COMPARATIVE STUDY OF USG AND NPK BRIQUETTE ON THE PERFORMANCE OF JHUM CROPS

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CERTIFICATE

This is to certify that the thesis entitled "**COMPARATIVE STUDY OF USG AND NPK BRIQUETTE ON THE PERFORMANCE OF JHUM CROPS"** 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 in SOIL SCIENCE**, embodies the result of a piece of bonafide research work carried out by **MOHAMMAD MOHIUDDIN AL MAMUN**, Registration **No. 20562/00118** 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 been duly acknowledged.

Dated:

Place: Dhaka, Bangladesh

(Dr. Alok Kumar Paul)
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COMPARATIVE STUDY OF USG AND NPK BRIQUETTE ON THE PERFORMANCE OF JHUM CROPS

ABSTRACT

Two experiments were conducted at Ramery para, Bandarban sadar, Bandarban hill district in Chittagong under the AEZ 29 (Northern and Eastern Hills Tract) during March 2017 to November 2017 to study of USG and NPK briquette on the performance of Jhum crops. In this experiment, Jhum rice, marpha, maize, sweet gourd and chili were used as the test crop. The experiment was conducted in two field and designed on Randomized Completely Block Design (RCBD). The treatments consisted of 7(seven) levels of NPK briquette i.e. T_1: Control, T_2: 100% USG and PK (RFD), T_3: 80% USG and PK (RFD), T_4: 120% USG and PK (RFD), $T_{5:}$100%NPK briquette (267.5 kg ha^{-1}), T_6: 80% NPK briquette (214.1 kg ha^{-1}), T_7: 120% NPK briquette (320.8 kg ha^{-1}). Ratio in 100 kg NPK briquette contain 50 kg urea:30 kg TSP:20 kg MoP and RFD value was N 60 kgha^{-1}, P 18 kg ha^{-1}, K 30 kg ha $^{-1}$ and S 8 kg ha^{-1}. The growth and yield of Jhum rice were significantly influenced by different levels of NPK briquette. Sometimes soil characteristics also influenced by NPK briquette. The highest plant height of jhum rice (139.23 cm), effective tillers hill^{-1} (16.60), panicle length (30.23 cm), highest number of filled grain panicle^{-1} (245.23), 1000 grain weight (28.0 gm), straw yield (4.15 t/ha) and grain yield (3.56 t/ha) were found from T_5 treatment treatment receiving 100%NPK briquette (267.5 kg ha^{-1})and for all cases lowest results were found in T_1 treatment receiving no fertilizer (control). Yield of others Jhum crops also significantly influenced by NPK briquette. The highest yield of marpha (734.88 kg ha^{-1}), maize (674.45 kg ha^{-1}), sweet gourd (1368.5 kg ha^{-1}), chili (155.51 kg ha^{-1}) and turmeric (422.82 kg ha^{-1}) were found in T_5 and for all cases lowest results were found in T_1 treatment.

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INTRODUCTION

Jhum cultivation (also called slash and burn agriculture, shifting cultivation or swiddan cultivation) is a centuries old agricultural practice of indigenous people of Chittagong Hill Tracts (CHT). It is closely related with the socio-cultural settings of some hill communities. However, jhum is a subsistence type of agriculture practiced by farmers of subsistence economy. It involves cutting of patches forest in the month of February to March burning of the slashed, dried vegetation after one month and then sowing of crop seeds in April in small holes made throughout sloppy fields(CARE,2011).

Harvesting of the crops is done in succession as they ripe between July to December. In Bangladesh, jhum cultivation is practiced in the hilly area of Chittagong Hill Tract. The Chittagong Hill Tracts(CHT) region comprises about one tenth of the total area of Bangladesh .The area covers 13,295 sq.km consisting of about 77% up land,20% undulating bumpy land and 3% plain with high potential for agricultural development (BBS,2008).

The life and culture of the ethnic peoples of hill areas depend to a great extent on jhum cultivation. But their production and yield reduced by their traditional cultivation system. Productivity of hill soil is constrained by erosion, no or little use of fertilizers, fertility depletion, strong soil acidity, inappropriate cropping and faulty management practices (Rasul and Thapa, 2002).

The depleted soil fertility is a major constraints to higher production in Chittagong Hill Tracts, Bangladesh (Farid*et al*.,2009).Continuous cultivation of highly exhaustive cropping sequence in most of the lands has resulted in the decline of soil physico-chemical condition. Average rice yield was recorded 1.15 t ha^{-1} under jhum cultivation(Uddin*et al*.,2010) which is much lower than national average of rice (3.73 t ha^{-1})(BARC,2012).

Once the land becomes inadequate for crop production it is then left to be reclaimed by natural jungle vegetation once again, while the same activity continues elsewhere, with this cycle continually repeating itself. They also cultivate many kinds of fruits and vegetables in the same month of the year, which may cause huge amount of soil erosion and depletion of soil nutrient .

Although Jhumcultivation is a non-viable resource utilization practice in Bangladesh, the tribal are clinging to this practice to sustain their livelihood due to their religious faith on it. In most cases, the jumia farmers does not use any fertilizer or use in little amount. As a result, the productivity of jhum crops declining day by day.

The recent advances in nutrient management in rice have been primarily driven by the continuing need to increase rice production. In addition, the fact that it will not be possible to continue the way the plant nutrients have been managed so far because agriculture adds globally significant and environmentally detrimental.

In some situation,by their jhum cultivation input and output values are same.For this reason many jhumia farmers lost their interest about jhum cultivation. However , A few experiments were conducted with fertilizer packages to evaluate the performance of jhum crops in Bangladesh. But due to application of normal form of fertilizer, there were a huge loss of nutrient through runoff , land degradation and cause of slopping(Farid*et a*l.,2009).

