EFFECT OF NPK BRIQUETTE ON THE GROWTH AND YIELD OF BARI JHAR SHEEM-2

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CERTIFICATE

This is to certify that the thesis entitled **'Effect of NPK Briquette on the Growth and Yield of BARI Jhar Sheem-2'** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **Master of Science** in **Soil Science**, embodies the result of a piece of *bona fide* research work carried out by **Mst. Sharmin Sultana**, Registration number: **10-03830** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

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TO

MY BELOVED PARENTS

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The Author

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ABSTRACT

The experiment was conducted at the research field of Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh during the Rabi season (November 2016 to February, 2017) to study the effects of NPK briquette on the growth and yield of BARI Jhar sheem-2 was used as the test crop in this experiment. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The treatments consisted of 8 (eight) levels of NPK briquette i.e. T_1: no fertilizer (Control), T_2: Recommended dose ($N_{120}P_{30}K_{50}S_{10}$ kg ha^{-1}), T_3: 120 Pieces NPK briquette at 15 DAS ($N_{90}P_{24}K_{40}$ kg ha^{-1}), T_4: 60 pieces NPK briquette at 15 DAS+60 pieces NPK briquette at 30 DAS, T_5: 140 pieces NPK briquette at 15 DAS, T_6: 70 pieces NPK briquette at 15 DAS+70 pieces NPK briquette at 30 DAS, T_7: 160 pieces NPK briquette at 15 DAS, T_8: 80 pieces NPK briquette at 15 DAS+80 pieces NPK briquette at 30 DAS. The growth and yield parameters were significantly affected by different levels of NPK briquette fertilizer. The highest plant height (52.20 cm) was found from T_7 treatment receiving 160 pieces NPK briquette at 15 DAS. Number of branches plant^{-1} (18.72), number of pod plant^{-1} (27.83), pod weight plant^{-1} (185.8 g), pod length (14.69 cm), 10 green pod weight (21.36 g), stover yield (4.701 t ha^{-1}) and pod yield (40.25 t ha$^{-1)}$ were found from T_5 treatment receiving 140 pieces NPK briquette at 15 DAS and for all cases lowest results were found in T_1 treatment receiving no fertilizer (control). NPK briquette fertilizer plays a significant role on the growth and yield of BARI Jhar sheem-2. The highest yield of BARI Jhar sheem-2 (40.25 t ha^{-1}), was found in T_5 treatment receiving 140 pieces NPK briquette at 15 DAS and for all cases lowest results were found in T_1 treatment that receiving no fertilizer.

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CHAPTER I
INTRODUCTION

Legumes are wonder gift of nature to the living universe and are the real gateway of sustainable agriculture. Bush bean (*Phaseolus vulgaris* L.) belongs to the family Fabaceae is important legume vegetable. It is derived from a wild species (*Phaseolus arborigenesis* L.) originated from Southern Mexico and Middle America (Ahlawal., 1989) is the second legume vegetable in the world and newly introduced as winter vegetables in Bangladesh. In Bangladesh, it is also called Jhar Sheem or Farashi sheem (Rashid, 1993).

It is the most widely cultivated as food legume being cultivated throughout the temperate, tropical, subtropical regions of the world (George, 1985). It is intensively grown in five major continental areas: Eastern Africa, North and Central America, South America, Eastern Asia, and Western and South Eastern Euorope. It is more suitable as winter crop in the north-eastern parts of India (AICPIP, 1987). According to FAO statistics, bush bean including other related species of the genus *Phaseolus* occupied 27.08 million hectares of the World’s cropped area and the production of dry pods was about 18.94 million tons with an average yield of 699 kg ha^{-1} (FAO, 2000). It is not new crop in our country. It is cultivated in Sylhet, Cox’s Bazar, Chittagong Hill Tracts and few other parts of the country in limited scale.

Few years back, it was only used for making “daal” (spicy soup) mostly the east and south-eastern parts of Bangladesh. It is very good in digestive system because of their fiber content. Both pods and seeds of French bean are nutritionally rich. Immature pods are marketed as fresh, frozen or canned vegetables. Foliage of the crop also provide as hay, silage and green manures. After harvest, the plants can be fed to cattle, sheep and horses. Its edible pod supplies protein, carbohydrate, fat, fibre, riboflabin, thiamin, Ca, Fe supplies (Shanmugavelu, 1989) and the seed contains significant amount of thiamin, niacin, folic acid. In present, cultivation of bush bean is gaining popularity in

Bangladesh as vegetables mainly because of it is demand as a commodity or export. Hortex Foundation exported 23.86 of vegetable bush bean during July-December, 2001 (Anonymous, 2001). So there is a tremendous scope to improve its cultivation in our country.

Production of BARI Jhar sheem-2 depends upon many factors such as quality of seed, variety, plant spacing, fertilizers and proper management practices. Bean crops depend on symbiotic fixation to meet part of their nitrogen requirements. Bush bean shows high yield potential, but it is unlike with other leguminous crops that it does not nodulate with the native rhizobia (Ali and Kushwaha, 1987). Therefore, Nutrient elements are essential and important factors for growth and development of the crop. Mobilization of nutrient elements take place within the plants during its life cycle. The extent of remobilization of elements (e.g.; N, P, K, etc), howover, depends on the ability of these elements take place for mobilization in the plants and their demand for photosynthesis. Shortened reproduction duration can be prolonged and applying fertilizer nitrogen and phosphorous can reduce early senescence. Nutrient requirement for different cultivars usually is similar except on poor soils (Adams, 1984).

Bush bean cultivation needs sufficient supply of nitrogen. It is necessary for germination to pod maturity of bush bean. An optimum amount of nitrogen is necessary to produce maximum yield of good quality bush bean. Bush bean, like other legumes has ability to fix atmospheric nitrogen through partnership with symbiotic root nodule bacteria *(Bacillus japonica*) and thus enrich the soil fertility (Mahabal, 1986). It fixes about 270 kg N ha^{-1} annually compared to 58 to 157 kg N ha^{-1} by other pulses. Nitrogenous and phosphetic fertilizers are most effective and critical input for increasing crop yield. The growth and development of bush bean increased with nitrogen and potassium (Tewari and Singh, 2000). Phosphorus is a component of the complex nucleic acid structure of plants, which regulates protein synthesis. The most obvious effect of potassium is on root development particularly the lateral and fibrous rootlets that are essential to fix the atmospheric nitrogen in legume crops (Arya and Kalara, 1988). Potassium also effects on seed formation (Buckman and Brady, 1980).

Briquette fertilizer is an important factor that has profound effect on plant growth and development of bush bean production. Deep placement of NPK briquette has given significantly highest yield in case of bitter gourd (32.16 t ha^{-1}) followed by urea briquette (30.45 t ha^{-1}) which was 12.34 and 7.41 percent higher yield over Prilled Urea (Akter *et al.*, 2015). Deep placement of fertilizer briquettes was given results in higher vegetable yields compared to conventional fertilizer practices (Bhattarai *et al.*, 2011). Farmers in Vietnam and Cambodia obtained 25% higher yields uses with deep placement of NPK briquettes over the uses of broadcasting of fertilizers (IFDC, 2007).

Maintenance of proper fertilizer application through NPK as briquette form is essential for rapid growth of plant, encourages blooming, root growth, photosynthesis, pod quality and reduction of diseases of jhar sheem. If NPK briquette fertilizer is applied in such a way that minimum leached out and maximum its utilization for crop production would be possible. By reducing leach out problem and make the plant for better growth and to ensure profound yield. Moreover, farmers are unaware about the use of NPK briquette fertilizer in Jhar Sheem-2 cultivation. So, attention should be given to increase yield through optimum doses of NPK briquette fertilizer. Hence, an experiment was conducted with different levels of NPK briquette fertilizer for Jhar Sheem-2 cultivation with the following objectives:

- ❖ To determine the effect of NPK briquette on the growth and yield of BARI Jhar sheem-2.
- ❖ To find out the optimum dose of NPK briquette for maximizing the growth and yield of BARI Jhar sheem-2.

CHAPTER II

RIVEW OF LITERATURE

Recently Jhar sheem (*Phaseolus vulgaris* L.) is one of the most important legume vegetables in the World. Researches on various aspects for its production technology have been carried out worldwide. For sustainable soil fertility and crop productivity fertilizer is the essential factor because it is the store house of plant nutrients. Optimum fertilizer dose are the most important factors for maximizing crop yield. Evidences of experimental research showed an intimate effect on the growth and yield attributes of in the use of nitrogen, phosphorus and potassium in case of Jhar sheem crops. Growth and yield contributing characters of BARI Jhar Sheem-2 crop is influenced considerably by different doses of NPK briquette fertilizer. Fertilizer briquettes plays an important part in the case of Fertilizer Deep Placement Technology program to help farmers of developing nations increase their agronomic productivity and thus their economic stability and profitability. Currently there are 2.5 million farmers in Bangladesh using fertilizer briquettes.

Many research works have been done in different parts of the world to study the effect of the NPK briquette on the growth and yield of BARI Jhar sheem-2. It has been newly introduced in Bangladesh. However, a very few researcher have been carried out their experiment on BARI Jhar sheem-2 production under Bangladesh conditions. The literature on the effect of ‘NPK’ as briquette fertilizer on the growth and yield are presented in this chapter. However, briquette fertilizer are used for the observation of vegetative growth and yield status of Jhar sheem-2 recently. But, the literature on the use of different concentrations of ‘NPK’ on Jhar Sheem-2 are meager. Some of the important findings related to the present study are reviewed in this chapter.

2.1 Influence of NPK briquette on growth and yield of related crops

Liu *et al.* (2016) deep placement of urea is quickly hydrolyzed at 8 Day After Flowering, but the first hydrolyzed NH-N is absorbed by soil particles around the fertilizer placement site, and further hydrolysis of urea and NH_4^+ movement away from the placement site was slow and restricted to a limited soil volume (4–13 cm soil depth), due to the negative charge of soil colloids and relatively high clay content (33–36%), and the diffusion was influenced by the ion-exchange process.

A field experiment was conducted by Hussain *et al*. (2016) in Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur during 2010-2011 to determine the effects and economic performance of urea super granule (USG) and prilled urea (PU) in the cases of growth and yield contribution of broccoli and to find out the optimum and economic doses of USG and PU for broccoli in Madhupur Tract. The performance of USG in terms of growth, yield and yield attributes, head quality (compactness coefficient) and economic profitability was found significantly that was higher as compared to PU. Howover, USG @ 160 kg N ha^{-1} and PU @180 kg N ha^{-1} along with other recommended fertilizers suggested for broccoli production.

Akter *et al*. (2015) observed that the experimental result significantly higher yield of fresh bitter gourd was recorded with the use of NPK briquette (T_6) as compared to prilled urea (PU) and urea briquette (T_5). Deep placement of NPK briquette (T_6) has given significantly highest yield of bitter gourd (32.16 t ha^{-1}) followed by urea briquette (30.45 t ha^{-1}) which was 12.34 and 7.41 percent higher yield over Prilled Urea (T_4).

