combination with "Flora" produced the maximum yield but in terms of economic point of view the treatment T_3 (STB) was found superior to other treatments.

Boonlertnirun *et al*. (2008) conducted an experiment on application of Chitosan in rice production. The results showed that application of Chitosan by seed soaking and soil application four times throughout cropping season significantly increased rice yield over the other treatments.

A number of Greenhouse experiments were conducted to determine the effect of Chitosan on drought recovery and grain yield of rice under drought conditions. Results revealed that the Chitosan applied before drought treatment gave the highest yield and yield components and also showed good recovery, Boonlertnirun *et al.* (2007)

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 mg L^{-1}.

2.2.5 Harvest index

The highest harvest index (38.50%) was observed from 50 mg L^{-1} GA_3 which was statistically identical with 25 mg L^{-1} and the lowest harvest index (32.96%) was obtained in control (Akter *et al*., 2007).

Harvest index is an important which expose sufficient idea about biomass and seed production in crops (Rahim, 2005). According to Begum (2006), the highest Harvest index (31%) was found with GABA at the concentration of 2mgL^{-1} and the lowest (29%) at the concentration 1mg$L^{-1.}$

Hoque (2002) soaked wheat seeds in 0.16, 0.33 and 0.66 mlL^{-1} solutions of GABA, TNZ-303 and CI-IAA respectively and observed that 0.33 mlL^{-1} of GABA was enhanced the highest harvest index (47.19%) which was statistically identical to that of 0.66 mlL^{-1} (46.4 1%) of same PGR.

Wheat cv. Sonalika grown with 100 mg L^{-1} GA3 or 10 mg L^{-1} IAA + $ZnSO_4$ enhanced the harvest index which was the highest over untreated control and other treatments (Baruah, 1990).

CHAPTER 3
MATERIALS AND METHODS

The experiment was conducted at the Sher-e-Bangla Agricultural University Farm, Dhaka under the Agro Ecological Zone-28 of Madhupur Tract,during the period from July 2014 to October 2014 to study the effect of organic growth promoting substance (chitosan) on growth and yield of BRRI dhan62. For better understanding the site, it is shown in the Map of AEZ of Bangladesh (Fig. 1).

This chapter presents a brief description of the soil, crop, experimental design, treatments, cultural operations, collection of soil and plant samples and analytic methods followed in the experiment. This chapter has been divided into a number of sub-heads described as below:

3.1 Experimental details of site

3.1.1 Soil

The experiment was conducted in typical rice growing silt loam soil at the Sher-e-BanglaAgricultural University Farm, Dhaka during T. Aman season of 2014.The farm belongs to the General soil type, ”Deep Red Brown Terrace Soil” under Tejgaon Series. The land was above flood level and sufficient sunshine was available during the experimental period. The morphological, physical and chemical characteristics of initial soil are presented in Tables 1 and 2.

3.1.2 Climate

The climate of the experimental area is characterized by scanty rainfall associated withmoderately low temperature during the *kharif*-2 season. The weather information regarding temperature, rainfall, relative humidity prevailed at the experimental site during the cropping season July 2014 to October 2014 have been presented in Appendix I.

3.1.3 Planting material

BRRI dhan62 was used as the test crop in this experiment. This variety was developed atthe Bangladesh Rice Research Institute. It is recommended for T. Aman season. Averageplant height of the variety is 98 cm at the ripening stage. The grains are mediumfine and white. It requires about on an average 100 days completing its life cycle with an averagegrain yield of 3.5-4.5 t/ha (BRRI, 2013).

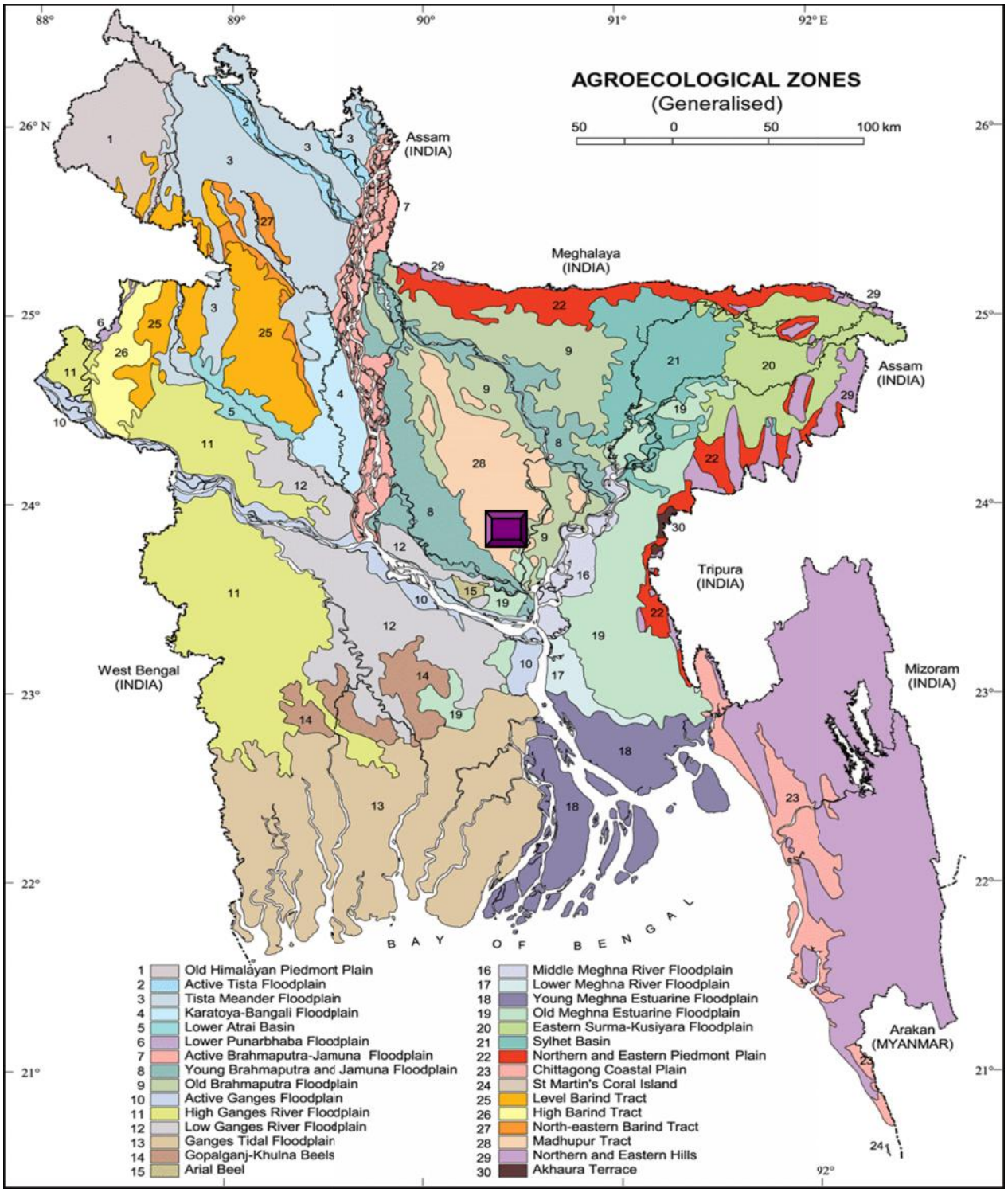


Figure 1. Agroecologcal zones of Bangladesh

Table 1. Morphological Characteristics of the Experimental Field

Morphology	Characteristics
Location	SAU Farm, Dhaka
Agroecological zone	Madhupur Tract (AEZ- 28)
General Soil Type	Deep Red Brown Terrace Soil
Parent material	Madhupur clay
Topography	Fairly level
Drainage	Well drained
Flood level	Above flood level
Soil series	Tejgaon

(FAO and UNDP, 1988)

Table 2.Physical and Chemical properties of the initial soil sample

Characteristics	Value
Particle size analysis	
% Sand (2.0-0.02 mm)	22.53
% Silt (0.02-0.002 mm)	56.72
% Clay (<0.002 mm)	20.75
Textural class	Silt Loam
pH (1: 2.5 soil- water)	5.9
Bulk Density (g/cc)	1.45
Particle Density (g/cc)	2.52
Organic carbon (%)	0.47
Organic matter (%)	0.81
Total N (%)	0.05
Available P (ppm)	18.1
Available K (meq/100g soil)	0.10
Available S (ppm)	22

3.1.4 Land preparation

The experimental field was first opened on August 2014 with the help of a power tiller, later the land was saturated with irrigation water and puddled by three successive ploughing and cross-ploughing. Each ploughing was followed by laddering to have a good puddled field. All kinds of weeds and residues of previous crop were removed from the field. The experimental plots were laid out as per treatment and design.

3.1.5 Experimental design

Experimental Design: Randomized Complete Block Design (RCBD)

No. of Treatment: 7

No. of Replication: 3

Total no. of Plot: 21

Plot size: 3.5 m ×3 m

Block to block distance: 0.75 m

Plot to plot distance: 0.50 m

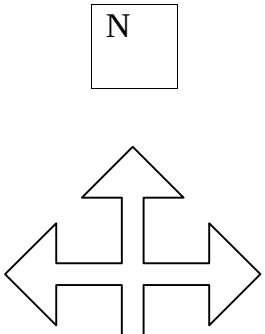
Area of land: 28.5m ×11m = 313 m^2

3.1.6 Layout of the experiment

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Each block was sub-divided into seven unit plots. The treatments were randomly distributed to the unit plots in each block. The total number of plots was 21 (7 ×3). The unit plot size was **3.5**m ×3 m. Block to block distance was 0.75 m and Plot to plot distance was 0.50 m. The layout of the experiment has been shown in Fig. 2.