At present Krishi Gobeshona Foundation (KGF), Ministry of Agriculture and some other NGO,s also trying to cultivate Jhum crops in every year with proper fertilizer management. A few experiments were conducted with fertilizer to evaluate the performance of jhum crops in Bangladesh.

But due to application of normal form of fertilizer in sloppy land, there were a huge loss of nutrient through runoff. Runoff nutrient loss also lead to environmental pollution or degradation. But loss of fertilizer nutrients can be minimized by using NPK briquette in sloppy hill area for better Jhum production.

By the system of fertilizer use in hilly areas, they could not get highest yield that's why an experiment was conducted by using USG and NPK briquette on the performance of jhum crops. A field experiment was carried out to assess the comparative advantages of using Urea Super Briquette (USG) and NPK briquette over normal urea and also predict the better performance of jhum crops in the hilly area.

The detailed study was under taken with the following objectives:

Objectives:

- To evaluate the effect of the USG and NPK briquette for increasing the productivity of jhum crops
- To increase the efficiency of fertilizers by using USG briquette and NPK briquette
- To create awareness about the use of USG and NPK briquette for jhum cultivation in jhimia families.

REVIEW OF LITERATURE

There are numerous building blocks of life that plants need for healthy and optimum growth. Without these nutrients, plants cannot grow to their full potential, will provide lower yields, and be more susceptible to disease. In cases where soils are lacking, nutrients must be put back into the soil in order to create the ideal environment for optimal plant growth. Each of the primary nutrients is essential in plant nutrition, serving a critical role in the growth, development, and reproduction of the plant. Experimental evidences in the use of nitrogen, phosphorus and potassium showed an intimate effect on the yield and yield attributes of jhum crops. Yield and yield contributing characters of jhum crops are considerably influenced by different doses of NPK briquette. So, the requirement of NPK and USG briquette for any crop varies with the cultivars, season and soil types in different agro ecological zones. Recently, the scientists of Farm Machinery Division of BARI have successfully developed a hand operated USG applicator. This applicator applies USG at 6 to 7 cm depth below the soil surface in the middle of four bunches of rice seedlings. When USG is applied by hand, 28 hours are required per hectare, whereas only 10 hours are required by the applicator (BARI, 2008). The biggest advantage of the applicator is the reduction of drudgery.Since review of literature forms a connection between the past and present research works related to problem, which helps an investigator to draw a satisfactory conclusion, an effort was thus made to present some research works related to the present study in this section. Some literature related to the "**COMPARATIVE STUDY OF USG AND NPK BRIQUETTE ON THE PERFORMANCE OF JHUM CROPS**"

are reviewed below:

Effect of NPK and USG briquette on the growth and yield of rice

Miah and Masum (2006) conducted that deep placement of all essential fertilizers may be more efficient and farmers can be more benefited from this compared to broadcast method. In rice cultivation farmers in this area usually use non urea fertilizer as basal during final land preparation. In this reason, most of the applied fertilizers are lost through different ways. An effective alternative may be the use of Urea Super Briquette (USG) or NPK briquette for higher yield and efficient use of nitrogen in rice cultivation.

Uddin *et al*. (2010) and Sohel *et al*. (2009) reported that the variations in yield might be due to genetic makeup of the varieties. Grain yield, straw yield and harvest index also varied significantly due to interaction effect between Fertilizer management and varieties. It is evident that the highest grain yield (4.05 t ha^{-1}) was found in USG and BRRIdhan48, highest straw yield (4.57 t ha^{-1}) was found in USG and BRRIdhan48 and highest HI (48.30%) at USG and BRRIdhan48. The lowest result found in grain yield and straw yield (1.82 t ha^{-1} and 2.55 t ha^{-1}) at no fertilizer with BRRIdhan55. Lowest harvest index (40.08%) at recommended dose with BRRIdhan55.

Fertilizer management differences regarding grain yield and Straw yield were also reported by Qiao *et al*. (2011). Though at recommended dose of all fertilizers (N1) applied highest amount of urea but it was applied in three splits where last two split was applied more than 30 cm flooded water. It may influence the wash out of the nutrient from the field. On the other hand harvest index showed highest (45.54 %) in NPK briquette and lowest (44.08) in absolute control.

Ashrafuzzaman *et al*. (2009) found that significant difference of 1000 grain weight among varieties. The highest filled grain per panicle (60.62) was observed in BRRIdhan48 and lowest (44.79) in BRRIdhan55. On the other hand the 1000 seed weight was highest (29.56 g) in BRRIdhan27 and lowest (22.65 g) in BRRIdhan55.

Jeng *et al*. (2006) found the similar result in respect of 1000 grain weight. Filled grain per panicle was highest in USG and BRRIdhan48 (67.83) and lowest in no fertilizer with BRRIdhan55. And in case of 1000 seed weight USG and BRRIdhan27 (30.10 g) provide the highest result and lowest in absolute control with BRRIdhan55 (21.77 g).

Results were reported by Ahammed (2008) Urea Super Briquette (USG) and NPK briquette fertilizers provide a better effect on LAI and Dry matter production. The highest result for LAI and Dry matter were observed in USG treated plots (2.97 and 24.18 g per hill) followed by NPK briquette applied plots (2.85 and 23.93 g per hill). The absolute control plots showed the lowest results (2.34 and 21.39 g per hill). In dry matter USG and NPK briquette showed statistically similar results.