Torane *et al*. (2014) was conducted an experiment on the field and found that all the treatments showed increase in available N and P_2O_5 status of soil over absolute control at all the stages of crop growth. The significantly highest available N (450.53, 365.86, and 334.50 kg ha^{-1}) and P_2O_5 (18.26, 20.52 and

17.50 kg ha^{-1}) were observed lowest in the treatment by receiving UB-10:26:26 briquettes @ 1 briquette in between two plants.

Kokare *et al*. (2013) reported that the maximum pH (5.44, 5.51, and 5.29) at all stages was recorded when i.e. application of UB-10:26:26 briquettes @ 1 briquette in between two plants. Although the reduction in soil pH in the treatments receiving inorganic fertilizer in straight as well as all three types of briquettes form as compared to other treatment. The behavior of soil reaction was get similar in the results conducted on lateritic soil increase of chilli.

IFDC, (2013) reported that Surface applied urea is cause to reach N losses as high as 35%. However, buried briquettes only lose approximately 4% of its N, which is a considerable improvement of N use efficiency.

Islam *et al*. (2011) conducted an experiment on the effects of NPK briquette on rice (*Oryza sativa* L.) in tidal flooded ecosystem. They trial different grades of NPK briquette on the field levels. Among them the NPK briquette (2.4g×2) showed better performance in terms of growth and yield of rice and higher N use efficiency. NPK briquettes (2.4g×2 and 3.4g×1) gave statistically similar yield as USG and PU, but the former saved 33kg ha^{-1} N compared to prilled urea. The 3.4g×1 size NPK briquette has shown N deficiency at later growth stage, due to its lower N rates (57 kg). The P, K & S application in some treatments had no effect on growth and yield of rice in that condition.

Deep placement of fertilizer briquettes was carried out by Bhattarai *et al*. (2011) and observed that give results in higher vegetable yields compared to conventional fertilizer practice. These results were consistent with the increases of yield was reported for cucumber (22%) and yard long bean (9%) by using fertilizer briquette deep placement compared to conventional fertilizer practices.

IFDC, (2007) reported that farmers in Vietnam and Cambodia obtained 25% higher yields uses with deep placement of NPK briquettes over the broadcasting of fertilizer.

Hossain *et al*. (2003) conducted an experiment on different vegetable crops. They observed that urea briquettes application has proved to be profitable in different upland crops such as brinjal, tomato, cabbage, cauliflower, potato, maize and banana. The results have shown that 10–20% urea would be saved and the yield increased substantially due to the use of urea briquettes instead of prilled urea.

Khalil *et al*. (2011) observed that several studies that deals with the application of fertilizers in the form of super granules or briquettes, also with promising results, although the scientific literature mostly deals with fertilizer effects on rice, particularly as briquette fertilizers are gaining in popularity throughout sub-tropical and tropical Asia compared to surface applied urea.

An experiment was conducted by Kadam, (2001) found that uses of urea briquette fertilizer is better than surface split applied urea in rice. The increase varied considerably from as little as 5 to 83% in rice grain yield. Another way, the briquettes were used a better fertilizer option than urea surface applied as a split to decrease N losses. Further observed that it is possible to deeply place urea briquettes mechanically and achieve the agronomic efficiency obtained by hand placement of briquettes. This anticipates the feasibility of agronomic application of briquettes in developed countries where nearly all of agriculture is machine based.

Nazrul *et al.* (2006) reported that the loss of N by leaching and volatilization is minimal in Urea Super Granule and it supplies more N to crops than Prilled Urea. In case of boro rice, Urea Super Granule is used by farmers in some part of the country, for upland vegetables crops uses like tomato, cabbage, broccoli, papaya, banana etc.

A research conducted by Muneshwar *et al.* (1992) reported that modified urea materials under different moisture regimes influence ammonia volatilization loss and significantly less NH_3-N loss was observed for Urea Super Granule treatments than from surface applied urea. So, the application of 10% less N fertilizer as Urea Super Granule also performed better result than the recommended prilled urea for its higher uptake and recovery rate of N, and minimum volatilization loss of N fertilizer.

Yadav and Singh (2000) conducted an experiment to see the effects of 3 fertilizer levels as 90 kg N ha^{-1} + 45 kg P ha^{-1}, 120 kg N ha^{-1} + 60 kg P ha^{-1} and 150 kg N ha^{-1} + 75 kg P ha^{-1} respectively on seed production and quality of LMS (female) and LM6 (male) inbred lines of the single cross maize hybrid (paras). The fertilizer treatment 150 kg N ha^{-1} + 75 kg P ha^{-1} gave the highest grain yield and seed quality in the single cross hybrid.

Rajander *et al*. (2003) reported that the effects of N (0, 10, 20 and 30 kg ha^{-1}) and P (0, 20, 40 and 60 kg ha^{-1}) fertilizer rates on mungbean genotypes MH 85-111 and T44. Results are observed that grain yield increased with increasing N rates up to 20 kg ha^{-1}.

Gangwar *et al*. (1998) run a field study at Pantnagar in *rabi* (winter) in 1994-95, and observed that the requirements of N, P and K were 8.25 kg, 1.03 kg and 5.65 kg, respectively for the production of 0.1 ton of vegetables pea seeds. The utilization of soil available N (organic carbon), P_2O_5 (Olsen-P) and K_2O (ammonium acetate-K) percentage was 36.59, 13.83 and 11.81, respectively. The contribution from fertilizer as a percentage and its nutrient content was 188.82, 20.79 and 46.57 for N, P and K, respectively.

Jesus *et al*. (2004) found that French bean when applied with N (20 kg ha^{-1}), P (50 kg ha^{-1}) and K (50 kg ha^{-1}), Mo (as sodium molybdate) was applied at @75 or 150 ppm. and B (as borax) at @2.5 ppm were individually and in combination. It sprays as foliar at 20 days after sowing and again at 40 days after sowing. Control plants were sprayed with distilled water. The highest plant height (35 cm), number of leaves plant^{-1} (14.6), number of branches plant^{-1} (4.3), tap root length (20.4 cm), leaf area plant^{-1} (941.2 cm), leaf area index (0.60) and DM production (62.8 g plant^{-1}) were counted with the 75 ppm. Mo + 2.5 ppm. B treatment.

Bhopal and Singh (1987) reported that French bean response with nitrogen and phosphorus fertilizers with *Phaseolus vulgaris L.* bean grown for green pods. Nitrogen rate of applied@ 0-90 kg ha^{-1} and P_2O_5 @ 0-120 kg ha^{-1}, and a basal dose of K_2O @ 50 kg ha^{-1}. The optimum doses of nitrogen: phosphorus was 67.3:79.7 kg ha^{-1}and yields over 210 q ha^{-1}.

Rahman *et al*. (2016) conducted a plot experiment at the field laboratory Department of Agronomy, PSTU, Dumki, during the period of March 2015 to August 2015 for assessment of the comparative advantages using Urea Super Granule (USG) and NPK briquette over normal urea and also counted the better performance of transplanted Aus rice in the tidal ecosystem. They observed that different fertilizer management practices with a few exceptions significantly influenced the growth, yield and yield attributes of the transplanted Aus rice varieties. The highest amount of plant height, number of effective tillers per hill, panicle length (cm), number of grains panicle^{-1}, nitrogen use efficiency (%), straw yield (t ha$^{–1}$) and grain yield (t ha$^{–1}$) were found when USG was applied with BRRI dhan48. Other cases, all the characters showed the lowest value when absolute control with BRRI dhan55. Number of effective tillers per hill (11.15) and grain yield (3.33 t ha$^{–1}$) was obtained highest applying USG and BRRI dhan48. Where lowest number of effective tillers per hill (9.21) and grain yield (2.28 t ha$^{–1}$) in absolute control with BRRI dhan55. They also noticed that the uses of NPK briquettes showed higher agronomic efficiency than Prilled Urea (PU) and Urea Super Granule (USG). The USG (1.8 g) and NPK briquettes (2.4 g) could save 11.3 kg N ha^{-1} and 19.55 kg N ha$^{–1}$ compared to recommended PU.

Moslehuddin, *et al.* (1997) reported that the vegetable crops are very responsive to soil fertility status, thus nutrient management strategies should be used on vegetable farms to maximize the benefits of fertilizer application on crop yields and fruit quality while minimizing nutrient loss to the environment.

Bautista *et al.* (2001) observed that fertilizer briquettes hammered into the ground reduce runoff, fixation, leaching, and volatilization loss.

Srinivas (2012) conducted a field trial at the Division of Vegetable Crops, Indian Institute of Horticultural Research, Bangalore, Karnataka, India to observe the influence of nitrogen and phosphorus fertilization on crop yield of sweet gourd on a sandy loam soil with low available N and P. N was applied at 50, 100, 150 and 200 kg ha^{-1} and P at 30, 60 and 90 kg P_2O_5 ha^{-1}. Half of the N, all the P and 90 kg K_2O ha^{-1} were applied before sowing; the rest of the N was applied as a top dressing 30 days after sowing. 150 kg N ha^{-1} and 90 kg P_2O_5 ha^{-1} were found the highest yield. Other parameters (number of fruits $plant^{-1}$, number of seeds $fruit^{-1}$ and 1000 seed weight) were also the highest with the highest rates of fertilizer application.

Moniruzzaman *et al.* (2008) conducted a field experiment on French bean on the variety of BARI Jhar Sheem-2 with five levels of nitrogen (0, 40, 80, 120 and 160 kg N ha^{-1}), four levels of each of phosphorous (0, 40, 80 and 120 kg P_2O_5 ha^{-1}), potassium (0, 30, 60 and 90 kg K_2O ha^{-1}) , sulfur (0, 10, 20 and 30 kg S ha^{-1}), three levels of each of zinc (0, 4 and 8 kg Zn ha^{-1}) and boron (0, 1 and 1.5 kg B ha^{-1}) at the Agricultural Research Station, Raikhali, Rangamati Hill District during Rabi (winter) seasons of 2005-2006 and 2006-2007. Results they found that significant changes noticed due to uses of fertilizers on plant height, number of branches and leaves per plant, pod length, number of green pods and pod weight per plant and green pod yield during both years. The highest pod yield of 23.14 t ha^{-1} (average of 2005-2006 and 2006-2007) was obtained with 120-120-60-20-4-1 kg of N-P_2O_5-K_2O-S-Zn-B plus 0.5 kg Mo ha^{-1} along with 10 tons cowdung per hectare that was closely followed by 120-80-60-20-4-1 kg of N-P_2O_5-K_2O-S-Zn-B plus 0.5 kg Mo ha^{-1} along with 10 tons cowdung per hectare. The response summation indicated that optimum level of 138.6 kg N, 131.5 kg P_2O_5, 63.4 kg K_2O and 17.4 kg S ha^{-1} for higher green fruit yield of French bean.