Plot size: 3.5 m ×3 m

Plot to plot distance: 0.50 m



Block to block distance: 0.75 m

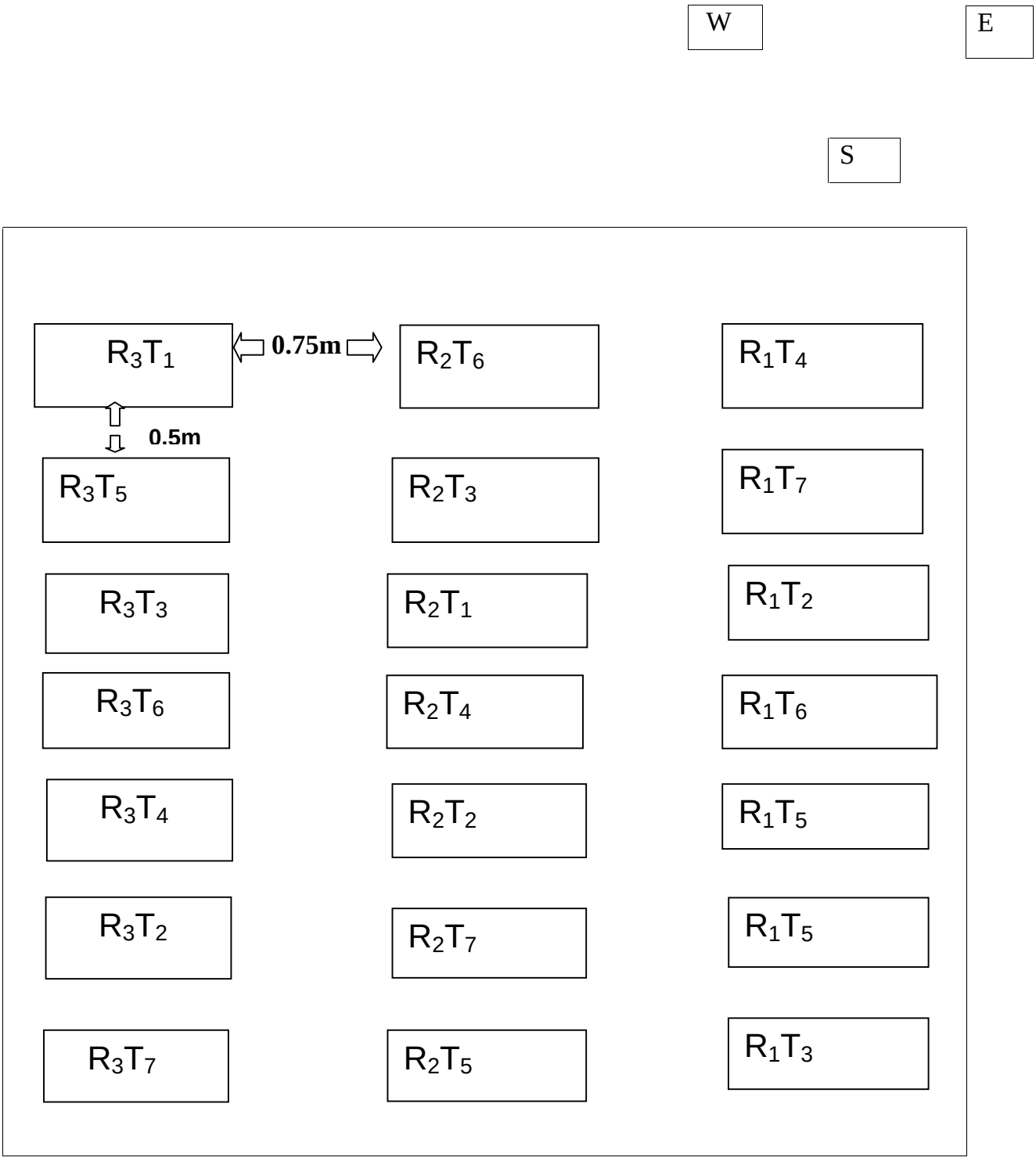


Figure 2. Layout of the experimental plot

3.1.7 Initial soil sampling

Before land preparation, initial soil samples at 0-15 cm depth were collected fromdifferent spots of the experimental field. The samples were drawn by means of an auger from

different location covering the whole experimental plot and mixed thoroughly to make a composite sample. The composite soil sample were air-dried,crushed and passed through a 2 mm (8 meshes) sieve. After sieving, the soil sampleswere kept in a plastic container for physical and chemical analysis of the soil.

3.1.8 Treatments

There were 7 treatment combinations. The treatment combinations were as follows:
T_1: No chemical fertilizer, no organic growth promoting substance like chitosan (Control)
T_2: Only Chitosan spray (Twice in a week until flower initiation i.e., mid September, 2014)
T_3: Recommended fertilizer (Urea 150 kg/ha + TSP & MOP 70 kg/ha each + Gypsum 40 kg/ha + $ZnSO_4$ 10 kg/ha)
T_4: Recommended fertilizer (Urea 150 kg/ha + TSP & MOP 70 kg/ha each + Gypsum 40 kg/ha + $ZnSO_4$ 10 kg/ha) + Chitosan spray(Twice in a week until flower initiation i.e., mid September, 2014)
T_5: Half of recommended fertilizer(Urea 75 kg/ha + TSP & MOP 35 kg/ha each+ Gypsum 20 kg/ha + $ZnSO_4$ 5 kg/ha)
T_6: Half of recommended fertilizer(Urea 75 kg/ha + TSP & MOP 35 kg/ha each + Gypsum 20 kg/ha + $ZnSO_4$ 5 kg/ha) + Chitosan spray (Twice in a week until flower initiation i.e., mid September, 2014)
T_7: Recommended fertilizer except urea (TSP & MOP 70 kg/ha each+ Gypsum 40 kg/ha + $ZnSO_4$ 10 kg/ha) + Chitosan spray (Twice in a week until flower initiation i.e., mid September, 2014)

3.1.9 Application of fertilizers

The fertilizers i.e. Urea, Triple super phosphate (TSP), Muriate of potash (MP), Gypsum and $ZnSO_4$ were used as sources of nitrogen, phosphorous, potassium, sulphur and Zinc applied @ 150 kg/ha, 70 kg/ha,70 kg/ha, 40 kg/ha and10 kg/ha respectively. At the time of final land preparation, full doses of TSP, MP, $ZnSO_4$, and gypsum were applied. Urea was applied in three equal splits. The first split was applied after 15 days of transplanting; the second split was applied after 35 days of transplanting i.e., at active vegetative stage and the third split was again applied at panicle initiation stage.

3.1.10 Application of plant growth regulator

Chitosan is a powder prior to spray. Chitosan was diluted to get working solution. Chitosan solution was applied in the form of fine foliar spray by hand sprayer. The spray was done at 10 DAT twice in a week until flower initiation i.e., mid September, 2014. The sprays were made at early hours to avoid dehydration effect.

3.1.11 Raising of Seedlings

The seedlings of rice were raised following the wet-bed methods. Seeds were sown on a well-prepared seedbed. During seedling growing, no fertilizers were used. Proper water and pest management practices were followed whenever required.

3.1.12 Transplanting

Twenty five days old seedlings of BRRI dhan62 were carefully uprooted from the seedlingnursery and transplanted on 29July, 2014 in well puddle plot. Three seedlings per hillwere used following a spacing of 20 cm × 15 cm. After one week of transplanting allplots were checked for any missing hill, which was filled up with extra seedlingswhenever required.

3.1.13 Intercultural operations

Intercultural operations were done to ensure normal growth of the crop. Plant protectionmeasures were followed as and when necessary. The following intercultural operationswere done.

3.1.13.1 Irrigation

T. Aman is cultivated in rainfed condition. So it is very difficult to maintain irrigationtreatments in the main plots. When supplemented irrigation was applied, treatment wiseirrigation levels were maintained. Necessary irrigations were provided to the plots as andwhen required during the growing period of rice crop. Irrigation treatment of saturatedcondition was not properly maintained due to rainy season.

3.1.13.2 Weeding

Few weeds, namely, Bermuda grass(*Cynodon dactylon),*Barnyard grasses**(***Echinochloa crusgalli*), **Nut** sedge *(Cyperus rotundus)*etc. were found in each plot after two weeks of transplanting of rice. They were uprooted immediately by hand pulling.

3.1.13.3 Insect and pest control

There was no infestation of diseases in the field but leaf roller (*Chaphalocrosismedinalis*,Pyralidae, and Lepidoptera) was observed in the field and used Malathion @ 1.12 L ha-1.

3.1.14 Plant sampling at harvest

Plants from 1 m^2 were randomly selected from each plot to record the yield contributing characters like plant height (cm), number of tillers $hill^{-1}$, panicle length (cm), and number of grains per panicle and 1000 grain weight (g). The selected hills were collected before harvesting. Grain yields were recorded plot-wise and expressed at t ha^{-1} on sundry basis.

3.1.15 Harvesting

The crop was harvested at full maturity when 80-90% of the grains were turned into straw colored on 15 October,2014. The crop was cut at the ground level and plot wise crop was bundled separately and brought to the threshing floor. Grain and straw yields were recorded separately plot-wise and moisture percentage was calculated after sun drying. Dry weight for both grain and straw were also recorded.

3.1.16 Data collection

The data on the following growth and yield contributing characters of the crop were recorded:

- Plant height (cm)
- Number of tiller
- Number of effective tiller

- Panicle length (cm)
- Number of grains/panicle
- Number of filled grains/panicle
- Number of unfilled grains/panicle
- Weight of raw straw (t/ha)
- Weight of dry straw (t/ha)
- Weight of fresh grain (t/ha)
- Weight of dry grain (t/ha)
- 1000 dry grain weight(g)

3.1.16.1 Plant height (cm)

The plant height was measured from the ground level to the top of the panicle. Plants of 10 hills (1 m^2) were measured and average for each plot.