Statistically result was found by Debnath (2012) that numerically the highest (24.45 cm) panicle length was found in BRRIdhan27 and lowest (21.84 cm) in BRRIdhan65. From the result it was observed that panicle length was significantly influenced by the interaction of fertilizer management and varieties. However numerically the highest panicle length was found in USG treated BRRIdhan27 (25.47 cm) and the lowest result was found in absolute control with BRRIdhan65 (21.10 cm).

Nori *et al*. (2008) conducted that the effect of fertilizer management on number of filled grain per panicle and 1000 seed weight were significant. The highest number of filled grain (58.91) was observed with USG while lowest (47.59) was found in no fertilizer. In 1000 seed weight USG (25.07 g) and NPK briquette (24.84 g) showed statistically similar result but lowest result found in no fertilizer (24.23 g. Filled grain per panicle and 1000 seed weight were significantly influenced by different *Aus* rice varieties .

According to Crasswell and de Datta (1980) broadcast application of urea on the surface soil causes losses up to 50% but point placement of USG in 10 cm depth may negligible loss. Urea Super Briquette (USG) is a fertilizer that can be applied in the root zone at 8-10 cm depth of soil (reduced zone of rice soil) which can save 30% nitrogen than prilled urea, increase absorption rate, improve soil health and ultimately increase the rice yield. The use of NPK briquette, which is a mixture of urea, Triple Super Phosphate (TSP) and Muriate of Potash (MOP) may help to reduce the loss of nutrients in tidal flooded ecosystem.

IFPRI., (2004) In Bangladesh, yield of rice was increased by 15-25% while expenditure on commercial fertilizer was decreased by 24-32% when fertilizer briquettes were used as the source of plant nutrients. Deep placement of fertilizer briquettes also environmental and economic benefits (A national survey conducted in Bangladesh during 2004 showed that more than 1800 briquette-making machines had been manufactured and sold and about 550000 rice farmers were using the technology in their fields (IFDC., 2007).

Bhuiyan *et al*. found that deep placement of urea super briquette resulted in significantly higher rice grain yield, better NUE and apparent N recovery than split application of prilled urea.

Singh *et al*.(1986) reported that placement of urea briquettes at 3-4 cm depth resulted in significantly taller plants (78 cm), longer (23.3 cm) and heavier panicle (2.4 g), higher 1000 grain weight (18.6 g) and more grain (4.6 t ha^{-1}) and straw (5.7 t ha^{-1}) yield of rice than surface application.

Vibhu Kapoor *et al*.(2013) recorded that deep placed N–P briquettes gave significantly higher grain yield, straw biomass, total P and K uptake, apparent P recovery, and agronomic N and P use efficiencies, when plant spacing was reduced from 20 x 20 cm to 20 X 10 cm. Closer plant spacing led to better utilization of P and K.

Singh *et al*. (1986) reported that placement of urea super briquette increased N use efficiency. The highest grain yield was obtained with 150 kg N ha^{-1} as urea super briquette with 489 panicles m-2 and 122 grains panicle^{-1}.

Dhane *et al*.(2003) reported that applying Gliricidia at 5 to 10 t ha-1 coupled with deep placement of urea at 25 or 50 kg N ha^{-1} at about 5-6 cm depth increased the rice yield significantly. The deep placement of N and P as pillow shaped urea briquettes (4:1 - N: P) using urea and DAP after transplanting was found to enhance the yield of rainfed rice.

Rajni R et al (2000)The combined application of 56 kg N ha^{-1} as USG and poultry manure produced the tallest plants (90.8 cm) which was statistically identical to those produced by the application of 112.5 kg N ha^{-1} as USG. This result is similar with the findings also reported that deep placement of USG resulted in the taller plant than prilled urea.

Wani AR, *et al.* (1999) The use of USG and Mixed fertilizer has often been advocated to minimize nitrogen losses because organic manures act as a great source of plant nutrients, especially of N, P, K and S, and also prevents leaching loss of the nutrients. USG @ 120 kg N ha^{-1} was the best in producing the yield and yield attributes of rice spikelet number per plant thus reduces the number of engorged pollen grains per anther and leading into increased spikelet sterility.

Afroz *et al*. (2013) conducted a field experiment at the Soil Science Field Laboratory of Bangladesh Agricultural University, Mymensingh during Boro season to investigate the effects of PU, USG, and NPK briquettes on growth and yield of BRRI dhan28 and found that USG performed better in increasing grain yield of rice compared to PU.

Jahan et al. (2014) reported that application of USG was more effective in producing higher rice effective tiller and at the same time reduce water pollution. Deep placement of N fertilizers into the anaerobic soil zone is an effective method to reduce volatilization loss. Again, the deep placement of USG and NPK briquette minimizes the concentration of NH4-N in floodwater compared to broadcast application of PU.

In rice production, nitrogen fertilizers provide the most essential nutrient – Nitrogen (N), which enhances the crop's vegetative growth and development, and yield (Naznin *et al*., 2014). Conventionally, nitrogen fertilizers come as prilled urea and are applied by farmers through broadcasting. This method of application coupled with high application rates and poor timing of application has been adjudged inefficient due to the significant loss of nitrogen through volatilization, denitrification, leaching, and runoff, resulting in both economic loss and environmental hazards.

Alam (2002) found that plant height increased significantly with the increase of level of USG/4 hills. Rahman (2003) also observed that different level of USG did not affect the non effective tiller.

Azam (2009) conducted an experiment with 3 varieties and observed, in general, the number of total tillers hill^{-1} was increased as the USG level increased but highest no. of total tillers hill^{-1} was produced when 55 kg N ha^{-1} applied as USG.

Alam (2002) observed that total tillers hill^{-1} and effective tillers hill^{-1} increased significantly with the increase of level of USG, when USG was applied as one, two, three and four briquette/4 hills during the boro season.