Durgude *et al*. (2008) observed that fertilizer briquettes with constant amounts of NP but with different doses of K (56-30-0, 56-30-15, 56-30-30, 56-30-45, and 56-30-60 kg ha^{-1}) against surface applied fertilizer of 100-50-50 kg ha^{-1}. Deeply placed 56-30-30 NPK briquettes proved to be the best fertilizer for rice grain and straw yield, all of the briquette combinations proved 15 better than the surface applied 100-50-50 NPK fertilizer each year.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted in the period from November, 2016 to February, 2017 to study the effect of NPK briquette on the growth and yield of BARI Jhar Sheem-2. This chapter includes materials and methods that were used in conducting the experiment are presented below under the following headings:

3.1 Experimental site

The experiment was conducted at the farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The experimental site is situated between $23^{0}74^{/}$N latitude and $90^{0}35^{/}$E longitude and at an elevation of 8.4 m from sea level (Anon., 1989).

3.1.1 Soil

The soil of the experimental area is under Tejgaon series which belongs to the Agro-ecological zone, Madhupur Tract (AEZ-28), which falls into Deep Red Brown Terrace Soils. Soil samples were collected from the experimental plots to a depth of 0-15 cm from the surface before initiation of the experiment and analyzed in the laboratory. The soil was having a texture of Clay Loam which pH was 5.7. The morphological characteristics of the experimental field and physical and chemical properties of initial soil are given in Table 1.

3.1.2 Climate

The climate of experimental site is subtropical, characterized by three distinct seasons, the winter from November to February and the pre-monsoon period or hot season from March to April and the monsoon period started from May to October.Characteristics of experimental field soil as analyzed by Soil Laboratory, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka

Table 1. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Exprimental field, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Deep Red Brown Terrace Soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

Table 2. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	30.0
% Silt	40.0
% clay	30.0
Textural class	Clay Loam
pH	5.7
Organic carbon (%)	0.78
Organic matter (%)	1.345
Total N (%)	0.04
Available P (ppm)	19.90
Exchangeable K (me/100 g soil)	0.12
Available S (ppm)	14.37

3.1.3 Planting material

The variety that used for test crop was the BARI Jhar Sheem-2. The seeds were collected from the Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. BARI Jhar Sheem-2 was the released variety of BARI. It was recommended by the National Seed Board. Green pod of this variety was harvested within 70-75 days as green pods and the highest pod yield was 12-15 t ha^{-1} was harvested possible if cultivate following modern technology.

3.1.4 Land preparation

The land was irrigated first, before ploughing. After geting “zoe” condition the land was first opened with the tractor drawn disc plough. Ploughed soil was harrowing and brought through desirable fine tilth by 3-4 ploughing, cross-ploughing. Laddering were also used for even the experimental soil. The weeds and stubble were also removed. The first ploughing and the final land preparation were done on 7th and 15th November, 2016 respectively. Experimental land was divided into unit plots following the design of experiment.

3.1.5 Treatments of the experiment

There were eight treatments. There were as follows:

T_1: No fertilizer (Control)

T_2: Recommended dose ($N_{120}P_{30}K_{50}S_{10}$ kg ha^{-1})

T_3: 120 pieces NPK briquette at 15 DAS ($N_{90}P_{24}K_{40}$ kg ha^{-1})

T_4: 60 pieces NPK briquette at 15 DAS+60 pieces NPK briquette at 30 DAS

T_5: 140 pieces NPK briquette at 15 DAS

T_6: 70 pieces NPK briquette at 15 DAS +70 pieces NPK briquette at 30 DAS

T_7: 160 pieces NPK briquette at 15 DAS

T_8: 80 pieces NPK briquette at 15 DAS +80 pieces NPK briquette at 30 DAS

3.1.6 Fertilizer application

Required amounts of NPK briquette fertilizers were applied as per treatments. According to the fertilizer recommendation guide, only gypsum were applied in the whole plots as basal doses.

3.1.6.1 Application of NPK briquette

NPK briquettes were applied in crop field in two times. First, at 15 DAS and second at 30 DAS. For the treatments T_3, T_5 and T_7, NPK briquette were applied at once at 15 DAS, and the number of NPK briquette were 120, 140 and 160 pieces, respectively. In case of treatments T_4, T_6 and T_8, half of NPK briquette i.e. 60, 70 and 80 pieces respectively per plot were applied at 15 DAS and rest half were applied at 30 DAS. NPK briquettes were applied in between two rows of BARI Jhar sheem-2 plants maintaining equal distribution.

3.1.7 Experimental design and layout

The single factor experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The plot was divided into three equal blocks. The related parameters of land were as follows:

Total number of plot = 24

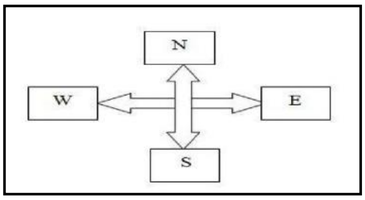
Individual plot size = 3 m × 2.5 m (7.5 m^2)

Plot to Plot distance = 0.5 m

Row to row distance = 30 cm

Plant to plant distance =25 cm

Block to block distance = 1 m.



Plot size: 3 m × 2.5 m (7.5 m^2)
Plot to plot distance: 0.5 m
Block to block distance: 1.0 m

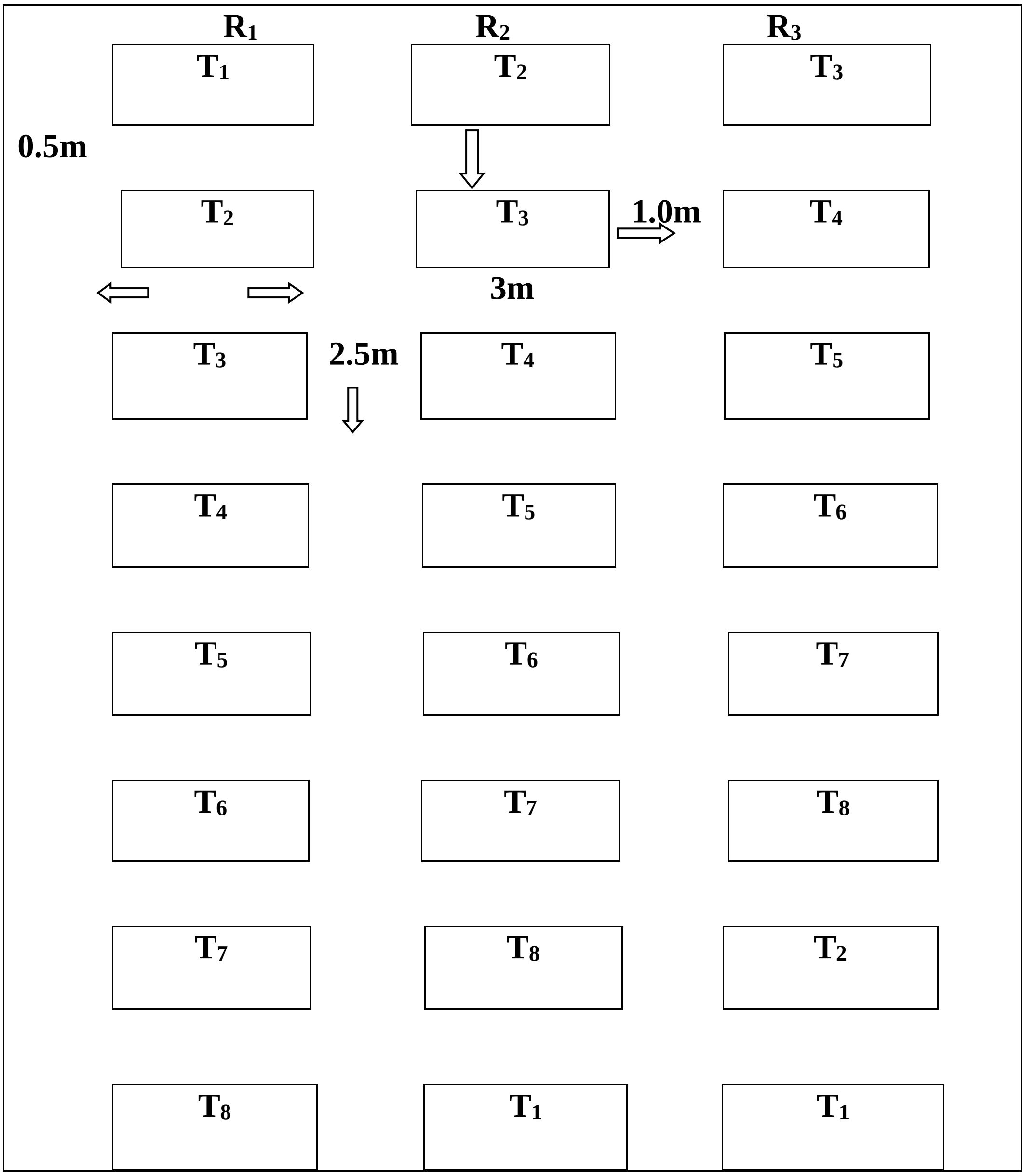


Figure 1: Layout of the experimental plot

3.1.8 Sowing of seeds

Two seeds were sown in each hill at 3.0 cm of the depth. The seeds were covered through the pulverized soil just after sowing and gently pressed with hand. The sowing was done on 23 November, 2016.

3.1.9 Intercultural operations

3.1.9.1 Gap filling

During the time of seed sowing, few seeds were sown in the border around of the plots. Seedlings were transferred to fill up the gap where seeds were failed to germinate. When seedlings are about 15 cm height, were transplanted from border rows with roots plunged with 5 cm below the soil in the hills. It was done in the evening and when watering was done to protect the seedling from wilting problem. After germination of seeds, all gap filled were completed within two weeks.

3.1.9.2 Thinning of seedlings

After 15 days of sowing one healthy plant $hill^{-1}$ was kept and remaining seedlings were plucked out from each of the plot.

3.1.9.3 Weeding

The experimental plots were kept weed free by hand weeding. Weeding were done in three times and when it was necessary and to break the crust. It also beneficial for soil moisture conservation**.**

3.1.9.4 Irrigation

Irrigation was done whenever necessary. The young plants were irrigated by watering can. Besides, irrigation was given five times at an interval of 10 days depending on soil moisture content in the field.

3.1.10 Plant protection Activities

a) Insect pests

At the early stage of growth, some plants were attacked by insect pests (Aphids and ant) and attacked by white fly at the flowering and fruit setting stage. Ripcord and malathaion 57 EC were sprayed at the rate of 2 ml/litter at an interval of 15days.

b) Diseases

Seedlings were attacked by damping off and root rot diseases. For recover those diseases, Dithane M-45 was sprayed at the rate of 2 ml/L at an interval of 15 days. Some plants were also attacked by bean common mosaic virus (BCMV), which is an important disease of BARI Jhar sheem-2. These plants were removed from the plots and destroyed.

3.1.11 Harvesting

At tender stage, immature green pods were harvested, when it was suitable for use as vegetable. First harvest were done after flowering stage when pods were immature conditions. Tender pods were first harvested in 29th January, 2017. Three times harvest were done. Harvesting was done through hand picking and weighed to estimate the yield of fresh pod. At harvest, pods were nearly full-size, with the seeds still small (about one quarter developed) with firm fresh (Swiader *et al.*, 1992).