3.1.16.2 Number of tillers hill^{-1}

Ten hills were taken at random from each plot and the number of tillers hill^{-1} were Counted.

3.1.16.3 Number of effective tillers hill^{-1}

The total number of effective tiller/hill was counted as the number of panicle bearinghill/plant. Data on effective tiller/hill were counted from ten selected hills and averagevalue was recorded.

3.1.16.4 Panicle length (cm)

Measurement was takenfrom basal node of the rachis to apex of each panicle.

Eachobservation was an average of 10 panicles.

3.1.16.5 Number of grains panicle^{-1}

Total number of grain counted from the both fertile and sterile grain per panicle.The data were recorded from each of the plants randomly selected from each plot.

3.1.16.6 Number of filled grains panicle^{-1}

The total numbers of filled grainswere calculated from selected ten plants of a plot onthe basis of no grain inthe spikeletand then average numbers of filled grain perpanicle was recorded.

3.1.16.7Number of unfilled grains panicle^{-1}

The total number of unfilled grains were calculated from selected 8 plants of a plot onthe basis of no grain in the spikeletand then average number of unfilled grain perpanicle was recorded.

3.1.16.8 Weight of raw straw plot^{-1}

Straw obtained from each unit plot were weighted carefully. The weight of straw of the respective unit plot yield was converted to t/ha.

3.1.16.9 Weight of dry straw plot^{-1}

Straw obtained from each unit plot were sun-dried and weighted carefully. Thedryweight of straw of the respective unit plot yield was converted to t/ha.

3.1.16.10 Weight of fresh yield plot^{-1}

Grains obtained from each unit plot were weighted carefully. The weight of grains of the respective unit plot yield was converted to tha^{-1}.

3.1.16.11 Weight of dry yield plot^{-1}

Grains obtained from each unit plot were sun-dried and weighted carefully. The dryweight of grains of the respective unit plot yield was converted to tha^{-1}.

3.1.16.12 1000-grain weight

One thousand seeds were counted randomly from the total cleaned harvested & dried seeds andthen weighted in grams and recorded.

3.1.17Physical and Chemical analysis of soil samples

Soil samples were analyzed for both physical and chemical properties in thelaboratory of Soil Science Department of Sher-e-Bangla AgriculturalUniversity(SAU),Sher-e-Bangla Nagar, Dhaka-1207. The properties studied included soil texture, soil pH, soil particle density,and organic carbon, total N, available P, exchangeable K and available S. The physicaland chemical properties of the initial soil have been presented in Table 2.The soilwas analyzed by standard methods.

3.1.17.1 Particle size analysis

Particle size analysis of soil was done by Hydrometer Method (Bouyoucos, 1962) and the textural class was determined by plotting the values for % sand, % silt and % clay to the "Marshall's Textural Triangular Coordinate" according to the USDA system.

3.1.17.2 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).

3.1.17.3 Particle density

Soil particle density was measured by Volumetric Flask Method. The result wasexpressed in g/cc.

3.1.17.4 Organic Carbon

Organic carbonin soilwas determined byWalkley 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 in percentage.

3.1.17.5 Total nitrogen

Total nitrogen of soil was determined by Micro Kjeldahl method where soil was digested with 30% H_2O_2, conc. $H_2SO_4$and catalyst mixture (K_2SO_4:$CuSO_4$.$5H_2O$:Se powder in the ratio of 100:10:1). Nitrogen in the distillate trapped in H_3BO_3 with 0.01 N H_2SO_4 (Bremner and Mulvaney, 1982).

3.1.17.6 Available phosphorus

Available phosphorus was extracted from soilby shaking with 0.5 M $NaHCO_3$ solution of pH 8.5 (Olsen *et al*., 1954). The phosphorusin the extract was then determined by developing

blue color using $SnCl_2$ reduction of phosphomolybdate complex. The absorbance of the phosphomolybdate blue color wasmeasured at 660 *n*m wave length by Spectrophotometer and available P was calculated with the help of standard curve.

3.1.17.7 Exchangeable potassium

Exchangeable potassium was determined by 1N NH_4OAc (pH 7.0) extract of the soil by using Flame photometer (Black, 1965).

3.1.17.8 Available sulphur

Available sulphur in soil was determined by extracting the soil samples with 0.15% $CaCl_2$ solution (Page *et al*., 1982). The S content in the extract was determined turbimetrically and the intensity of turbid was measured by Spectrophotometer at 420 *n*m wave length.

3.18 Statistical Analysis

The data obtained for different parameters were statistically analyzed to find out thesignificant difference of different treatments on yield and yield contributing characters ofBRRI dhan62. The mean values of all the characters were calculated and analysis ofvariance was performed by MSTAT-C. The significance of the difference among thetreatment means was estimated by the Duncan's Multiple Range Test (DMRT) at 5%level of probability (Gomez *et. al.*, 1984).

CHAPTER 4
RESULTS AND DISCUSSION

The overall results observation, discussion and findings of similar results of the experiment were presented in this chapter with some tables and figures under the following headings and sub-headings. The experiment was conducted to study the effect of organic growth promoting substance (chitosan) on the growth and yield of BRRI dhan62. The results are presented and discussed under the following parameters.

4.1 Growth and yield components

4.1.1 Plant height

Plant height of BRRI dhan 62 was significantly influenced by combined application of fertilizer and chitosan spray T_4 treatment (Table 3) but there was not so significant role of

only chitosan spray on plant height (T_2 treatment). All the treatment were recorded with significantly higher plant height over the control (T_1 treatment). Plant ranged from 81.17 to 87.78 cm. The tallest plant of 87.78 cm was found in T_4 receiving full dose of fertilizer along with chitosan spray. However, plant height recorded either with single or combined application of fertilizer and chitosan was higher than that of control treatment. The shortest plant height of 81.17 cm was found in T_1 (control) treatment having no fertilizer and chitosan spray. Treatment T_4 receiving full dose of fertilizer (Urea 150 kg/ha, TSP & MOP 70 kg/ha, Gypsum 40 kg/ha, $ZnSO_4$ 10 kg/ha) along with foliar spray of chitosan produced 8.14% higher plant height compared to control treatment (Fig. 3). The treatments may be ranked in the order of $T_4>T_3>T_6>T_5>T_7>T_2>T_1$ treatments. This result was supported by the work of Chibu *et al.* (2000) in rice who reported that plant height increased in Chitosan applied plants as compared to control plants and similar result was also found by Martinez *et al.* (2007) in tomato. On the other hand Khan *et al*. (2002) who found that foliar application of oligomeric chitosan did not affect soybean height. The increased plant height through the application of fertilizer along with chitosan was also reported by many other scientist (Supachitra *et al*. (2011), Chibu and Shibayama, 2001), but only chitosan spray has no significant effect on increasing plant height (Boonlertnirun *et al*., 2008).

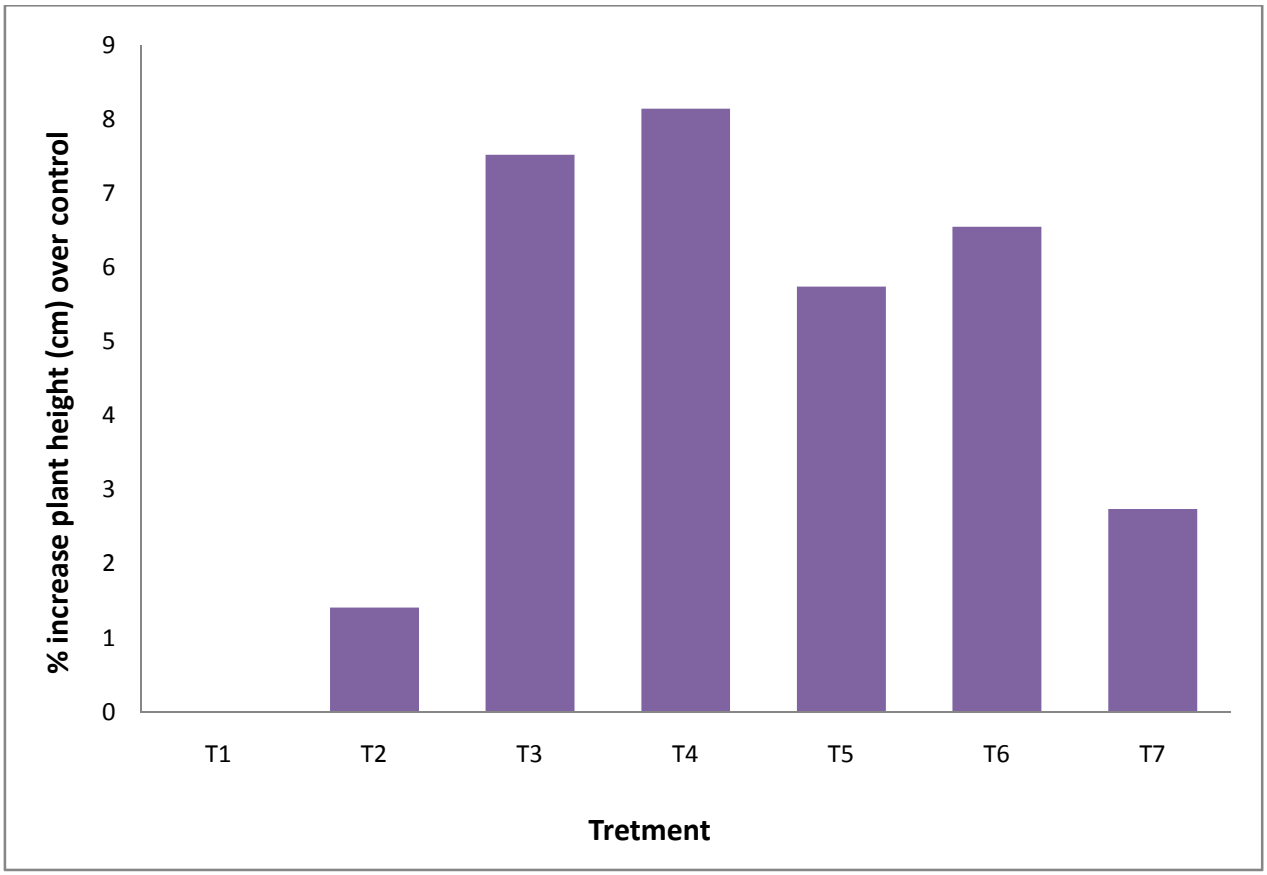


Figure 3. Effect of Organic Growth Promoting Substance (Chitosan) on Percent increased plant height over control of BRRI dhan62