Lal *et al.* (1983) studied the effects of deep placement of USG or PU on yields of cv. Jaya and Govind revealed that with random transplanting, deep placement of USG increased yield of cv. Jaya and Govind by 0.4 and 1.1 t ha^{-1} respectively over yields with broadcast application of PU.

Zohra *et al*. (2012) conducted an experiment with different level of USG on 3 different varieties of T. *aman* rice. Among the 6 doses of USG, highest grain yield was produced when the crop was fertilized with 2 pellet of USG/4 hills and lowest grain yield was recorded in the control treatment.

Hasan (2007) found the effect of level of USG significantly influences all the yield attributes except 1000 grain weight. In his experiment, the highest grain and straw yields were found (5.20 and 7.45 t ha^{-1}, respectively) from the level of USG @ 3 pellets/4 hill or 90 kg N ha^{-1} as USG.

Iqbal (2011) carried out an experiment on determination of the effects of five fertilizer application rates on vertical leaching from 30 cm and 60 cm soil layers and) found that during paddy growth, nitrogen losses from different nitrogen treatments varied 2.82-5.07% application of the urea compared to USG.

Effect of NPK and USG briquette on the yield of marpha (cucumber)

Mikkelsen *et al*. (1978) conducted that the low use efficiency of N and P is because of various reasons such as volatilization, denitrification, surface runoff, leaching losses for nitrogen and fixation of phosphorus in soil. Deep placement of fertilizers Urea Super Briquette (USG) and NPK briquette into the anaerobic soil zone is an effective method to reduce volatilization loss.

Krishna *et al*. (1995) showed that the effect of different fertilizer briquette, showed the significant results with respect to number of branches per plant at various stages except 30 DAS. The increase in the number of branches per plant may due to the better uptake of plant nutrients due to application in briquette form.

Moreover, deep placement method of fertilizer application is environment-friendly and will not decrease the normal fertility of land (BRRI, 2010). Urea briquette/USG/UB-DAP briquette has less surface area as compared to prilled urea, therefore it dissolved slowly and maintains higher level of NO-3-N in soil up to maximum period of crop growth and found beneficial in transplanted rice crop under anaerobic condition

Bulbule *et al*. (2008) showed increase in phosphorus uptake due to deep placement of briquettes containing NPK in different levels. Whereas the significantly highest uptake of K by cucumber (3.86 kg ha^{-1}) was recorded to the tune of in the treatment T6 by receiving UB-10:26:26 briquettes @ one briquette in between two plants which was found at par with RDF, KAB @1 briquette in between two plants and UB-10:26:26 briquettes @ 1 $plant^{-1}$.

Mishra *et al*. (1999) Application of urea and NPK briquette proved to be profitable in different upland crops such as tomato, cabbage, cauliflower and potato. By using of UDP and NPK briquette technology, yield increased significantly with less use of urea about 10-20 percent as compared to prilled urea

These results are consistent with the yield increases reported by Kadam and Sahane (2001) on tomato by 26 percent on cucumber by 22 percent and yard long bean by 9 percent with fertilizer briquette deep placement compared to conventional fertilizer practice. In this study, deep placement of fertilizer briquette resulted in greater vegetable yield compared to conventional fertilizer practice. The N, P, and K uptake were significantly higher due to NPK deep placement of briquette, although 10 percent less NPK fertilizers were applied compared to PU treatment. The N and K uptake with the deep placement of NPK briquettes was significantly higher than broadcast application.

(Mahmood *et al.* (1999); Onyia, *et al.*, (2012); Enujeke, (2013) observed that the yields obtained by farmers in the region often are very low especially, in intensive cropping systems due to imbalance in the use of fertilizer and continuous cropping which have led to several nutrients becoming deficient.

Makinde *et al.*, (2007) also reported increased melon growth and optimum yield with organo-mineral fertilizer.The combined rates of USG and NPK fertilizer produced longest vines, highest number of very broad leaves. Also cucumber fruit length, fruit girth, and fruit yield were significantly (P = 0.05) influenced by application of USG and NPK fertilizer.

This is in line with the study of El-Shakweer *et al*. (1998) who reported that elevated rates of USG among other soil amendments increased tomato yield. The treatment containing the highest rates of combination of USG and NPK fertilizer recorded the highest yield. This indicates that the increase in USG and NPK fertilizer will result to significant increase in fruit yield.

Nirmala *et al*. (1999) For days taken to first male and female flower appearance, plants fertilized with 75% RDF + 75% FYM + AZT + PSB + TD (T2) recorded least number of days (30.00 ; 30.40 and 30.36 ; 36.00 days) taken for first male and flower appearance which was on par with T6 (30.50 ; 30.50 and 31.13 ; 37.33 days) during the year summer 2005 and rabi 2006 respectively. This could be attributed to vigorous growth of the plants due to balanced nutrient levels with bio-fertilizers. Phosphorus is an important element and essential for initiation of flowering, PSB along with NPK known to increase the availability of phosphorus resulted in early flowering.

Combination of organic, inorganic,NPK Briquette and bio-fertilizers helped in enhanced uptake of nutrients which promotes faster plant growth leading to increase production of higher number of male and female flowers. These results are in conformity with the findings of Arora et al. (1994) in ridge gourd and muskmelon.

Muniz *et al*. (1992) experimented that increased yield was also related to balanced nutrition, better uptake of nutrients by the plants which helped for better fruit set and fruit yield. More yield of cucumber in present study could be due to the influence of bio-fertilizers in combination with NPK and USG enhanced the synthesis of photosynthates by increasing the synthesis of growth regulators like IAA, GA, amino acids, and vitamins. More number of fruits per plant and fruit weight per plant ultimately resulted in more fruit yield per hectare.