3.1.12 Crop sampling and data collection

Five plants from each treatment were randomly selected and marked with sample card. Plant height and stover yield were recorded from selected plants at final harvesting time.

3.1.13 Post-harvest operation

The sample plants were harvested separately for determining yield and yield components. The harvested crop was cleaned up, dried, shelled and finally dried plot by plot separately to collect necessary data on various aspects.

3.1.14 Collection of data

Five plants were selected at random in such a way that the border effect could be avoided. The details of data recording are given below:

i.Plant height (cm)

ii. Number of branches plant^{-1}

iii. Number of pods plant^{-1}

iv. Pod weight plant^{-1}

v. Pod length (cm)

vi. 10 green pods weight (g)

vii. Pod yield (t ha^{-1})

viii. Stover yield (t ha^{-1})

ix. Soil pH, organic matter, % total N, available P, exchangeable K and available S were determined from initial and post harvest soil.

3.1.14.1 Procedure of data collection

3.1.14.2 Plant height (cm)

Five plants were randomly selected for measuring the heights of plant from the base of the plant to the tip of the tallest leaf. The height of plants was recorded in cm and the mean values of 5 plants for each plot were determined.

3.1.14.3 Number of branches per plant

Five plants were randomly selected for measuring the number of branch in the plant from the base of the plant. The height of plants was recorded in number and the mean values of 5 plants for each plot were determined.

3.1.14.4 Number of pods per plant

The number of pods per plant from five randomly selected sample plants of each plot were counted, averaged and recorded at the time of final harvest.

3.1.14.5 Pod weight per plant

The number of pods per plant from five randomly selected sample plants of each plot were counted, averaged and recorded at the time of final harvest.

3.1.14.6 Length of green pod (cm)

Five pods were selected randomly from each plants for measuring the length were using centimeter scale and mean value was calculated and was expressed in centimeter (cm).

3.1.14.7 Weight of 10 green pods (g)

Ten cleaned green pods were collected and counted from each harvest sample and weighed by using a digital electric balance and weight was expressed in gram (g).

3.1.14.8 Pod yield (t ha^{-1})

Green pods were harvested at regular interval from each unit plot and their weight was recorded. As harvesting was done at different interval and the total pod weights were recorded in each unit plot and expressed in kilogram (kg). The green pod yield per plot was finally converted to yield per hectare and was expressed in ton (t).

3.1.14.9 Stover yield (t ha^{-1})

After separating the pods from the plants and drying the harvested plants in the sun, total weight of stover of each plot was taken in kilograms and converted into ton per hectare.

3.1.15 Collection and analysis of soil sample

Soil samples were collected at 0- 15 cm soil depths after the harvesting of crop from five locations of each experimental plot. Three samples of each plot were mixed together made a composite sample and analyzed for soil texture, soil pH, organic matter, total nitrogen, available phosphorus, exchangeable potassium, and available sulphur from soil samples.

3.1.15.1 Particle size analysis of soil

Hydrometer method was used for particle size analysis of the soil (Bouyoucos, 1927). The textural class was determined using Marshell's Triangular co-ordinate as designated by USDA (1951).

3.1.15.2 Soil pH

The glass electrode pH meter was used to determine the pH of the soil samples. The ratio of soil and water in the solution was maintained 1: 2.5 (Jackson, 1973).

3.1.15.3 Organic carbon (%)

Walkley estimated soil organic carbon and Black's wet oxidation method as outlined by Jackson (1973).

3.1.15.4 Organic matter (%)

Soil organic matter content was calculated by multiplying the percent value of organic carbon with the Van Bemmelen factor, 1.724 as described by Piper (1942).

% organic matter = % organic carbon × 1.724.

3.1.15.5 Total nitrogen (%)

Micro Kjeldhal method used for determining total nitrogen in the soil samples (Page *et al.*, 1982). The procedure was digestion of soil sample by conc. H_2SO_4, 30% H_2O_2 and catalyst mixture (K_2SO_4: C_uSO_4. $5H_2O$: S_e) = 10:1:0.1) followed by distillation with 40% NaOH and by titration of the distillate trapped in H_3BO_3 with 0.01 N H_2SO_4 (Black, 1965).

3.1.15.6 Available phosphorus (ppm)

Available phosphorus was extracted from the soil with 0.5 M $NaHCO_3$ solutions, pH 8.5 (Olsen *et al.,* 1954). Phosphorus in the extract was measured spectrophotometrically after development of blue colour (Black, 1965).

3.1.15.7 Exchangeable potassium (meq/100g soil)

Exchangeable potassium in the soil samples was extracted in the normal ammonium acetate at pH 7.0 (Black, 1965) and was determined by using a flame photometer.

3.1.15.8 Available sulphur (ppm)

Available S in soil was determined by extracting the soil samples with 0.15% C_aCl_2 solution (Page *et al.*, 1982). The S content in the extract was determined turbidimetrically and the intensity of turbid was measured by spectrophotometer at 420 nm wave length.

3.1.16 Statistical analysis

The data obtained for different parameters were statistically analyzed to find out the significant difference of different levels of zinc and boron. The mean values of all the characters were calculated and analysis of variance was performed by the "F" (variance ratio) test. The significance of the difference among the treatment means was estimated by the Least Significant Difference (LSD) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULT AND DISCUSSION

The experiment was conducted to study the effect of NPK briquette on the growth and yield of BARI Jhar Sheem-2. Data on different growth parameter, yield and characteristics of post harvest soil was recorded. The findings of the experiment have been presented and discusses with the help of table and graphs and possible interpretations were given under the following headings:

4.1 Yield contributing characters and yield of bush bean:

4.1.1 Effect of NPK briquette

4.1.1.1 Plant height (cm)

Plant height was significantly increased by different doses of NPK briquette fertilizer application in BARI Jhar Sheem-2 variety. (Table 3). The tallest plant (52.20 cm) was produced with T_7 treatment which was statistically similar to T_2, T_3, T_4, T_5, T_6 and T_8 treatments respectively. The shortest plant (43.70 cm) was found in T_1 (control) treatment. It was observed that plant height increased gradually with the increment of NPK briquette doses up to T_5 treatment as dose. NPK fertilizer ensured the availability of macro nutrients i.e. N, P, K that created a favorable condition for the growth of Jhar Sheem-2 with optimum vegetative growth and the ultimate results was the tallest plant. Ghosal *et al*. (2000) found that plant height increased with the increasing application of N. (Fig.-2).

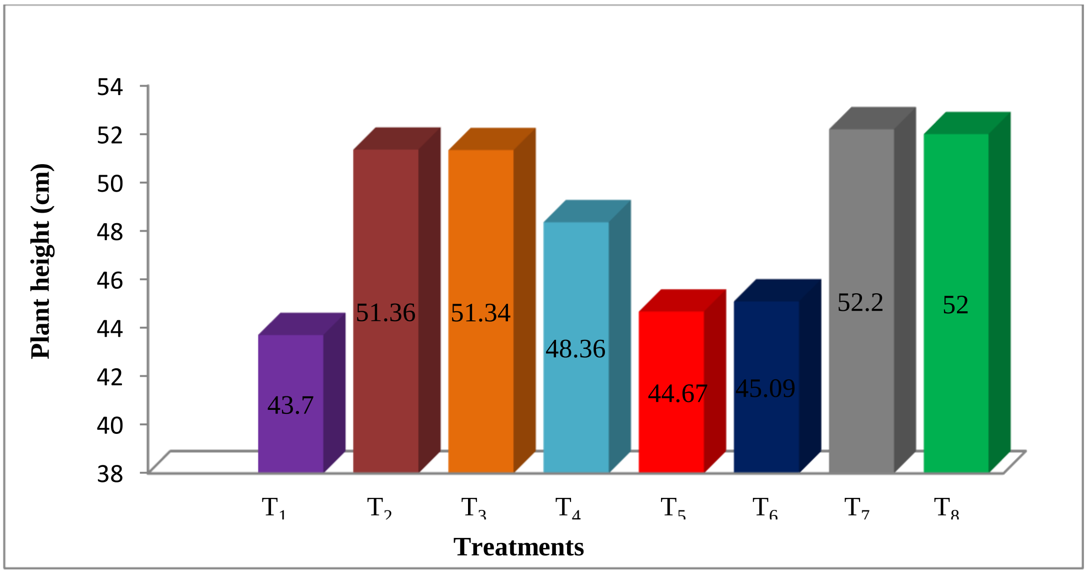


Figure 2: Effect of NPK briquette on plant height (cm)

4.1.1.2 Number of branches plant^{-1}

Number of branches showed statistically significant variation in the case of BARI Jhar Sheem-2 due to different levels of NPK briquette fertilizer application (Table 3). The highest number of branches (18.72) was found in T_5 treatment receiving from 140 pieces briquette fertilizer at 15 DAS application. The lowest number of branches (14.17) was found from T_1 (control) treatment which was statistically similar to T_2, T_3 and T_7 treatments respectively. (Fig.-3).

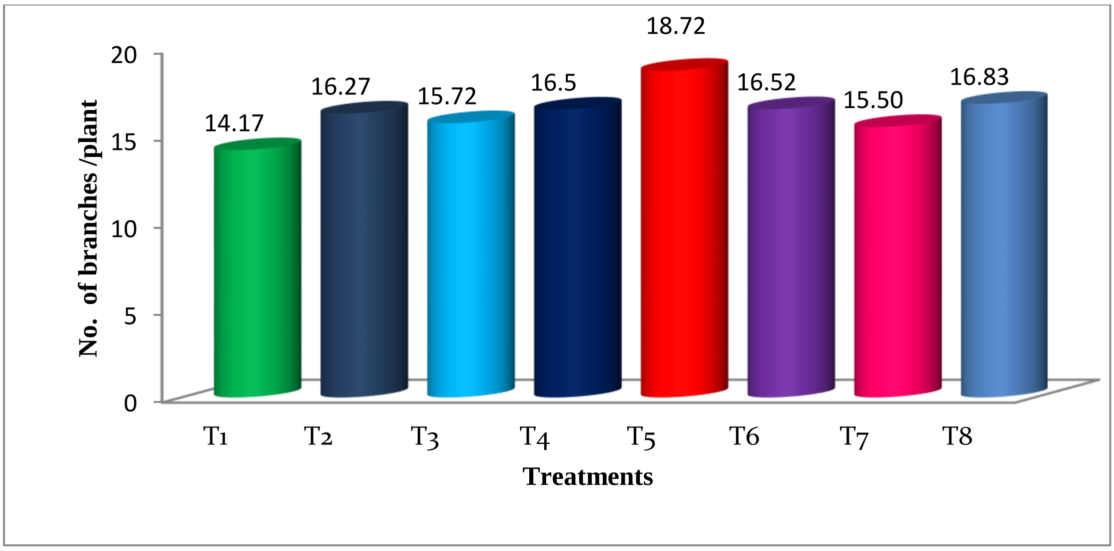


Figure 3: Effect of NPK briquette on number of branches plant^{-1}

4.1.1.3 Number of pods plant^{-1}

Different levels of NPK briquette fertilizer showed significant variation in terms of number of pod plant^{-1} of BARI Jhar Sheem-2 (Table 3). The maximum number of pods plant^{-1} (27.83) was found from T_5 receiving 140 pieces NPK briquette fertilizer at 15 DAS which was statistically identical with T_4 treatment. The minimum number of pods plant^{-1} was found from T_1 (Control) treatment which was statistically identical with T_2, T_6, T_7 and T_8 treatments respectively. In case of rice plant, Pandey (2009) observed that application of NPK fertilizers increases the effective tillers hill^{-1}. (Fig.-4).