4.1.2 Number of tillers hill^{-1}

The foliar application of Chitosan along with fertilizer had no statistically significant effect on the production of tillers hill^{-1} in BRRI dhan62 but higher number of tillers/hill were found between only chitosan application compared to control. (Table 3). The result revealed that Chitosan treated plants produced the higher number of tillers compare to

control (T_1 treatment). The number of tillers/hill ranged from 17 to 21.80. The highest number of tiller per hill (21.80) was found in T_4 receiving full dose of fertilizer (Urea 150 kg/ha, TSP & MOP 70 kg/ha, Gypsum 40 kg/ha, $ZnSO_4$ 10 kg/ha) along with foliar spray of chitosan and the lowest was found in T_1 (17) treatment.The treatments may be ranked in the order of $T_4>T_3>T_6>T_5>T_7>T_2>T_1$ in terms of number of tillers hill^{-1} (Fig. 4). Treatment T_4 produced 28.24% higher number of tillers per hill over control treatment (Fig. 4).

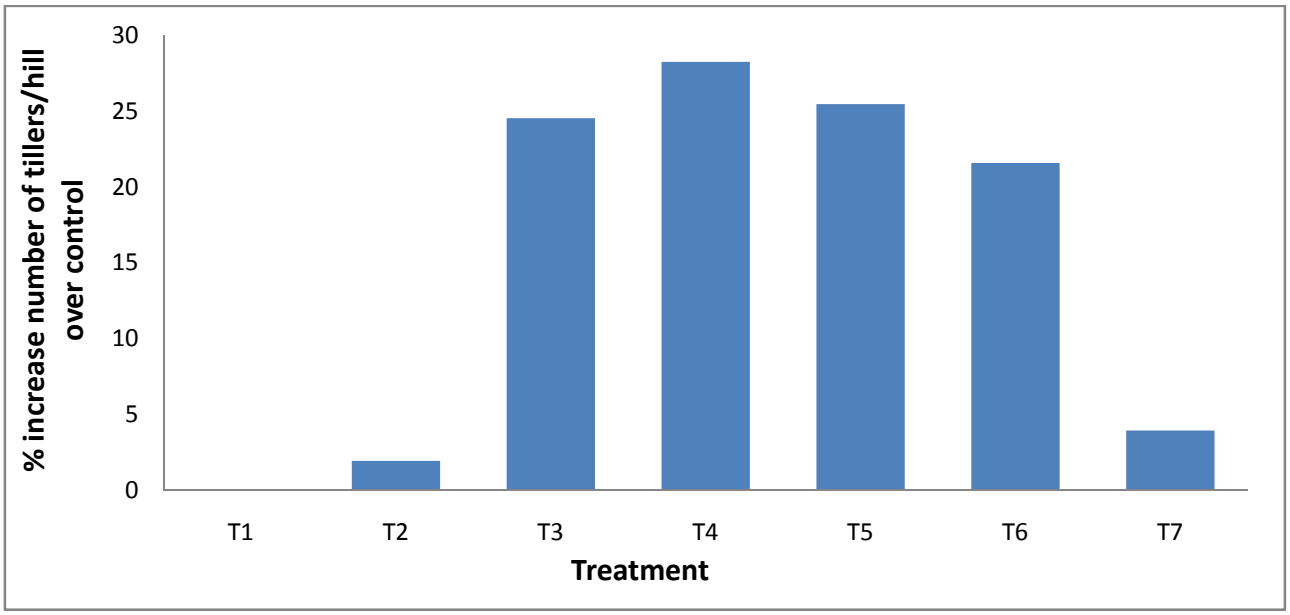


Fig. 4. Effect of Organic Growth Promoting Substance (Chitosan) on percent increase in number of tillers hill^{-1} over control of BRRI dhan62

4.1.3 Number of effective tillers hill^{-1}

The foliar application of Chitosan along with fertilizer had no statistically significant effect on the production of effective tillers hill^{-1} in BRRI dhan62 (Table 3). The result revealed that Chitosan treated plants produced the higher number of effective tillers compared to control(T_1 treatment). The number of effective tiller/hill ranges from 15.70 to 20.34. The highest number of effective tiller per hill (20.34) was found in T_4 receiving full dose of fertilizer (Urea 150 kg/ha, TSP & MOP 70 kg/ha, Gypsum 40 kg/ha, $ZnSO_4$ 10

kg/ha) along with foliar spray of chitosan and the lowest was found in T_1 (15.70) treatment. The treatments may be ranked in the order of $T_4>T_3>T_5>T_6>T_2>T_7>T_1$ in terms of number of effective tillers hill^{-1} (Fig. 5). Treatment T_4 produced 29.55% higher number of effective tillers per hill over control treatment (Fig. 5).

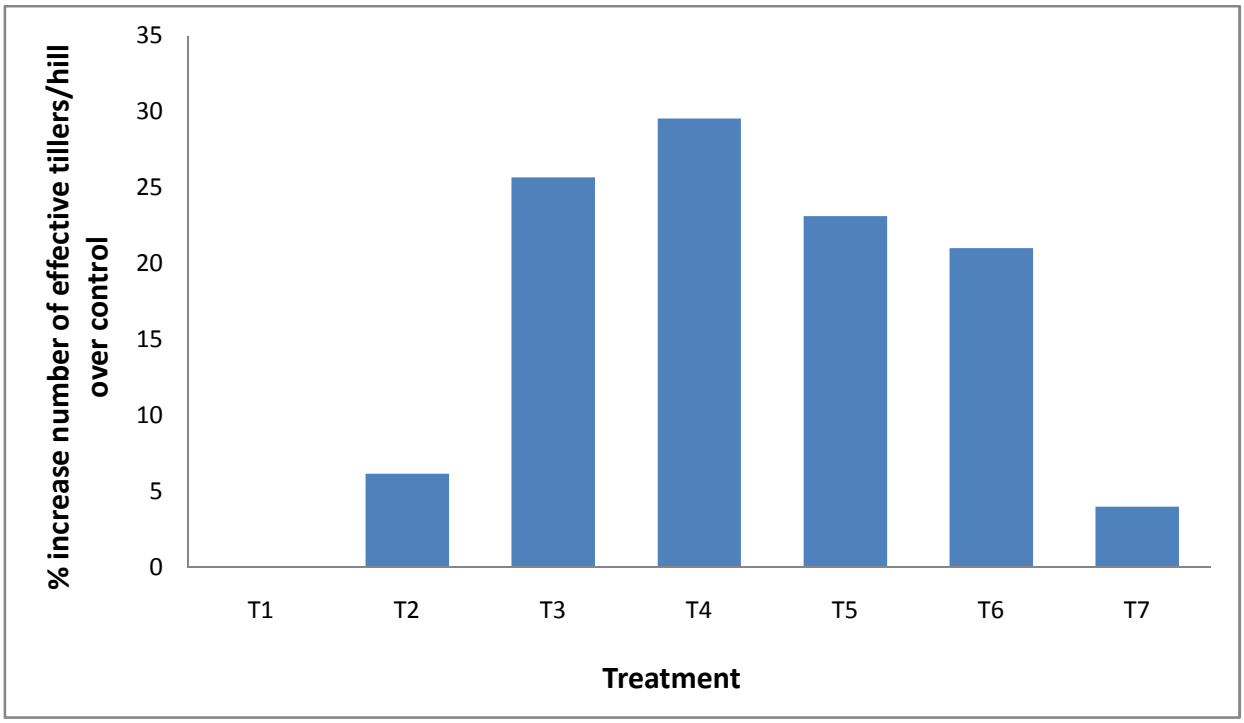


Fig. 5. Effect of Organic Growth Promoting Substance (Chitosan) on percent increase number of effective tillers hill^{-1} over control of BRRI dhan62

4.1.4 Panicle length

The effects of different treatments on panicle length are shown in Table 3. The highest panicle length (22.31 cm) was found in T_4 treatment which was receiving full dose of fertilizer (Urea 150 kg/ha, TSP & MOP 70 kg/ha, Gypsum 40 kg/ha, $ZnSO_4$ 10 kg/ha) along with foliar spray of chitosan and the lowest was found in T_1 (19.01 cm) treatment. The treatments may be ranked in the order of $T_4>T_3>T_6>T_5>T_7>T_2>T_1$ in terms of number of panicle length (Fig. 6). Treatment T_4 produced 17.36% higher panicle length over control treatment (Fig. 6).