2.2 Effect of NPK and USG briquette on the yield of maize

Thamir *et al*. (1984) indicated that under current N fertilizer recommendation for maize, urea might have adverse effects on growth when applied in band. The banded application of urea and di ammonium phosphate resulted in 19 and 24 percent increase in grain yield compared with the unfertilized plots. However, addition of lingosulfonate to the high rate of urea and DAP increased grain yield by 20 percent in band placement. In general, lignosulfonate significantly increased maize N uptake from urea. Mean recovery of 15N in total dry matter of grain and stover was 51.9 and 47.9 per cent respectively.

K. V. P. Shanti *et al*.(1997) Significantly higher grain yield was recorded with fertilizer level F_3 (90 : 60 : 40) being at par with F_2 (75 : 50 : 30) and showed significant increase over F_1 (60 : 40 : 20) with superiority of 5.4 and 5.7 per cent during 2011 and 2012, respectively. The findings of the study concluded that ridge method of sowing of maize with NPK levels of 75 : 50 : 30 kg ha^{-1} showed better performance of crop in terms of growth, yield, and yield attributes.

Kamal *et al.* (1991) used different forms of urea and level of nitrogen @ 29, 58, 87 kg N ha^{-1} in maize. They reported that total tiller varied significantly due to forms in 1985, but during 1986 there was no significant variation. PU was significantly inferior to the other forms. The highest number of cobs was produced in treatment where USG were applied.

Bhale and Salunke (1993) conducted a field trial to study the response of upland irrigated maize to nitrogen applied through urea and USG. They found that grain yield increased with up to 120 kg N ha^{-1} as urea and 100 kg N ha^{-1} as USG.

Mohanty *et al.* (1989) observed that placement of USG in maize gave significantly higher grain and straw yields of 36% and 39% in dry and 17% and 18% in wet season, respectively than split application of PU.

Amanullah *et al.*, (2009) observed that the highest grain yield obtained from the treatment with phosphorus content (64 kg N ha^{-1}+ 20 kg P ha^{-1} (100 kg DAP ha^{-1}+100 kg urea ha^{-1})) in the presence of nitrogen may be due to the higher translocation and activity of phosphorus into fruiting and seed formation, which resulted in highest grain yield of the maize plant.

This increase in leaf area could be due to the synergistic effect of nitrogen and phosphorus on plant growth. The same effect of nitrogen and phosphorous was reported by Rai *et al*. (1982), who found that both elements increased plant growth up to 100 days from sowing.

Amin M., *et al*. (2006) Nitrogen (N) is a vital plant nutrient and a major determining factor required for maize production. It is very essential for plant growth and makes up 1–4% of dry matter of the plants. Nitrogen is a component of protein and nucleic acids and when N is suboptimal, growth is reduced. Its availability in sufficient quantity throughout the growing season is essential for optimum maize growth.

2.2 Effect of NPK and USG briquette on the yield of sweet gourd

Iqbal (2011) carried out an experiment on determination of the effects of five fertilizer application rates on vertical leaching from 30 cm and 60 cm soil layers and) found that during sweet gourd growth, nitrogen losses from different nitrogen treatments varied 2.82-5.07% application of the urea compared to USG.

Gaudin (2012) carried out an experiment on the kinetics of ammonia disappearance from deep-placed urea super briquette (USG) in sweet gourd the effects of deep placement USG application and PU fertilizer. He found that ammonia disappearance from the placement site is faster for the second application, and it appears that the sweet gourd 14 roots took up ammonia at a higher concentration: 20 mM for the second application versus 10 mM for the first application.

Zaman *et al.* (1993) found that USG consistently produced significantly higher grain yield than PU. Application of 900 kg ha^{-1} for sweet gourd plants at 50 cm apart resulted highest yield and number of fruits. Singh and Chhonkar (1986)made trails with musk melon, application of 100 kg N, 60 kg P and 50 kg K per hectare gave the best relative growth, fruit weight and yield. The closest spacing i.e. 60 cm gave a higher yield than spacing at 90 or 120 cm.

Bolotskikh and Leivi (1987) conducted trials on sweet gourd and found that the highest yield of 28.2 t ha^{-1} and economic returns were produced after applying 90 kg N, 60 kg each of P_20_5 and K_20 and 40 t NPK/ha, at a plant density of 150000 per hectare.

Kumar *et al*. (1990) also observed that the number of fruit per plant increased from 111.3 at Zero N to 167.16 at 60 kg ha^{-1} and declined to 165.44 at the highest N rate. With P, the number of fruit/plant increased from 130.82 at Zero P to 150.8 at highest P rate. The present investigation was conducted to find out the suitable doses of NPK fertilizers and suitable distances between the plants, in order to get higher yield of this vegetable crop under the agro-climatic conditions.

Shukla and Prabhakar (1987) observed that the Sweet gourd with the spacing of plants at 300×45 cm gave the highest average yield of 384.54 q ha^{-1}. The average yield was 385.37 q ha^{-1} with the full dose of NPK and 300.74 q ha^{-1} with the reduced dose.

Arora and Mallik (1990) reported that ridge gourd Luffa acutangula was sown on 2×4 m raised beds with 12,9 or 6 plants per bed. A spacing of 9 plants per bed gave the highest number and weight of fruit and yields

Madayag (1984) who also observed that increased application of NPK improved the fruit weight in cucurbits i.e., bitter gourd and muskmelon.The data, regarding the fruit volume (ml), reveals that both the factors viz. plant spacing and fertilizer levels had significant effect on the fruit volume. The highest fruit volume of 627.38 ml was observed in 100 cm plant spacing, followed by 75 cm and 50 cm with 606.66 ml and 585.98 ml of fruit volume, respectively. Maximum fruit volume was obtained in 164-114-164 fertilizer level whereas the minimum fruit volume was recorded in Control.