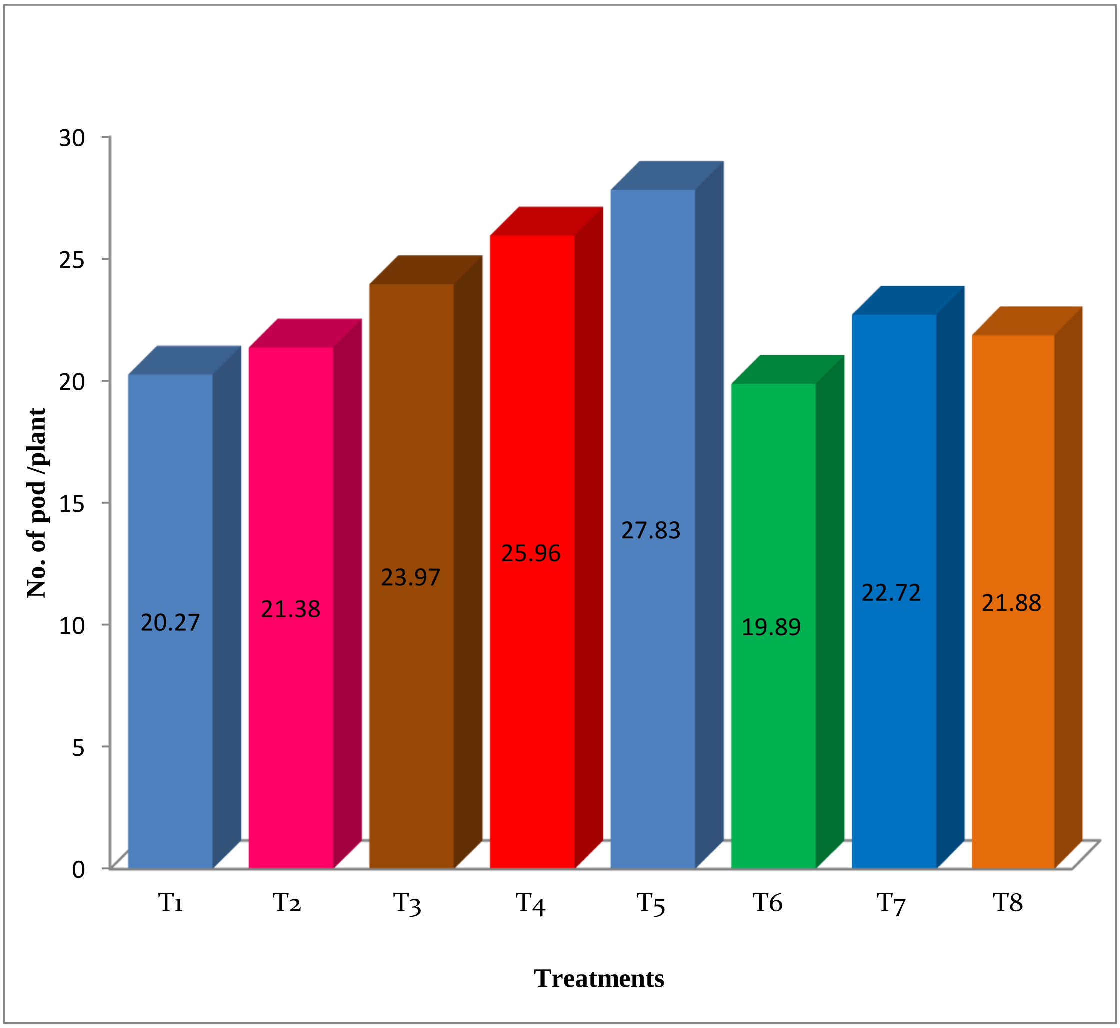


Figure 4: Effect of NPK briquette on number of pod plant^{-1}

4.1.1.4 Pod weight plant^{-1}

Different levels of NPK briquette fertilizer showed significant variation in the case of pod weight plant^{-1} of BARI Jhar Sheem-2 (Table 3). The maximum weight of pods plant^{-1} (185.8) was found from T_5 treatment receiving 140 pieces briquette fertilizer at 15 DAS which was statistically similar to T_4 treatment. The minimum weight of pods plant^{-1} (108.7) was found from T_1 (control) treatment which was statistically similar with T_2, T_3, T_6, T_7 and T_8 respectively (Fig.-5). Singh *et al*. (1993) reported that pod yield of mungbean was increased by the application of 20 kg N ha^{-1} and 40 kg P_2O_5 ha^{-1}, whereas K_2O application has no significant effect.

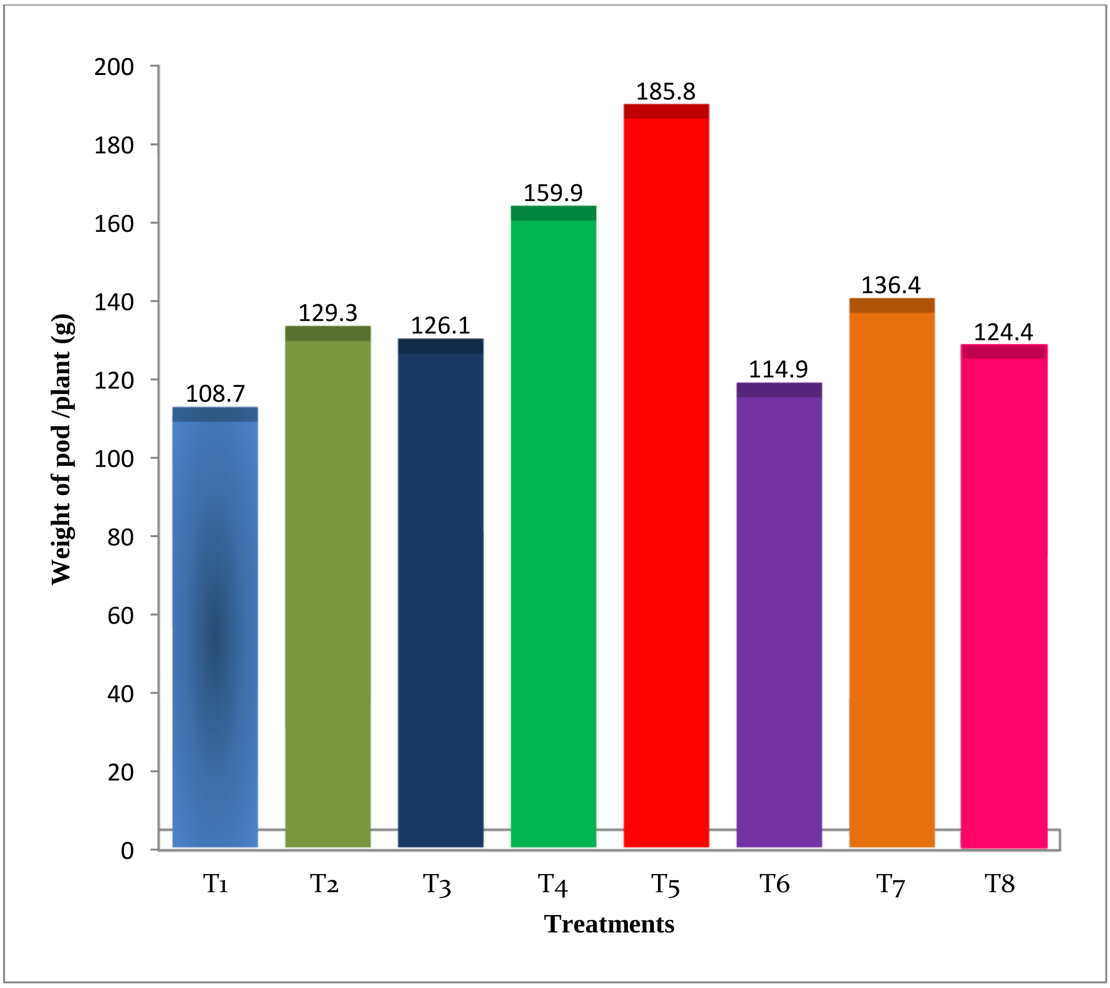


Figure 5: Effect of NPK briquette on pod weight plant^{-1}

4.1.1.5 Pod length (cm)

Significant variation was recorded in the cases of pod length of BARI Jhar Sheem-2 due to different levels of NPK briquette application (Table 3). The longest pod (14.69 cm) was obtained from T_5 receiving 140 pieces NPK briquette fertilizer at 15 DAS which were statistically identical with T_3, T_4 and T_6 treatments. The shortest pod (11.96 cm) was recorded from T_1 (Control) treatment which was statistically identical with T_8 treatment respectively (Fig.-6).

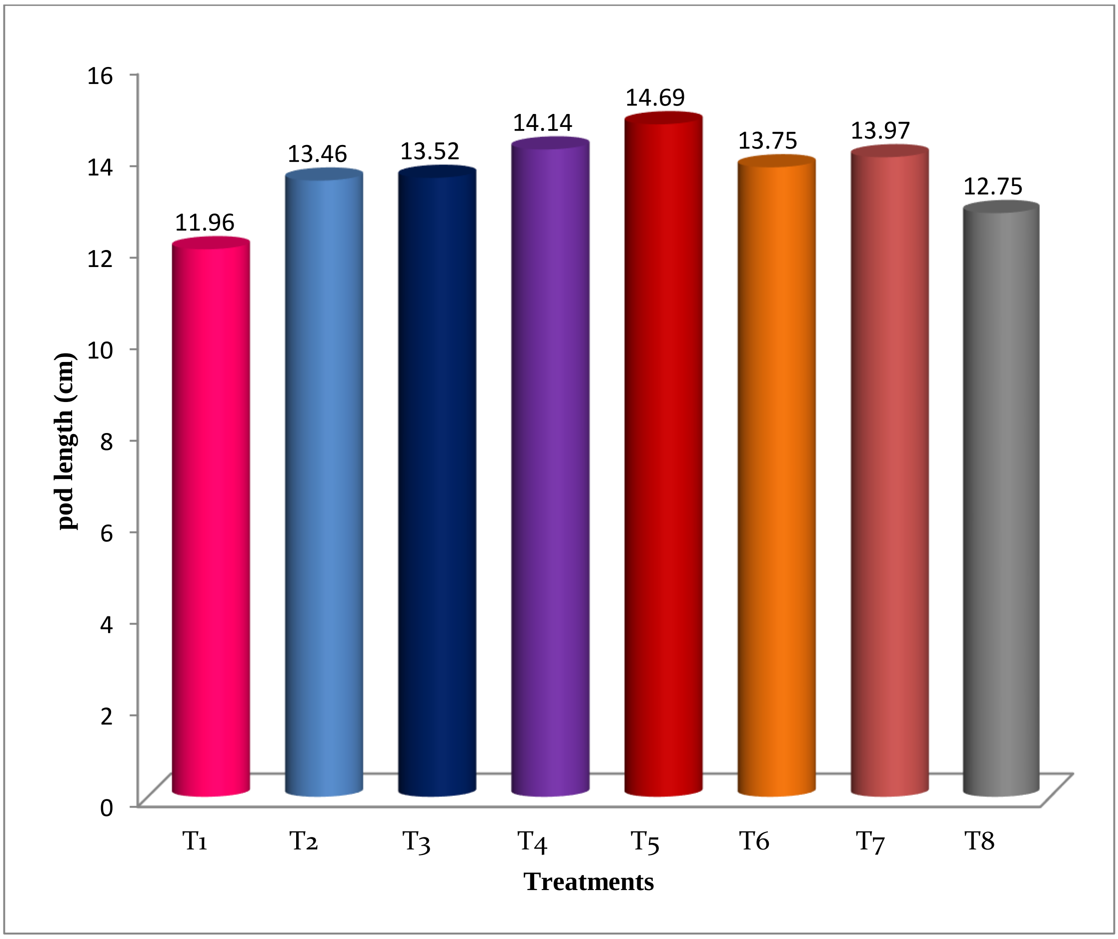


Figure 6: Effect of NPK briquette on pod length (cm)