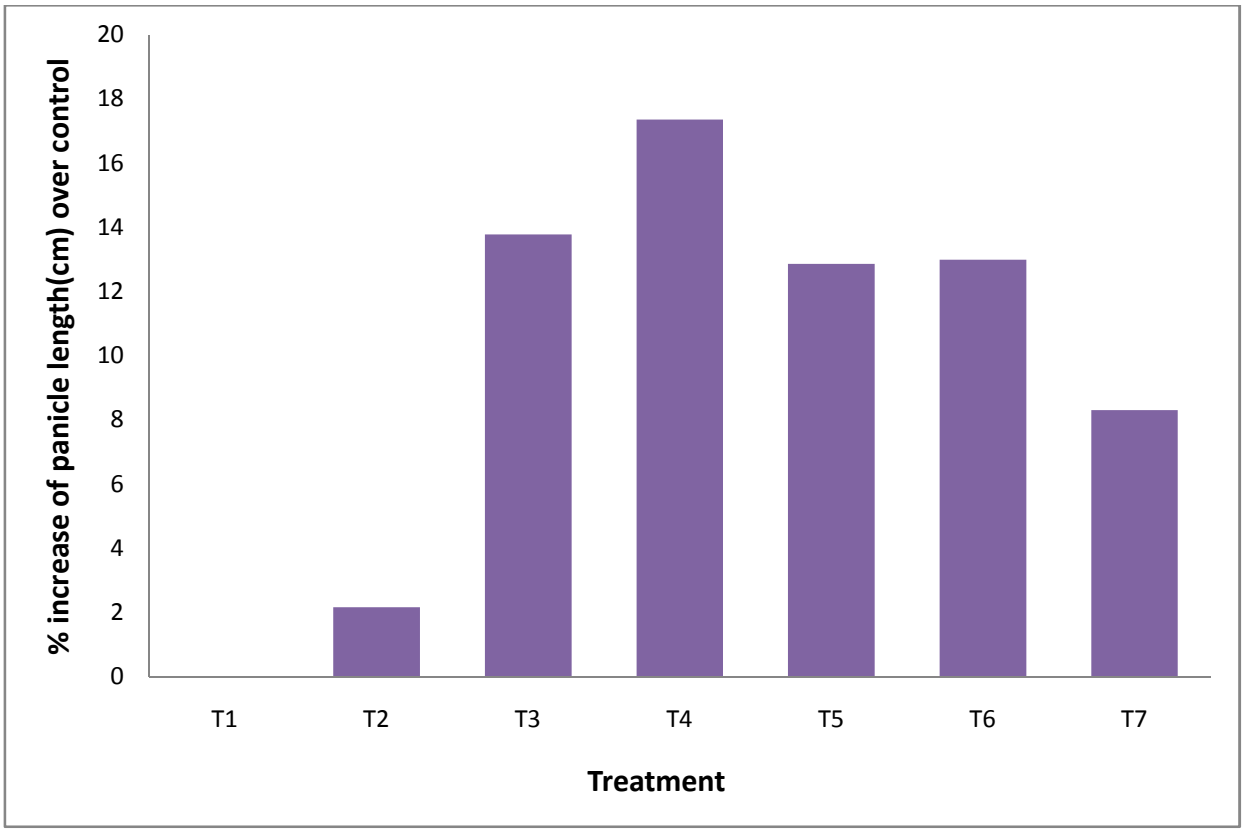


Fig. 6. Effect of Organic Growth Promoting Substance (Chitosan) on percent increase panicle length over control of BRRI dhan62

4.1.5 Number of grains panicle^{-1}

There was no statistically significant effect of the treatments on grains per panicle (Table 3). The number of grain panicle^{-1} ranged from 74.67 to 86.67. The maximum number of grains panicle^{-1} (86.67) was noted when Urea 150 kg/ha, TSP & MOP 70 kg/ha, Gypsum 40 kg/ha, $ZnSO_4$ 10 kg/ha was applied along with foliar spray of chitosan but no statistically significant differences were found between only chitosan application compared to control. The minimum number of grains per panicle (74.67/panicle) was recorded in T_1 treatment receiving no chemical fertilizer and chitosan spray. The treatments may be ranked in the order of $T_4>T_3>T_6>T_5>T_2>T_7>T_1$ with the respect of the

number of grains panicle^{-1} (Fig. 7). Treatment T_4produced 16.07% higher number of grains per panicle over control (Fig. 7).

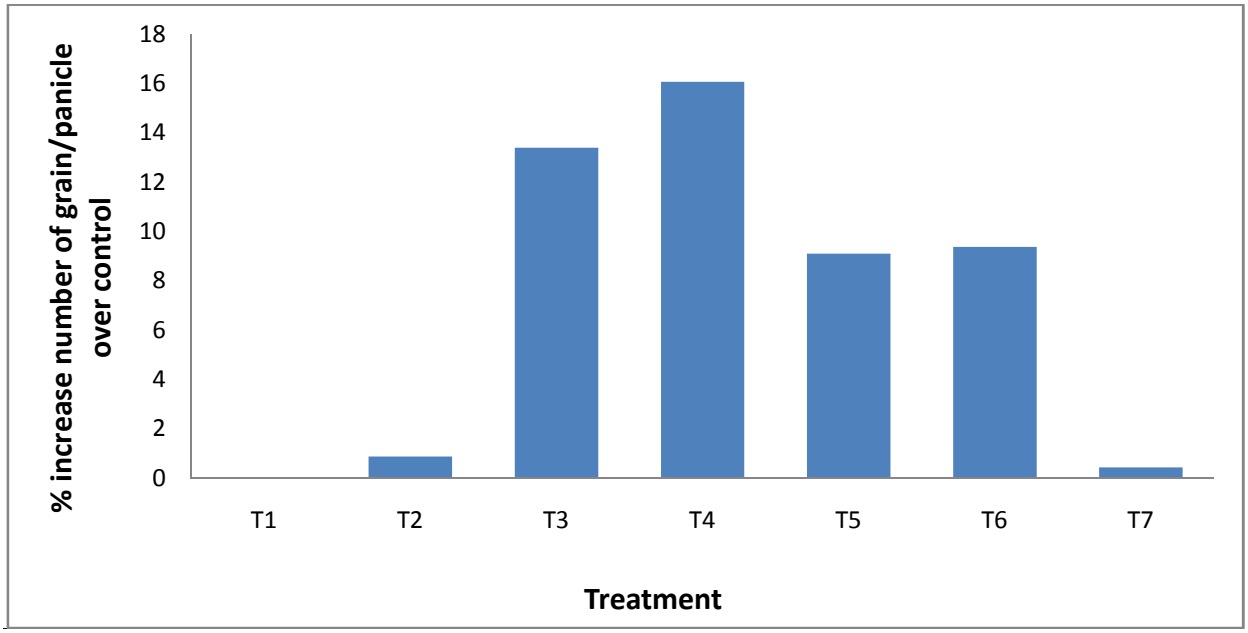


Fig. 7. Effect of Organic Growth Promoting Substance (Chitosan) on percent increase in number of grains/panicle over control of BRRI dhan62

4.1.6 Number of filled grains panicle^{-1}

There was no statistically significant effect of treatments on filled grains per panicle (Table 3). The number of filled grains panicle^{-1} ranged from 64.67 to 70.17. The maximum number of filled grains panicle^{-1} (70.17) was noted when Urea 150 kg/ha, TSP & MOP 70 kg/ha, Gypsum 40 kg/ha, $ZnSO_4$ 10 kg/ha was applied along with foliar spray of chitosan but no statistically significant differences were found between only chitosan application compared to control. The minimum number of filled grains per panicle (64.67/panicle) was recorded in T_1 treatment receiving no chemical fertilizer and chitosan spray. The treatments may be ranked in the order of $T_4>T_3>T_6>T_5>T_7>T_2>T_1$ with the

respect of the number of grains panicle^{-1} (Fig. 7). Treatment T_4 produced 8.50% higher number of grains per panicle over control (Fig. 8).

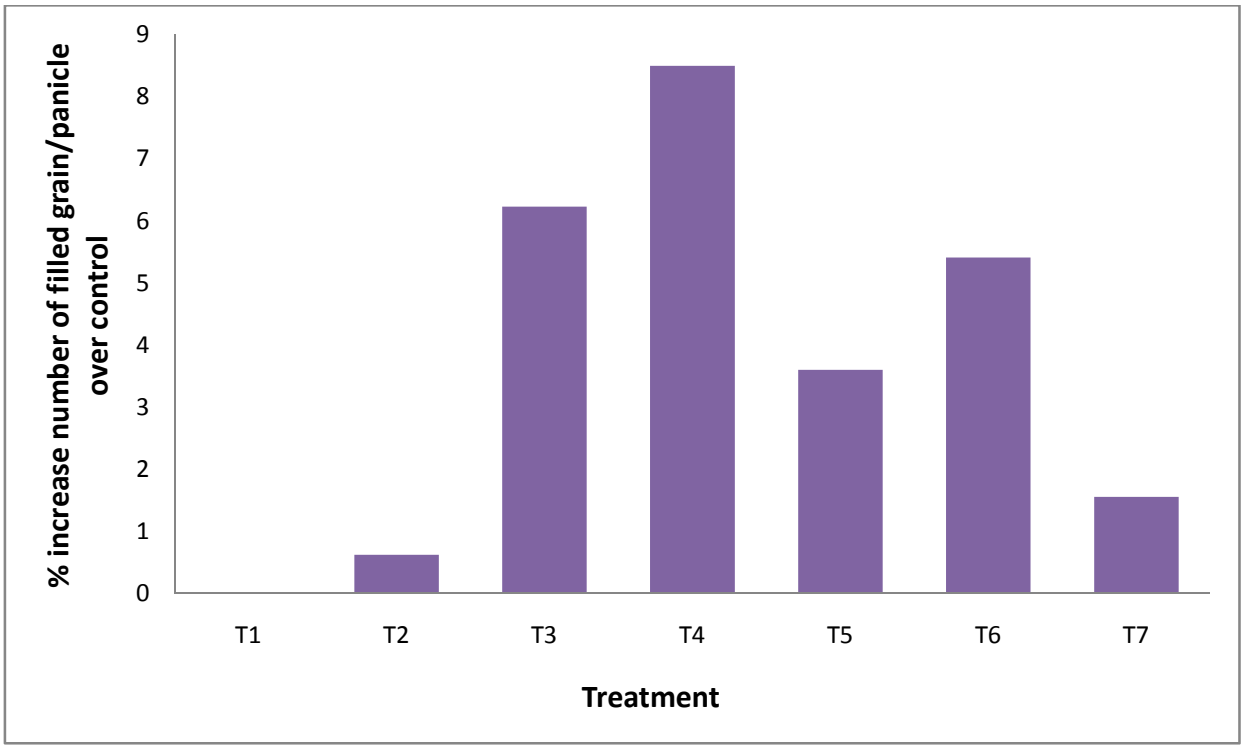


Fig. 8. Effect of Organic Growth Promoting Substance (Chitosan) on percent increase number of filled grain/panicle over control of BRRI dhan62