Chauhan and Gupta (1973), also reported that the number of green pods per plant of Okra were increased by increasing the application of NPK. The fertilizer levels also had a significant effect on number of fruits per vine as the maximum number of fruits 5.61 per vine were observed in 164-114-164 Kg NPK ha^{-1}and the minimum number of fruits per vine were recorded in Control. The results observed showed that higher the fertilizer levels higher would be the number of fruits per vine.

Purewal and Dargan (1961), who concluded that wider spacing gave the tallest plants in Onions. The data further revealed that by increasing the NPK fertilizer level, the vine length also increased significantly. The maximum vine length was recorded in 164-144-164 Kg NPK hectare, whereas the minimum vine length was recorded in Control.

2.2 Effect of NPK and USG briquette on the yield of chili

Pandey and Tiwari (1996) evaluated the rate of 87 kg N ha^{-1} as a basal application of USG and to dressing as PU and observed that pod yield of chili and N use efficiency were the highest with N applied as a basal application of USG.

The Nitrogen application increases the productivity but the geography including soil, climate plays an important role in the response of nitrogen fertilizer for overall effect on the productivity (Lebauer and Treseder, 2008).

Oikeh *et al*. (2006) combination of 60 kg N, 13 kg P and 25 kg K ha^{-1}` (low to moderate input) has proved sufficient to double yield to 4 t ha^{-1} as compared to zero fertilizer application. He recommended 120 kg N, 26 kg P and 25 kg K ha-1 appropriate for high input farmers which generates 145% more yield compared to no NPK fertilizer application

Saito *et al*. (2005) conducted an experiment with three traditional and three improved cultivars were grown under four fertilizer treatments *viz.* 0 kg N ha^{-1}, 90 kg N ha^{-1}, 50 kg P_2O_5 ha^{-1} and NP. They reported applying P with N increased yield over N application alone.

Vijaya and Subbaiah (1997) showed that plant height of rice increased with the application of USG and were greater with the deep placement method of application both N and P compared with broadcasting

Roy *et al.* (1991) compared deep placement of urea super briquette (USG) by hand and machine and prilled urea (PU) by 2 to 3 split applications in rainfed rice. They obtained highest 1000-grain weight from USG treated plots.

Brohi *et al*. (1997) also conducted an experiment to identify the effect of N and P fertilization on the yield and nutrient status of chili. They found that interaction effect of N and P for grain and straw was highest with 240 kg N ha^{-1} and 150 kg P_2O_5 ha^{-1}.

MATERIALS AND METHOD

Two experiments were conducted at Ramery para, Bandarban sadar, Bandarban hill district in Chittagong under the AEZ 29 (Northern and Eastern Hills Tract) during March 2017 to November 2017. The selected land was slashed and burned and partially burnt plant parts was cleaned before final land preparation. The experiment was laid out in Randomized Completely Block Design (RCBD). NPK granule was applied at the time of final land preparation by dibbling method. It is shown in the Map of AEZ of Bangladesh (Fig. 1). This part has been divided into a number of sub-divisions describe as below:

Details of Experimental site

Climatic condition

The climate is tropical in Bandarban. Bandarban has significant rainfall most months, with a short dry season. The average temperature in Bandarban is 25.9 °C. About 2528 mm of precipitation falls annually. The muggier period of the year lasts for 8.8 months, from March 7 to December 1, during which time the comfort level is muggy, oppressive, or miserable at least 26% of the time. Details of weather data in respect of temperature (^{0}C), rainfall (mm) and relative humidity (%) for the study period was collected from Bangladesh Meteorological Department, Agargoan, Dhaka-1207.

Soil

General soil type of this areas is **“**Brown Hill Soils**”**. During experimental period the land was above flood level, sloppy and sufficient sunshine was available. Nature of parent materials strongly determine the texture of the soils. Shale results heavy silt loam or silty clay loam subsoil. Soils developed on sandstone have dominant textural class of sandy loams with occasional loamy sand or loam texture. Soils subject to erosion have topsoil with less clay content. The steepness of the landscape determines the depth of the soil. Soils are in general shallow in depth. In Tables 1 and 2 showed the morphological, physical and chemical characteristics of initial soil

Planting material

Most of the Jhumia families used their own local variety for Jhum cultivation. In rice cultivation they used mainly most of the areas Mymensingh and Cockrow as a local variety. Other crops also cultivate by their local collection of previous year Jhum cultivation. In my experiment we were used seed of Mymensingh local variety for rice cultivation and for the cultivation of other crops jhumia families were use their previous year collected seed.

Table 1. Morphological distinctiveness of the experimental field

Morphology	Characteristics
Location	Ramery Para (Bandarban)
Agro-ecological zone	Northen and Eastern Hills (AEZ-29)
General soil type	Brown Hill soil(loamy and acidic)
Topography	Sloppy and Steep
% Slope	30-35%
Drainage	Well drained
Flood level	Above flood level

Table 2. Physical and chemical properties of the soil sample before planting

Characteristics		Value	
		Field 1	Field 2
Particle size analysis	% Sand	22	11
	% Silt	41	21
	% Clay	37	68
Textural class		Clay loam	Clay
pH		4.5	4.7
Bulk Density (g/cc)		1.42	1.39
Particle Density (g/cc)		2.55	2.58
Organic carbon (%)		1.78	1.79
Organic matter (%)		2.91	2.83
Total N (%)		0.090	0.080
Available P (µg/g)		10.3	11.7
Exchangeable K (meq/100g soil)		0.19	0.09
Available S (µg/g))		6.9	7.0

Crop

In jhum areas rice cover about 90-95% of total area and other crops cover 5-10% area of the land. Cultivators use many traditional varieties for each of the above mentioned crops. In the past 15 to 20 crops used to be grown together, which used to supply almost all the necessities of food and fiber. At present 5 to 8 crops were usually grown in a Jhum field. Besides, few Jhum cultivators were more interested to produce cash crops like ginger and turmeric rather than paddy, which was the common feature throughout the CHT. Rice, Marpha, Maize, Sweet Gourd, Chilly and Turmeric were used as test crop.