4.1.1.6 Weight of 10 green pods (g)

Different levels of NPK briquette varied significantly for weight of 10 pods of BARI Jhar Sheem-2 under the present trial (Table 3). The highest weight of 10 pods indicates (21.36 g) was recorded from T_5 treatment receiving 140 pieces of NPK briquette fertilizer at 15 DAS. The lowest weight found in the case of 10 pods (19.0 g) from T_1 (control) treatment which was statistically similar with T_2, T_3, T_4, T_6, T_7 and T_8 treatments respectively. (Fig.-7).

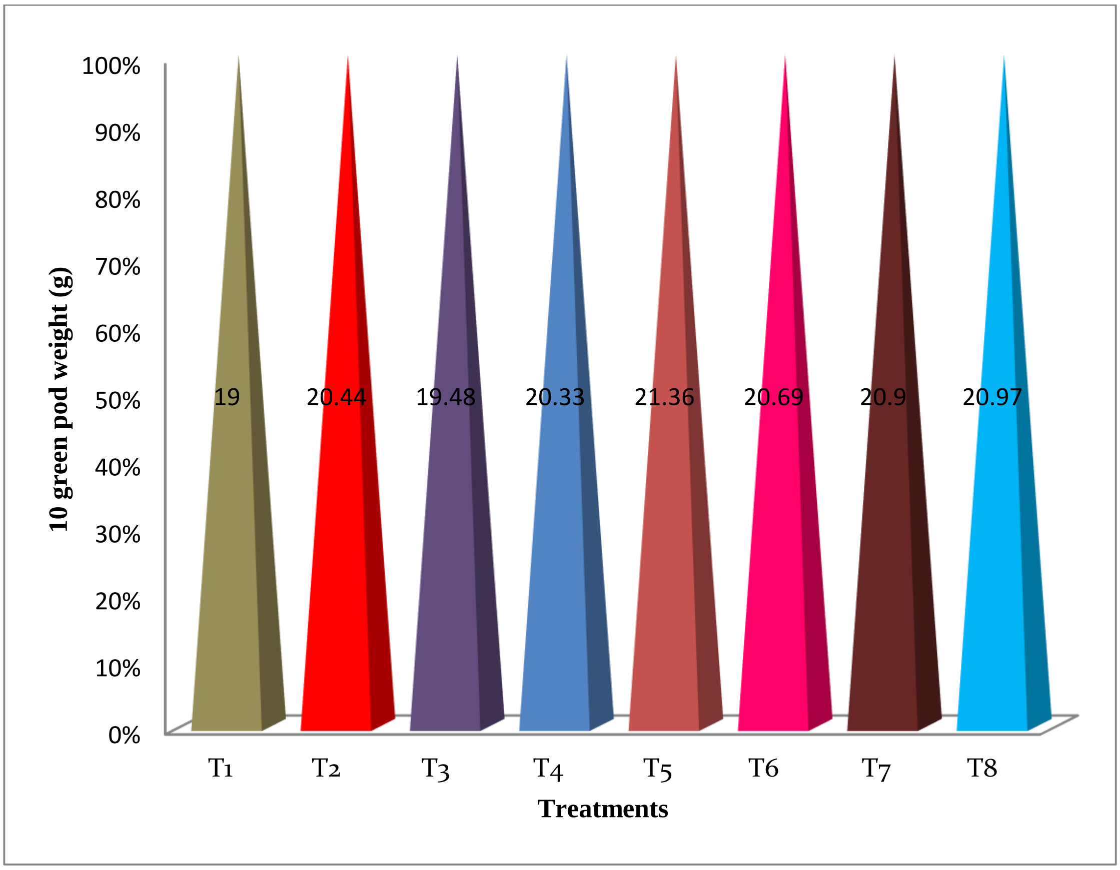


Figure 7: Effect of NPK briquette on wt. of 10 green pods (g)

4.1.1.7 Pod yield (t ha^{-1})

The pod yield of BARI Jhar Sheem-2 varied significantly changes due to application of different rates of NPK briquette fertilizer treatments (Table 3). The maximum yield was found (40.25 t ha^{-1}) from T_5 receiving 140 pieces NPK briquette fertilizer at 15 DAS treatment which was statistically similar to T_4 and T_7 treatments. The lowest pod yield (26.08 t ha^{-1}) was found in T_1 (control) treatment which was statistically similar with T_2, T_3, T_6 and T_8 treatments respectively. Akter *et al*. (2015) reported that uses of Deep placement of NPK briquette (T_6) has given significantly highest yield in case of bitter gourd (32.16 t ha^{-1}) followed by urea briquette (30.45 t ha^{-1}) which was 12.34 and 7.41 percent higher yield over prilled urea (T_4). (Fig.-8).

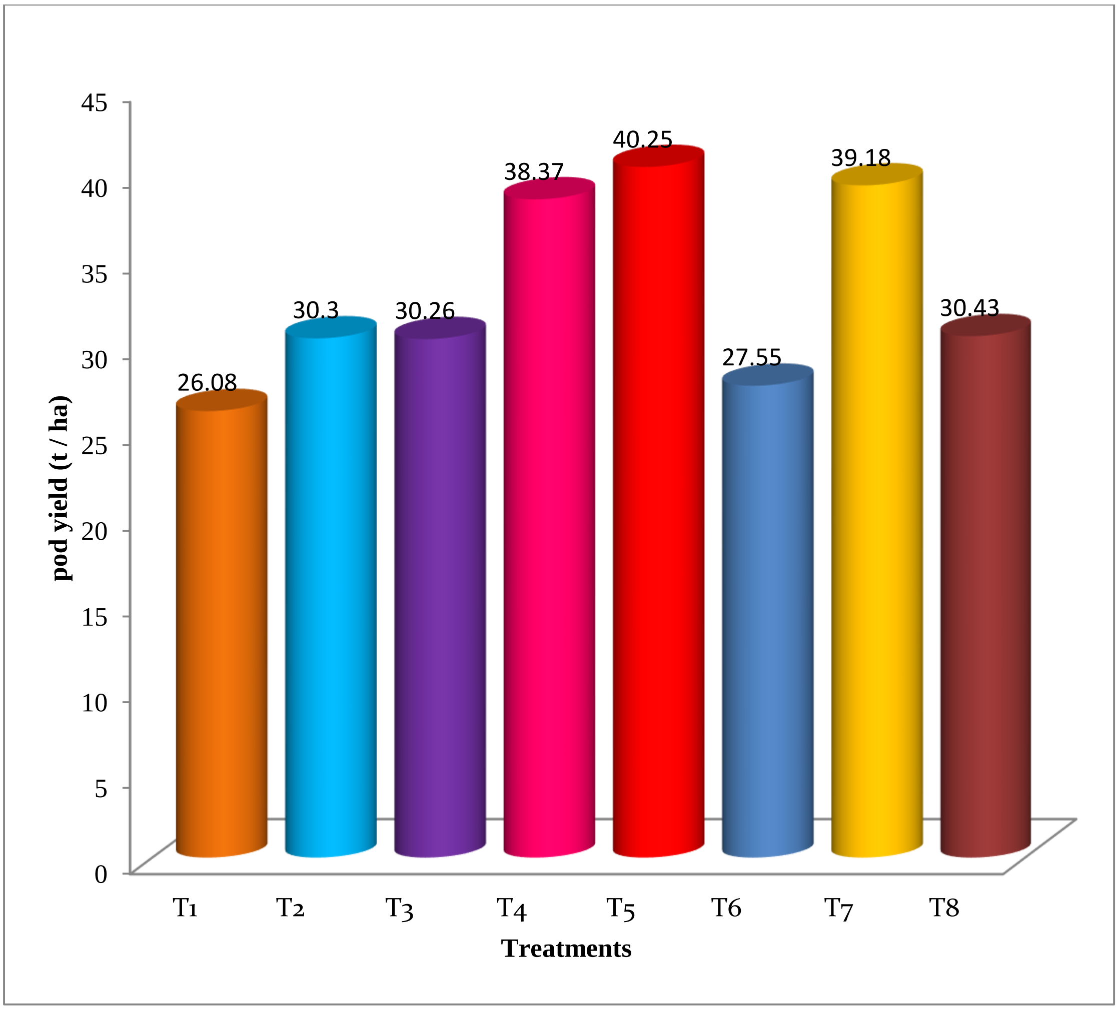


Figure 8: Effect of NPK briquette on pod yield (t ha^{-1})

4.1.1.8 Stover yield (t ha^{-1})

Statistically significant variation was recorded in terms of stover yield (t ha^{-1}) of BARI Jhar Sheem-2 variety due to application of different levels of NPK briquette fertilizer (Table 3). The highest stover yield (4.710 t ha^{-1}) was found from T_5 receiving 140 pieces of NPK briquette fertilizer at 15 DAS which was statistically similar with T_2, T_4 and T_8 treatments respectively. The lowest stover yield (3.290 t ha^{-1}) was found from T_1 (control) treatment which was similar with T_3, T_6 and T_7 treatments respectively. (Fig.-9).