4.1.7 Number of unfilled grains panicle^{-1}

The effects of different treatments on number of unfilled grains per panicle are shown in Table 3. The number of unfilled grains per panicle ranged from 9 to 12. The highest number of unfilled grains per panicle (12/panicle) was noted in treatment T_1 (control). The lowest number of unfilled grains per panicle (9/panicle) was recorded in T_4 treatment receiving Urea 150 kg/ha, TSP & MOP 70 kg/ha, Gypsum 40 kg/ha, $ZnSO_4$ 10 kg/ha was applied along with foliar spray of chitosan. The treatments may be ranked in order of $T_1>T_6>T_3>T_5>T_7>T_2>T_4$ with respect of the number of unfilled grains per panicle (Fig. 9).

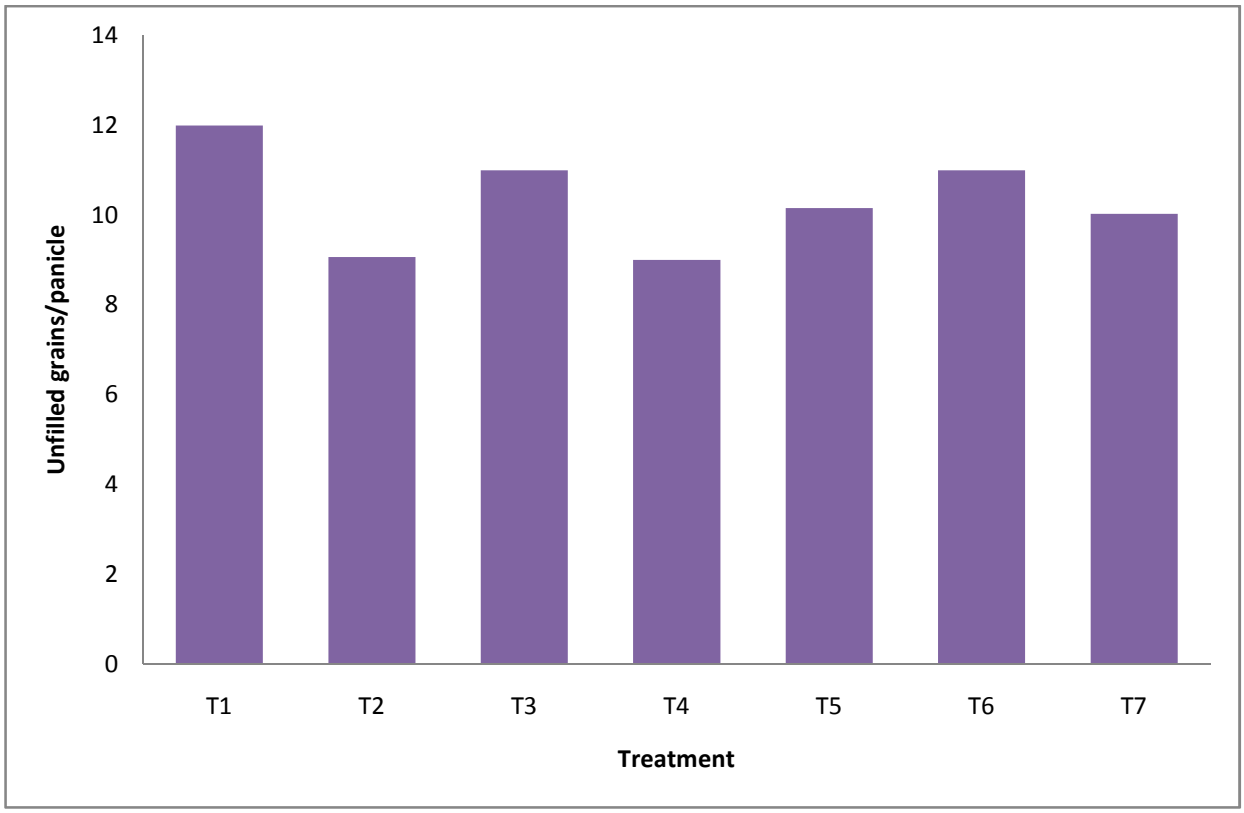


Fig. 9. Effect of Organic Growth Promoting Substance (Chitosan) on number of unfilled grains/panicle over control of BRRI dhan62

4.1.8 1000-grain weight

A significant difference in 1000-grain weight was observed at different treatments (Table 3). The 1000-grain weight ranged from 21 to 23 g. The highest weight of 1000-grain weight (23 g) was observed withUrea 150 kg/ha, TSP & MOP 70 kg/ha, Gypsum 40 kg/ha, $ZnSO_4$ 10 kg/ha were applied along with foliar spray of chitosan and the lowest weight of 1000-grain weight (21 g) was observed in T_1 treatment receiving no chemical fertilizer and chitosan spray. The treatments may be ranked in the order of $T_4>T_3>T_7>T_2>T_6>T_5>T_1$ with respect of 1000-grain weight (Fig. 10).

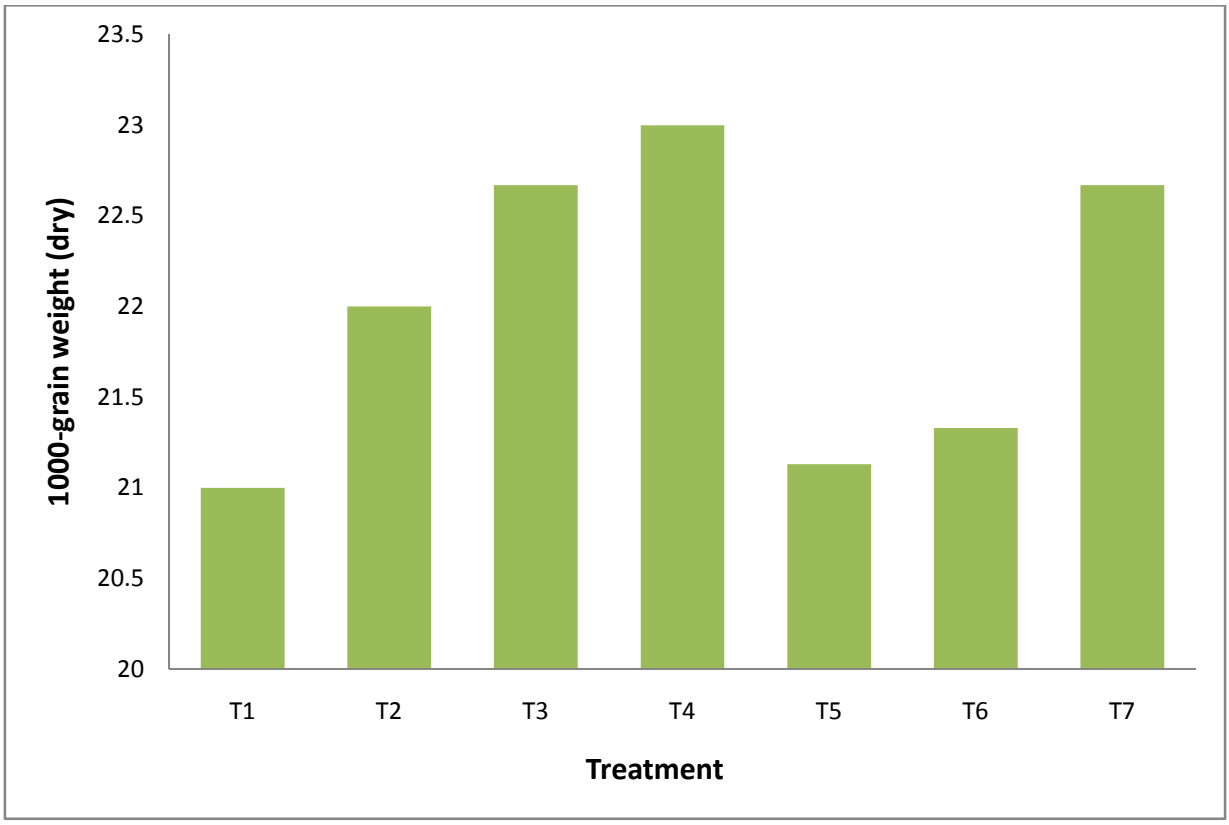


Fig. 10. Effect of Organic Growth Promoting Substance (Chitosan) on 1000-grain weight (dry) of BRRI dhan62

Table 3. Effect of Organic Growth Promoting Substance (Chitosan) on Plant height, Number of tillers hill^{-1}, Effective tillers hill^{-1}, Panicle length, Number of grains panicle^{-1}, Number of filled grains panicle^{-1}, Number of unfilled grains panicle^{-1}, 1000-grain weight of BRRI dhan62