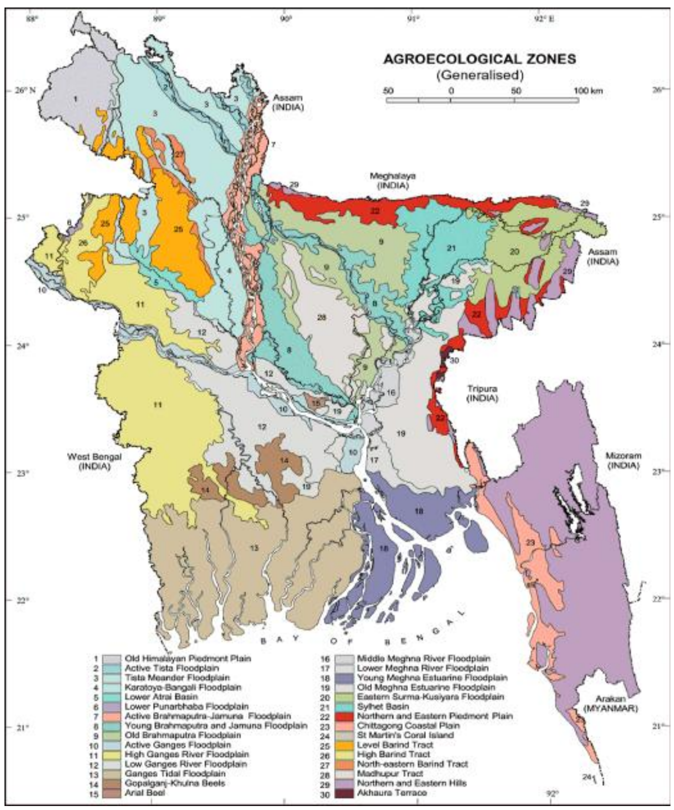


Figure1. Map showing the experimental site under study

Land selection:

Land selection is done during the month of February-March. Soil fertility, degree of hill slope, accessibility and distance from the villages are the main consideration for the selection of land for Jhum. Cultivator determines soil fertility from the soil color and growth of the bushes. Black colored soil and lands with vigorous growth of vegetation are considered as fertile land suitable for Jhum cultivation. Accessibility and closeness of the Jhum land from the hilly field are also considered while selecting land.

Figure 2. Land selection of the experimental site

Land preparation:

Land preparation usually starts from March. First, the standing vegetation are slashed and allowed to dry during the dry period. The dried vegetation and the fallen logs are burnt in the month of April and May. The partially burnt or unburned logs are then dragged out of the Jhum land and piled up. Some of these woods are used to create fences to keep wild animals away from the Jhum land.Then experimental plots were laid out as per treatment and design.

Experimental design

Design: Randomized Completely Block Design (RCBD)

Treatment: 7

Replication: 3

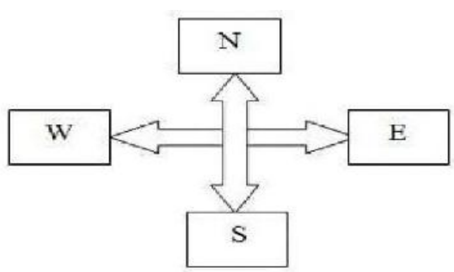
Total number of plots: 21

Plot size: 4m x 3m

Block to block distance: 0.5 m

Plot to plot distance: 0.5 m

The experiment was laid out in a Randomized Completely Block Design (RCBD) with three replications. The total number of plots was 21(3*7). The unit plot size was 4 m x 3m. Block to block distance was 0.5 m and plot to plot distance was 0.5m. The layout of the experiment has been shown in Fig. 4.