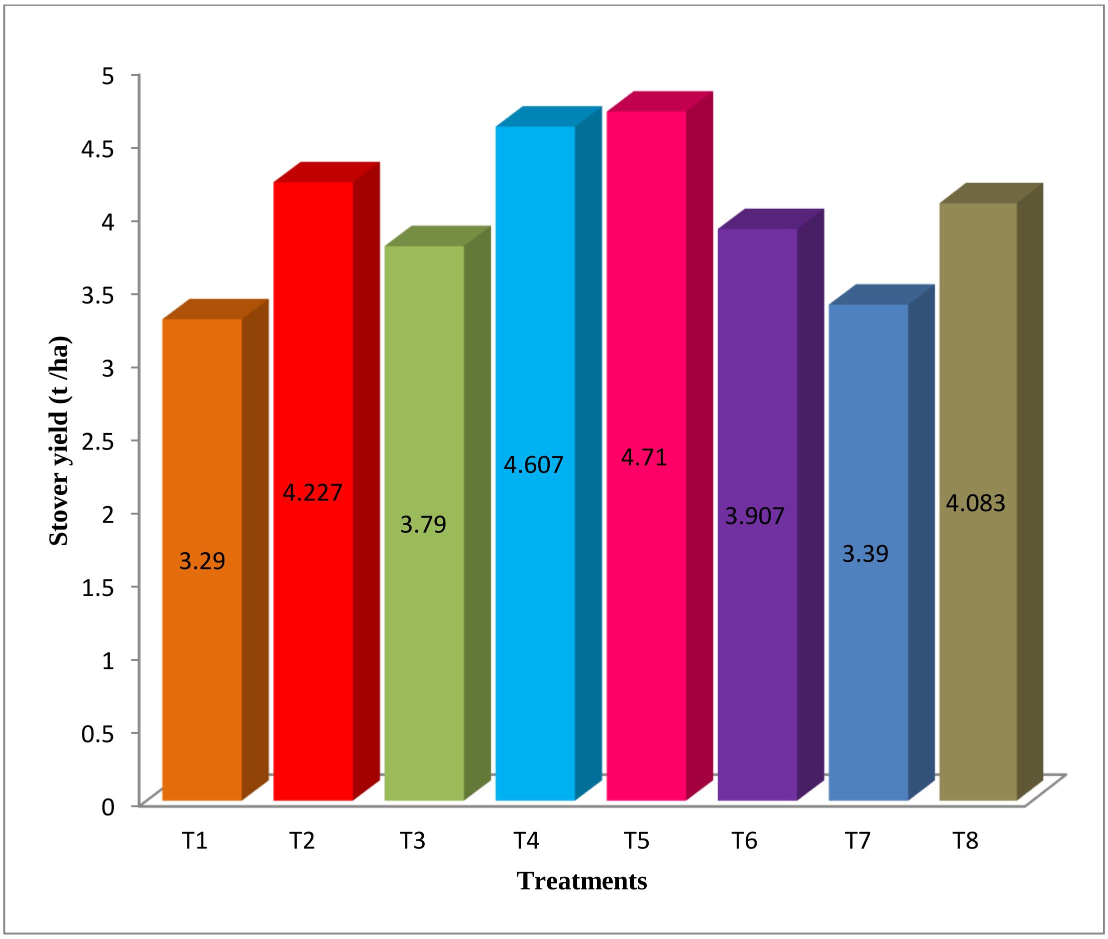


Figure 9: Effect of NPK briquette on stover yield (t ha^{-1})

Table 3. Effect of NPK briquette fertilizer on plant height, number of branches plant^{-1}, number of pods plant^{-1}, pod weight plant^{-1}, pod length (cm), 10 green pod weigh (g), pod yield (t ha^{-1}), stover yield (t ha^{-1})

Treatment	Plant height (cm)	No. of branches/plant	No. of pod/plant	Pod wt./ plant (g)	Pod length (cm)	10 green pod wt.(g)	Pod yield (t /ha)	Stover yield (t /ha)
T_1	43.70^{b}	14.17^{c}	20.27^{c}	108.7^{c}	11.96^{c}	19.00^{b}	26.08^{c}	3.290^{e}
T_2	51.36^{a}	16.27^{bc}	21.38^{bc}	129.3^{bc}	13.46^{b}	20.44^{ab}	30.30^{bc}	4.227^{abc}
T_3	51.34^{a}	15.72^{bc}	23.97^{b}	126.1^{bc}	13.52^{ab}	19.48^{ab}	30.26^{bc}	3.790^{cde}
T_4	48.36^{ab}	16.50^{b}	25.96^{a}	159.9^{ab}	14.14^{a}	20.33^{ab}	38.37^{ab}	4.607^{ab}
T_5	44.67^{ab}	18.72^{a}	27.83^{a}	185.8^{a}	14.69^{a}	21.36^{a}	40.25^{a}	4.710^{a}
T_6	45.09^{ab}	16.52^{b}	19.89^{c}	114.9^{bc}	13.75^{ab}	20.69^{ab}	27.55^{c}	3.907^{b-e}
T_7	52.20^{a}	15.50^{bc}	22.72^{bc}	136.4^{bc}	13.97^{b}	20.90^{ab}	39.18^{ab}	3.390^{de}
T_8	52.00^{a}	16.83^{b}	21.88^{bc}	124.4^{bc}	12.75^{bc}	20.97^{ab}	30.43^{bc}	4.083^{a-d}
LSD $_{(0.05\%)}$	7.583	2.2	1.9	47.17	1.5	2.264	9.405	0.7326
CV%	6.42%	13.15%	17.58%	19.85%	5.05%	6.25%	16.37%	10.44%

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

T_1: No fertilizer (Control)
T_2: Recommended dose ($N_{120}P_{30}K_{50}S_{10}$ kg ha^{-1}),
T_3: 120 Pieces NPK briquette at 15 DAS ($N_{90}P_{24}K_{40}$ kg ha^{-1})
T_4:60 pieces NPK briquette at 15 DAS +60 pieces NPK briquette at 30 DAS
T_5: 140 pieces NPK briquette at 15 DAS
T_6: 70 pieces NPK briquette at 15 DAS +70 pieces NPK briquette at 30 DAS
T_7: 160 pieces NPK briquette at 15 DAS
T_8: 80 pieces NPK briquette at 15 DAS + 80 pieces NPK briquette at 30 DAS

4.2 pH, organic matter, N, P, K and S content in post harvest soil

4.2.1 pH

No significant variation was observed from post harvest soil pH due to the application of different levels of NPK briquette fertilizer for BARI Jhar sheem-2 crop cultivation (Table 4). The numerically highest pH was recorded from post harvest soil (6.1) was found from T_7 treatment receiving 160 pieces of NPK briquette fertilizer at 15 DAS. Whereas, the numerically lowest pH was found in post harvest soil (5.80) was recorded from T_1 treatment that receiving no fertilizers.

4.2.2 Organic matter

Organic matter in post harvest soil was no significant variation with different levels of NPK briquette fertilizer in case BARI Jhar sheem-2 cultivation (Table 4). The numerically highest organic matter in post harvest soil was recorded (1.380%) from T_7 treatment receiving 160 pieces of NPK briquette fertilizer at 15 DAS which was statistically superior above the rest of the treatment under study. The numerically lowest organic matter in post harvest soil (1.290%) was observed from T_1 (no fertilizer) treatment.

4.2.3 Total nitrogen

Total nitrogen in post harvest soil showed statistically significant at different levels of NPK briquette fertilizer in case of BARI Jhar sheem-2 cultivation (Table 4). The highest total nitrogen observed in post harvest soil (0.053%) from T_8 treatment receiving 80 pieces NPK briquette at 15 DAS+80 pieces NPK briquette at 30 DAS. On the other hand, the lowest total nitrogen in post harvest soil was (0.026%) obtained from T_1 treatment (control) with no fertilizer.

4.2.4 Available phosphorous

A significant difference was found in available phosphorous content of post harvest soil at different levels of NPK briquette fertilizers for BARI Jhar sheem-2 cultivation (Table 4). The highest available P (24.89 ppm) was recorded in the post harvest soil in T_8 treatment receiving 80 pieces NPK briquette at 15 DAS+80 pieces NPK briquette at 30 DAS which was statistically identical with T_3, T_4, T_5, T_7 and T_8 treatments respectively. The lowest available P (19.85 ppm) was noted in T_1 (control) treatment.

4.2.5 Exchangeable potassium

Exchangeable potassium in post harvest soil showed statistically significant at different levels of NPK briquette fertilizer for BARI Jhar sheem-2 cultivation (Table 4). The maximum exchangeable potassium of post harvest soil (0.163 meq/100g soil) was recorded in T_7 treatment receiving 160 pieces of NPK briquette fertilizer at 15 DAS which was statistically superior treatment under rest all of the study. The lowest available K (0.122meq/100g soil) was observed in T_1 (control) treatment received no fertilizers which was statistically similar with T_2 treatment respectively.

4.2.6 Available sulphur

A significant difference in the case of available sulphur content of post harvest soil was observed at different levels of NPK briquette fertilizer for BARI Jhar sheem-2 cultivation (Table 4). The highest available S (20.64 ppm) was found in the post harvest soil from T_7 treatment which was statistically similar with T_5 treatment. The lowest available S (15.05 ppm) was found in T_1 treatment, which was statistically similar to T_8 treatment respectively.

Table 4. Effect of NPK briquette fertilizer on pH, organic matter, N, P, K and S content in post harvest soil of BARI Jhar sheem-2 cultivation

Treatment	pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (%me/100 g of soil)	Available S (ppm)
T_1	5.80	1.290	0.026^{c}	19.85^{c}	0.122^{d}	15.05^{d}
T_2	5.82	1.291	0.030^{b}	20.67^{b}	0.132^{cd}	17.86^{bc}
T_3	5.91	1.350	0.045^{ab}	23.95^{a}	0.151^{ab}	18.67^{bc}
T_4	5.97	1.328	0.049^{a}	24.73^{a}	0.153^{ab}	17.30^{c}
T_5	5.88	1.299	0.052^{a}	23.52^{a}	0.139^{bc}	19.62^{ab}
T_6	5.85	1.293	0.039^{ab}	22.61^{b}	0.137^{c}	16.72^{c}
T_7	6.1	1.380	0.040^{ab}	24.89^{a}	0.163^{a}	20.64^{a}
T_8	6.05	1.377	0.053^{a}	24.90^{a}	0.156^{a}	15.17^{d}
$LSD_{0.05}$	NS	NS	0.015	2.250	0.015	1.940
CV (%)	4.41	4.90	6.54	6.42	3.90	7.27

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

T_1: No fertilizer (Control)

T_2: Recommended dose ($N_{120}P_{30}K_{50}S_{10}$ kg ha^{-1}),

T_3: 120 Pieces NPK briquette at 15 DAS ($N_{90}P_{24}K_{40}$ kg ha^{-1})

T_4:60 pieces NPK briquette at 15 DAS + 60 pieces NPK briquette at 30 DAS

T_5: 140 pieces NPK briquette at 15 DAS

T_6: 70 pieces NPK briquette at 15 DAS + 70 pieces NPK briquette at 30 DAS

T_7: 160 pieces NPK briquette at 15 DAS

T_8: 80 pieces NPK briquette at 15 DAS + 80 pieces NPK briquette at 30 DAS

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted during the period from November, 2016 to February 2017 at the farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh to study the effect of NPK briquette on the growth and yield of BARI Jhar Sheem-2. The variety BARI Jhar Sheem-2 was used as the test crop. The soil of the experimental field was clay loam in texture that belongs to the Tejgoan soil series of the Madhupur Tract (Agro ecological zone AEZ -28). Soil pH was 5.7 (at 0-15 cm) depth. The soil contained sand was 30.0%, silt 40.0%, clay 30.0%, Total N 0.04%, organic-C 0.78%, OM 1.345%, available P was 19.90 ppm, exchangeable K 0.12% and 14.37 ppm available S. The selected plot was a medium high land that remained fallow during the previous summer.