Treatment*	Plant Height (cm)	Tiller No./hill	Effective Tillers/ hill	Panicle Length (cm)	No. of Grains/ Panicle	No. of Filled Grains/ Panice	No. of Unfilled Grains/ Panicle	1000 Grain Wt
T_1	81.17 ^{B}	17.00 ^{A}	15.70 ^{A}	19.01 ^{B}	74.67 ^{A}	64.67 ^{A}	12.00 ^{A}	21.00 ^{B}
T_2	82.32 ^{AB}	17.33 ^{A}	16.67 ^{A}	19.42 ^{AB}	75.33 ^{A}	65.07 ^{A}	09.07 ^{A}	22.00 ^{AB}
T_3	87.28 ^{A}	21.17 ^{A}	19.73 ^{A}	21.63 ^{AB}	84.67 ^{A}	68.70 ^{A}	11.00 ^{A}	22.67 ^{A}
T_4	87.78 ^{A}	21.80 ^{A}	20.34 ^{A}	22.31 ^{A}	86.67 ^{A}	70.17 ^{A}	09.00 ^{A}	23.00 ^{A}

T_5	85.83 ^{AB}	21.33 ^{A}	19.33 ^{A}	21.45^{AB}	81.47 ^{A}	67.00 ^{A}	10.16 ^{A}	21.13 ^{B}
T_6	86.49 ^{AB}	20.67 ^{A}	19.00 ^{A}	21.48 ^{AB}	81.67 ^{A}	68.17 ^{A}	11.00 ^{A}	21.33 ^{B}
T_7	83.39 ^{AB}	17.67 ^{A}	16.33 ^{A}	20.59 ^{AB}	75.00 ^{A}	65.67 ^{A}	10.03 ^{A}	22.67 ^{A}
LSD	5.51	NS	NS	3.08	NS	NS	NS	0.83

Means in a column followed by same letter(s) are not significantly different at 5% level of significance by LSD.

4.2 Yields

4.2.1 Grain yield

The grain yield of BRRI dhan62 varied significantly due to application of different treatments (Table 4). The grain yield ranged from 1.8 to 3.61 t/ha. The highest grain yield (3.61 t ha^{-1}) was observed in T_4 treatment receivingUrea 150 kg/ha + TSP & MOP 70 kg/ha each + Gypsum 40 kg/ha + $ZnSO_4$ 10 kg/ha along with foliar spray of chitosan. The lowest value (1.8 t/ha) was found in T_1 (control) treatment. Second highest yield (3.45 t/ha) was found in T_3 treatment receiving Urea 150 kg/ha + TSP & MOP 70 kg/ha + Gypsum 40 kg/ha + $ZnSO_4$ 10 kg/ha of fertilizer only which was identical with T_5 & T_6. The treatments may be ranked in the order of $T_4>T_3>T_6>T_5>T_7>T_2>T_1$ with respect of grain yield. The percent increase in grain yield over control ranged from 5.56 to 100.56% where the maximum increase was recorded in T_4 treatment and the lowest value being noted in T_2 treatment i.e. there was no statistically significant differences found between only chitosan applications compared to control (Fig. 11). 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 mg L^{-1}.

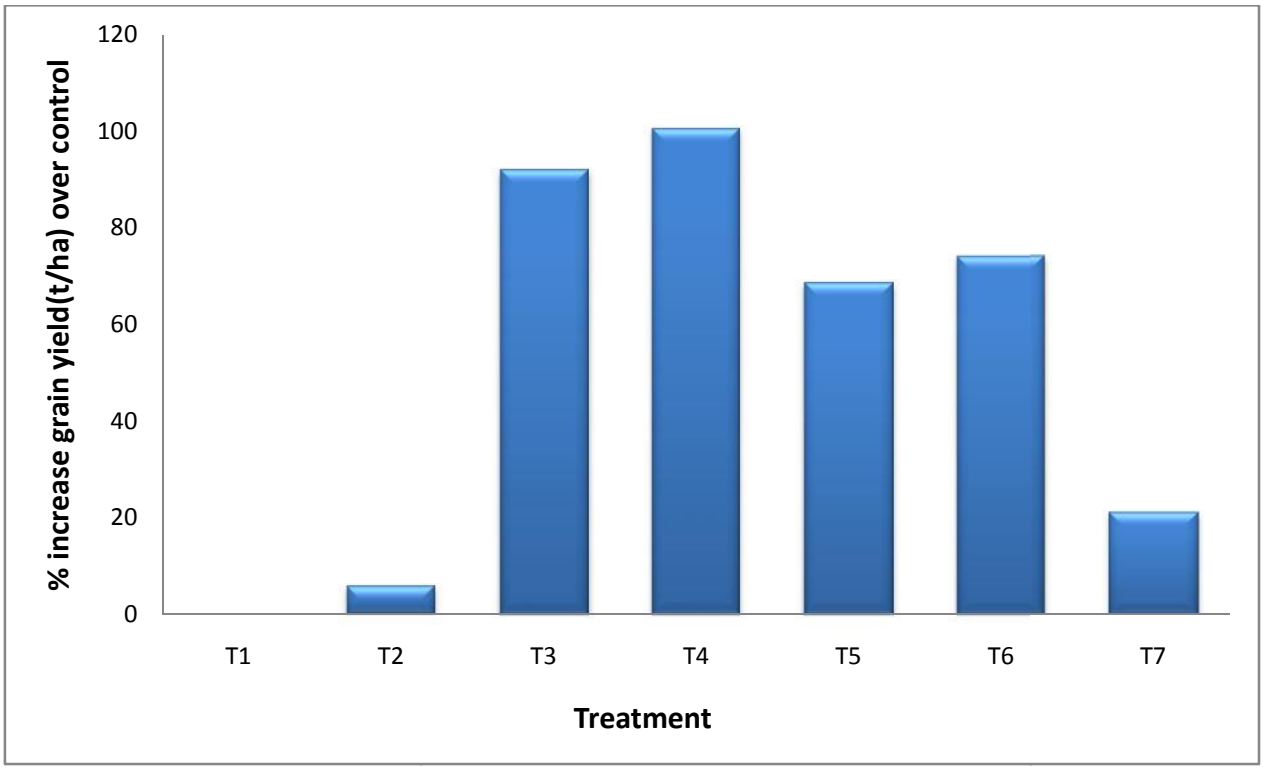


Fig. 11. Effect of Organic Growth Promoting Substance (Chitosan) on % increase grain yield (t/ha) over control of BRRI dhan62

4.2.2 Straw yield

Straw yield of BRRI dhan62 also varied significantly by different treatments under study (Table 4). The yields of straw ranged from 2.19 to 4.41 t ha^{-1}. The highest straw yield of 4.41 t ha^{-1} was obtained in T_4 treatment receiving Urea 150 kg/ha + TSP & MOP 70 kg/ha + Gypsum 40 kg/ha + $ZnSO_4$ 10 kg/ha along with foliar spray of chitosan which was statistically differed with other treatments except T_3&$T_6$and the lowest value of 2.19 t ha^{-1} was noted in T_1 (control) treatment. The treatments may be ranked in the order of $T4>T_3>T_6>T_5>T_7>T_2>T_1$ in terms of straw yield. Regarding the percent increase of straw yield, maximum straw yield increase over control (101.37%) was noted in T_4 treatment and the minimum (8.22%) was found in T_2 treatment i.e. there was not so significant increase in straw yield through chitosan spray only(Fig. 12).

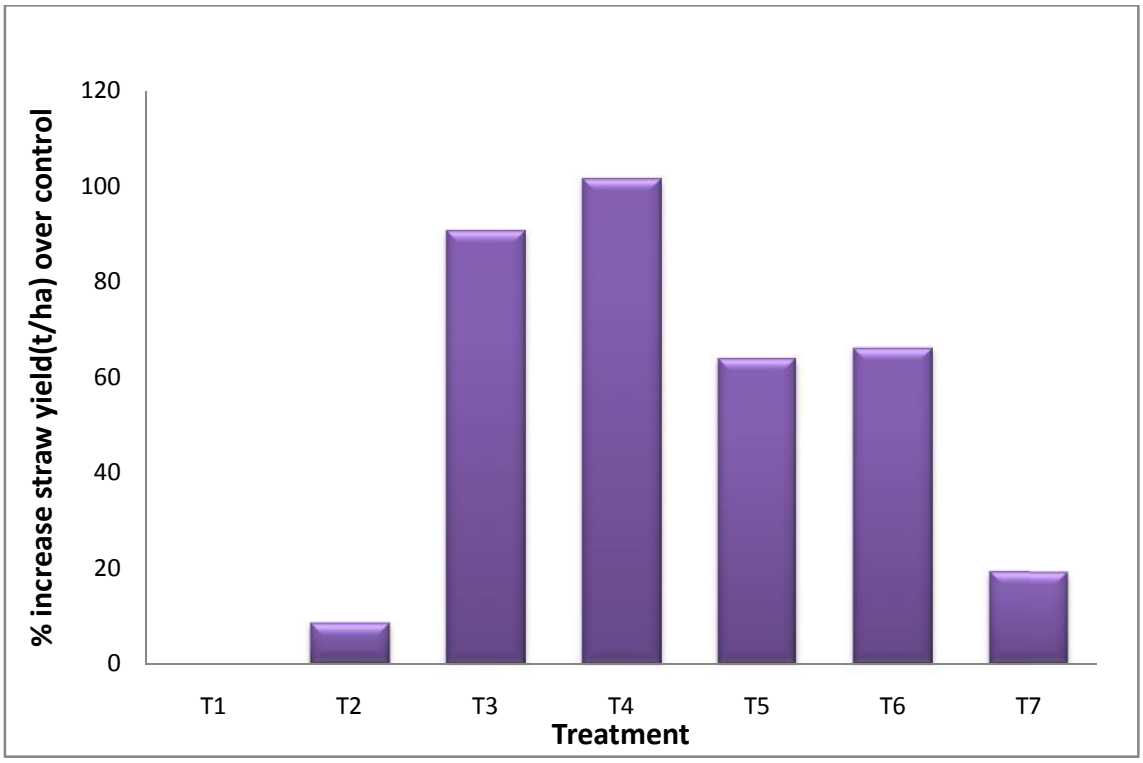


Fig. 12. Effect of Organic Growth Promoting Substance (Chitosan) on % increase straw yield(t/ha) over control of BRRI dhan62

Table 4. Effect of Organic Growth Promoting Substance (Chitosan) on grain and straw yield (t ha^{-1}) of BRRI dhan62

Means in a column followed by same letter(s) are not significantly different at 5% level of significance by LSD.

Treatment	Grain yield (t/ha)	Straw Yield (t/ha)
T_1	1.80 ^{C}	2.19 ^{C}
T_2	1.90 ^{C}	2.37 ^{C}
T_3	3.45 ^{AB}	4.17 ^{AB}
T_4	3.61 ^{A}	4.41 ^{A}
T_5	3.03 ^{ABC}	3.59 ^{B}
T_6	3.13 ^{ABC}	3.63 ^{AB}
T_7	2.18 ^{BC}	2.61 ^{C}
LSD	1.42	0.61

4.3 Nutrient content in post harvest soil

4.3.1 Total nitrogen

The combined effect of different levels of chemical fertilizer and chitosan was significant (Table 5). The highest total nitrogen of post harvest soil (0.08%) was recorded in T_4 through the application of Urea 150 kg/ha + TSP & MOP 70 kg/ha + Gypsum 40 kg/ha + $ZnSO_4$ 10 kg/ha along with foliar spray of chitosan. It was statistically similar with T_3 treatment but superior to the rest of the treatments of post harvest soil. The lowest total nitrogen of post harvest soil (0.06%) was recorded in T_1 (control) treatment.

4.3.2 Available phosphorus

A significant difference in available phosphorus content of post harvest soil was observed at different levels of fertilizers and chitosan (Table 5). The highest available P (19.91 ppm) in the post harvest soil was recorded in T_3 treatment and the lowest available P (15.23 ppm) was noted in T_1 (control) treatment.

4.3.3 Exchangeable potassium

There was significant difference among the treatments in recording exchangeable potassium content of post harvest soil (Table 5). The maximum exchangeable potassium

of post harvest soil (0.157 meq/100g soil) was found in T_3 treatment which is statistically superior to the rest of the treatments under study. The lowest available K (0.112 meq/100g soil) was noted in T_1 (control) treatment.

4.3.4 Available sulphur

A significant difference in available sulphur content of post harvest soil was observed at different levels of fertilizers and chitosan (Table 5). The highest available S (30.86 ppm) in the post harvest soil was recorded in T_4 treatment and the lowest available S (19.11 ppm) was noted in T_1 (control) treatment.

Table 5.Effect of Organic Growth Promoting Substance (Chitosan) on N, P, K and S content in post harvest soil of BRRI dhan62

Treatment	Total N (%)	Available P(ppm)	Exchangeable K(meq/100g soil)	Available S (ppm)
T_1	0.06^{C}	15.23^{E}	0.112^{D}	19.11^{F}
T_2	0.07^{B}	16.46^{D}	0.134^{C}	21.60^{E}
T_3	0.08^{A}	19.91^{A}	0.157^{A}	30.12^{B}
T_4	0.08^{A}	18.97^{B}	0.148^{B}	30.86^{A}
T_5	0.07^{B}	17.29^{C}	0.141^{B}	26.12^{D}
T_6	0.07^{B}	17.14^{CD}	0.139^{C}	28.97^{C}
T_7	0.07^{B}	18.23^{AB}	0.149^{B}	29.94^{BC}
LSD	0.17	1.096	0.17	0.45

Means in a column followed by same letter(s) are not significantly different at 5% level of significance by LSD.

CHAPTER 5
SUMMARY

To evaluate the effects of organic growth promoting substance (chitosan), an experiment was conducted in T-aman season during the period from 5 July 2014 to 15 October 2014

at the research farm of Sher-e-Bangla Agricultural University, Dhaka-1207.

The experiment was carried out to assess the effects of organic growth promoting substance (chitosan) on the growth and yield of BRRI dhan62 in T-aman season.

The single factor experiment was laid out in a randomized complete block design (RCBD) with three replications and the differences between means were evaluated by Duncan's New Multiple Range Test (DMRT). Foliar application of Chitosan was done at 10 days after transplanting (DAT).Then combined application of fertilizers along with foliar spray of Chitosan was done.

Then data were recorded on plant height (cm), number of tillershill^{-1}, number of effective tillershill^{-1}, panicle length (cm), number of grainspanicle^{-1}, number of filled grainspanicle^{-1}, number of unfilled grains panicle^{-1}, weight of raw straw plot^{-1} (kg), weight of dry straw plot^{-1}(kg), weight of fresh yield plot^{-1} (kg), weight of dry straw plot^{-1} (kg), 1000-grain weight (g) and straw yield (t ha^{-1}), grain yield (t ha^{-1}) were calculated.

The result of the experiment revealed that growth and yield contributing characters were increased due to combined application of fertilizer and chitosan spray. But only Chitosan spray had not played much significant role in increasing growth and yield contributing characters. However, combined application of fertilizer at the rate of Urea 150 kg/ha + TSP & MOP 70 kg/ha each + Gypsum 40 kg/ha + $ZnSO_4$ 10 kg/ha+ Chitosan spray (T_4 treatment) performed best in recording growth and yield contributing characters of BRRI dhan62.

In post harvest soil total nitrogen, available phosphorus, exchangeable potassium and available sulphur were increased due to combined application of fertilizer and chitosan. The maximum soil nitrogen and available sulphur was noted in T_4 (Urea 150 kg/ha + TSP & MOP 70 kg/ha + Gypsum 40 kg/ha + $ZnSO_4$ 10 kg/ha + Chitosan spray) treatment and the maximum exchangeable potassium & available sulphur was recorded in T_3(Urea 150 kg/ha + TSP & MOP 70 kg/ha each + Gypsum 40 kg/ha + $ZnSO_4$ 10 kg/ha) treatment.

The maximum plant height (87.78 cm), number of tillershill^{-1} (21.80), number of effective tillershill^{-1} (20.34), panicle length (22.31 cm), number of grainspanicle^{-1} (86.67), number of filled grainspanicle^{-1} (70.17),1000-grain weight (23g) and straw yield (4.41 t ha^{-1}), grain yield (3.61 t ha^{-1}) were recorded in T_4 (Urea 150 kg/ha + TSP & MOP 70 kg/ha + Gypsum 40 kg/ha + $ZnSO_4$ 10 kg/ha + Chitosan spray) treatment and maximum number of unfilled grain was recorded in T_1 (control) treatment.However, control or untreated results of the most of the parameters were statistically more or less similar to T_2 (only chitosan spray) treatment.

CONCLUSION

Total time required from sowing to harvesting of BRRI dhan62 was 103 days in T-aman season. So, farmers can easily cultivate boro rice after harvesting of BRRI dhan62 rice crop.

From the present study it can be concluded that combined application of fertilizer along with chitosan had varying degree of integrated effects on BRRI dhan62 rice crop. Combined application of fertilizer along with chitosan performed the best result in recording growth and yield contributing characters of BRRI dhan62 rice crop though only growth promoting substance (chitosan) didn't perform any significant result in recording growth and yield contributing characters of BRRI dhan62 rice crop.

Recommendation

Considering the above observation of the present experiment, further studies in the following areas may be suggested.

- Further research may be needed to ensuring the effect of chitosan on growth and yield performance of BRRI dhan62.

- Another combination of fertilizers and organic growth promoting substance(chitosan) may be included for further study.

CHAPTER 6

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CHAPTER 7

APPENDICES

Appendix I. Monthly mean weather

AppendixI. Records of meteorological information (monthly) during the period from July, 2014 to October 2014.

Name of the Months	Average Air temp 0C (0F)		Relative humidity (%)	Rainfall/Precipitation mm (inches)
	Maximum	Minimum		
July, 2014	31.4 (88.5)	26.2 (79.2)	72	373.1 (14.689)
August, 2014	31.1 (88.0)	26.1 (79.0)	73	342.5 (13.484)
September, 2014	30.8 (87.4)	25.8 (78.4)	74	262.4 (10.331)
October, 2014	30.5 (86.9)	22.3 (72.1)	63	135.4 (5.331)

Source: "Weatherbase: Historical Weather for Dhaka, Bangladesh". Weatherbase.com "Bangladesh - Dacca" (in Spanish). Centro de Investigaciones Fitosociológicas. "Average Conditions - Bangladesh - Dhaka". BBC

Appendix II. Some Commonly Used Abbreviations and Symbols

Abbreviations	Full word
%	Percent
@	At the rate
^{0}C	Degree Celsius
^{0}F	Degree Fahrenheit
AEZ	Agro-Ecological Zone
Agric.	Agriculture
Agril.	Agricultural
Agron.	Agronomy
ANOVA	Analysis of variance
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BD	Bangladesh
BSMRAU	Bangladesh Sheikh Mujibur Rahman Agricultural University
CEC	Cation Exchange Capacity
cm	Centi-meter
CV%	Percentage of coefficient of variation
DMRT	Duncan's Multiple Range Test
et al.	and others
etc	et cetera
FAO	Food and Agricultural Organization
g	gram
hr.	Hours
j.	Journal
kg	Kilogram
Kg/ha	Kilograms per hectare

t/ha	**Ton per hectare**
m	Meter
mm	Millimetre
MSE	Mean square of the error
No.	Number
ppm	Parts per million
RCBD	Randomized complete block design
Rep.	Replication
Res.	Research
SAU	Sher-e-Bangla Agricultural University
Sc.	Science
SE	Standard Error
Temp	Temperature
Univ.	University
var.	Variety
Wt.	Weight