The treatments consisted of 8 (eight) levels of NPK briquette fertilizers i.e. T_1: no fertilizer (Control), T_2: Recommended dose ($N_{120}P_{30}K_{50}S_{10}$ kg ha^{-1}), T_3: 120 pieces NPK briquette at 15 DAS ($N_{90}P_{24}K_{40}$ kg ha^{-1}), T_4: 60 pieces NPK briquette at 15 DAS + 60 pieces NPK briquette at 30 DAS, T_5: 140 pieces NPK briquette at 15 DAS, T_6: 70 pieces NPK briquette at 15 DAS + 70 pieces NPK briquette at 30 DAS, T_7: 160 pieces NPK briquette at 15 DAS, T_8: 80 pieces NPK briquette at 15 DAS + 80 pieces NPK briquette at 30 DAS.

The single factor experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The unit plot size was 7.5 m^2 (3m x 2.5m) and the space between block and between plots were 1m and 0.5m respectively. Seeds were shown in the plot 23 November, 2016. Intercultural operations were done as when it was necessary. From each unit plot 5 plants were randomly selected to record data on growth and yield attributes. Data on different growth parameters, yield and nutrient of post harvest soil was recorded and statistically significant variation was observed from application of different level of NPK briquette fertilizer. Data were analyzed using through the computer package M-STAT and the difference between means was compared by LSD test. At the time of final land preparation soil sample and after harvest soil sample were taken for chemical analysis and to assess the nutrient status condition in the experiment site soil. Results of the samples were also statistically analyzed. The individual effect of NPK briquette on the growth, yield and nutrient status of soil of BARI Jhar sheem-2 were studied.

Data on plant characters were recorded at different stages. NPK briquette fertilization at different levels individually influenced plant characters. The individual effects of NPK briquette on growth, yield and nutrient content were found positive. Both the growth and yield increased with increasing doses of NPK briquette fertilizer application.

NPK briquette fertilizer plays a significant role on the yield of BARI Jhar sheem-2. Plant height was significantly influenced by different level of NPK briquette fertilizer. The tallest plant (52.20 cm) was produced with T_7 treatment, received of 160 pieces of NPK briquette at 15 DAS and the shortest plant (43.70 cm) was found in control treatment. The highest number of branches plant^{-1} (18.72 cm) was recorded from T_5 treatment, while the smallest number of branches plant^{-1} (12.56 cm) was found from T_1 treatment (control). The maximum number of pod plant^{-1} (27.83) was found from T_5 treatment receiving 140 pieces NPK briquette at 15 DAS while the minimum number of number of pod plant^{-1} (20.27) was found from T_1 treatment (control). The maximum pod weight plant^{-1} (185.8 g) was recorded from T_5 treatment receiving 140 pieces NPK briquette at 15 DAS. The minimum weight of pods plant^{-1} (108.7g) was found in the control treatment. The largest pod length (14.69 cm) was received from T_5 treatment receiving 140 pieces NPK briquette at 15 DAS. On the other hand, the shortest length of pods (11.96 cm) was recorded from T_1 (control). The highest weight of 10 green pods (21.36 g) was observed from T_5 treatment receiving 140 pieces NPK briquette at 15 DAS whereas the lowest weight of 10 green pods (19.0 g) was observed from T_1 (control). The highest stover yield (4.710 t ha^{-1}) was attained from T_5 treatment receiving 140 pieces NPK briquette at 15 DAS. The lowest stover yield (3.290 t ha^{-1}) was found from T_1 (control) treatment. The maximum yield of green pod (40.25 t ha^{-1}) was recorded with T_5 treatment application of 140 pieces NPK briquette at 15 DAS, which was significantly different with other treatments and the minimum yield of green pod (26.08 t ha^{-1}) was found from the control treatment where no briquette fertilizer was applied.

The chemical properties of post harvest soil were affected by application of different levels of NPK briquette fertilizer. The numerically highest pH of post harvest soil (6.1) was recorded from T_7 treatment receiving 160 pieces of NPK briquette at 15 DAS and the lowest pH in post harvest soil (5.80) was found from T_1 treatment with no fertilizer (Control).

The highest organic matter in post harvest soil (1.380%) was found from T_7 treatment receiving 160 pieces of NPK briquette at 15 DAS whereas, the lowest organic matter (1.290%) was recorded from T_1 treatment (control). The highest total nitrogen (0.053%) and available P (24.90 ppm) in post harvest soil were recorded from T_8 treatment receiving 80 pieces NPK briquette at 15 DAS + 80 pieces NPK briquette at 30 DAS. On the other hand, the lowest total nitrogen (0.026%) and available P (19.85 ppm) in post harvest soil were found in T_1 treatment with no fertilizer (control). In case of exchangeable K (0.68 meq/100 g soil) and available sulphur was (20.64 ppm) recorded highest in T_7 treatment receiving 160 pieces of NPK briquette at 15 DAS. The lowest exchangeable K (0.122 meq/100 g soil) and available S (15.05 ppm) in post harvest soil was found in T_1 treatment (control) respectively.

Conclusion

From the above findings it can be concluded that NPK briquette fertilizer had a significant effect on growth and yield characters of BARI Jhar sheem-2. The application of 140 piece NPK briquette at once fertilizer was most favorable for improving growth and yield character of BARI Jhar Sheem-2.

Considering the above results of this experiment, further studies in the following areas may be suggested:

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional compliance and other performances.
2. Another combination of NPK briquette as fertilizer may be included for further study.

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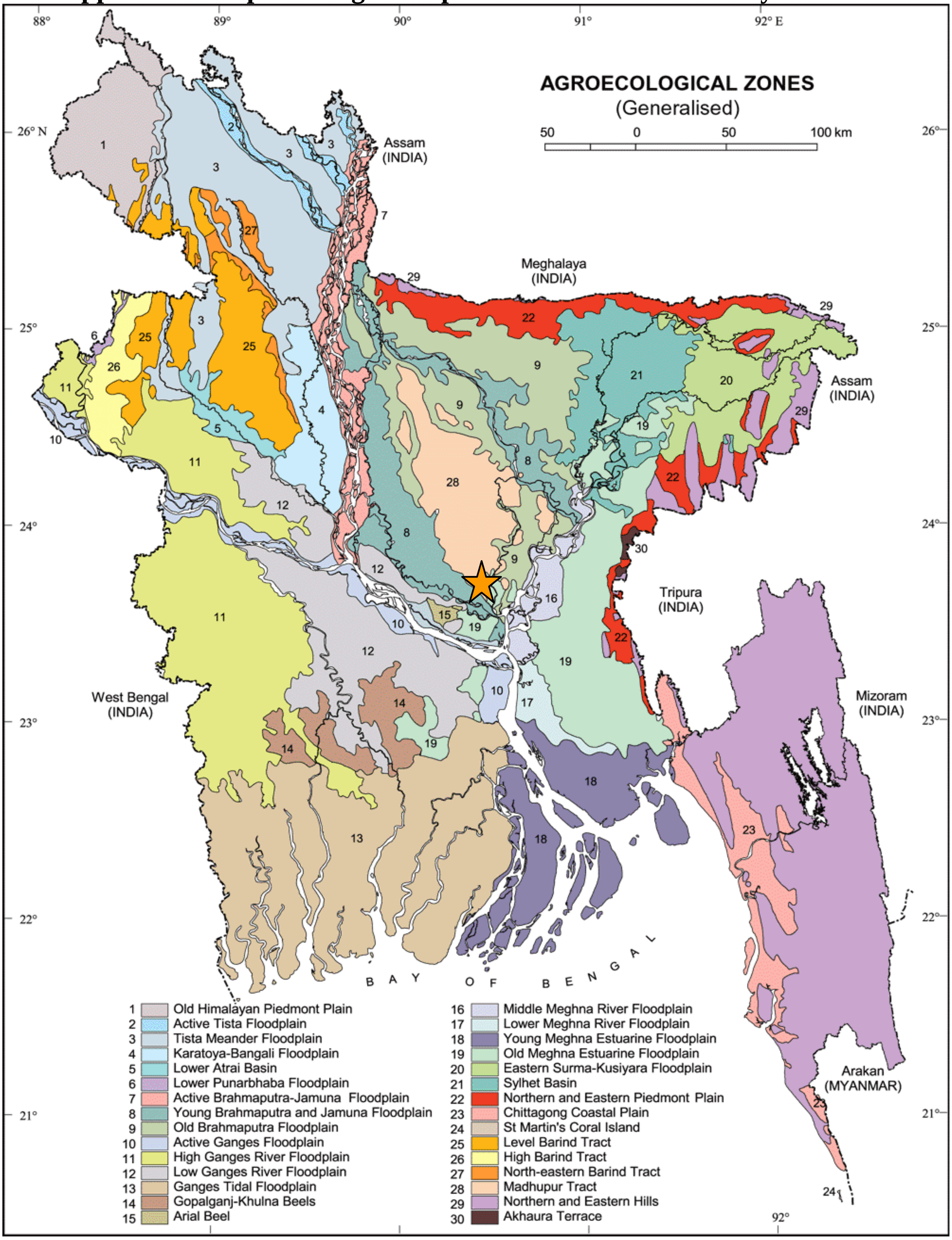
APPENDICES

Appendix I. Map showing the experimental sites under study



Appendix II. Monthly record of air temperature, relative humidity and rainfall (average) of the experimental site during the period from November 2016 toFebruary 2017, SAU.

Month	Air temperature(^{0}C)		Relative humidity (%)	Rainfall (mm)
	Maximum	**Minimum**		
November, 2016	26.5	19.4	81	22
December, 2016	25.8	16.0	78	00
January, 2017	25.8	12.2	72	6
February, 2017	28.4	14.7	64	21

Source: Bangladesh Meteorological Department (Climate and weather division) Agargoan, Dhaka-1207.

Appendix III. Some commonly used abbreviations and symbols

Abbreviations	Full words
%	Percent
@	At the rate
AEZ	Agro-Ecological Zone
Agric.	Agriculture
Agril.	Agricultural
Agron.	Agronomy
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
cm	Centi-meter
CV%	Percentage of coefficient of variation
DAS	Day After Sowing
et al.	and others
FAO	Food and Agricultural Organization
g	gram
IFDC	International Fertilizer Development Center
j.	Journal
LSD	Least Significant Difference
ppm	Parts per million
PSTU	Patuakhali Science and Technology University
PU	prilled urea
RCBD	Randomized Complete Block Design
Res.	research
SAU	Sher-e-Bangla Agricultural University
UB	Urea Briquette
USG	Urea Super Granule
Var.	variety
Wt.	Weight