Plot size: 4 m x 3 m

Plot to plot distance: 0.5 m

Block to block distance: 0.5 m

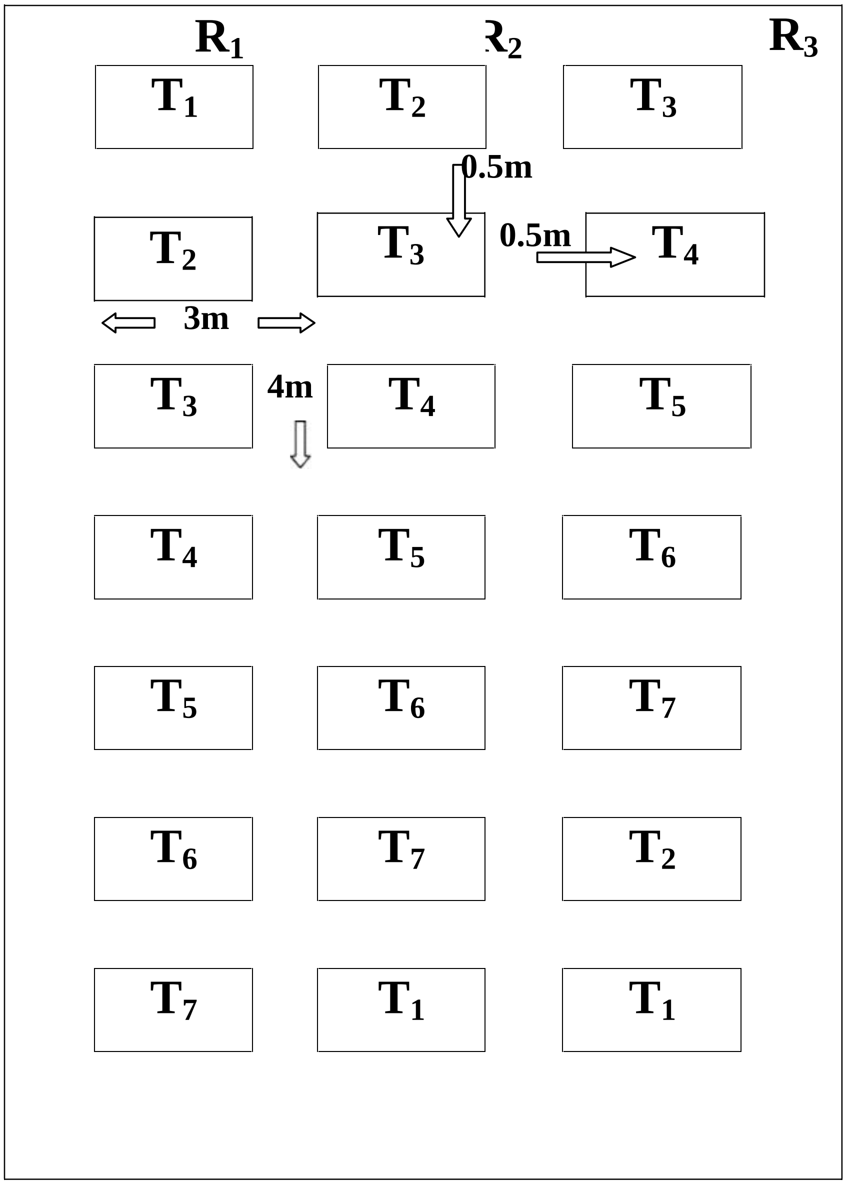


Figure 3. Layout of the experiment

Collection and preparation of initial soil sample

In the experiment before land preparation the initial soil samples were collected a 0-15 cm soil depth. An auger was used for drowning the samples by means from different location covering the whole experimental plot and mixed thoroughly to make a composite sample. The plant roots, leaves etc. were picked up and removed after collection of soil samples, then the samples were air-dried.

Seed sowing

Sowing commences as soon as the monsoons starts and the ground is saturated, generally in the months of May and June. In Jhum cultivation dibbling method is used for sowing the seed with the help of Da. Sometimes Khurpi, tagol (knife) is also used In this method seeds are sown directly on the soil without disturbing the soil. Seeds of different Jhum crops except turmeric and zinger were mixed together before sowing. Turmeric was sown before seeding of rice. The quantity of rice seed is greater than that of other types sown by this process, as rice is the staple food and cultivator aim to maximize growth of this crop. When rice seeds are sown in the field seeds of Maize , Marpha ,Sweet gourd ,Chili were mixed together and sown in the field. Normally, Jhumia families sowing the seed without maintaining distance but in experiment they maintaining a distance to get the proper utilization of NPK granule.

Treatments

There were 7 treatment combinations. The treatment combinations were as follows:

T_1 = Control

T_2 = 100%USG and PK(RFD)

T_3 = 80%USG and PK(RFD)

T_4 = 120%USG and PK (RFD)

T_5 = 100%NPK granule

T_6 = 80%% NPK granule

T_7 = 120% NPK granule

RFD: N 60 kgha^{-1},P 20 kg ha^{-1} and K 30 kg ha $^{-1}$

Sources of the fertilizers

Ordinary Urea, TSP, MOP, and NPK granule were used as the source of nutrients

Table 3 . Sources of different fertilizer elements in the experiment

Elements	Source
N	Urea
P	TSP
K	MoP

NPK Granule Ratio: Per 100 kg NPK granule contain 50 kg Urea: 30 kg TSP: 20 kg MoP

Application of fertilizers

Generally In the experiment Urea, TSP, MoP and Gypsum were used as a source of N, P and K. Half urea and full amount of TSP and MoP and some amount of gypsum were applied at the time of final land preparation by dibbling method. After that seed were sown in the field. When seedling emergence then, after 8-10 days of seed sowing NPK granule were used every plot by dibbling method without control. The amounts of nitrogen, phosphorus and potassium fertilizers required per plot were calculated from NPK granule ratio rate per hectare.

Application of NPK briquette:

When seedling emergence, after 8-10 days of seed sowing NPK briquette were used every plot by dibbling method without control. The amounts of nitrogen, phosphorus and potassium fertilizers required per plot were calculated from NPK briquette ratio rate per hectare. T_5 :100%NPK briquette (267.5 kg ha^{-1}), T_6: 80% NPK briquette (214.1 kg ha^{-1}), T_7: 120% NPK briquette (320.8 kg ha^{-1}).

Intercultural operations

Intercultural operation is one kind of operation in which all kinds of crops were free from abnormal hazards in field. For ensuring the normal growth of the field of Jhum cultivation some necessary intercultural operation were done such as top dressing of urea was done as per schedule and the normal cultural practices including weeding ,insecticides spray and disease management were done .

Weeding: Jhum requires minimum weeding. Weeds are controlled manually by using the tagol. Two to three times weeding are necessary. Each and every cultivator in turn helps his or her neighbor in weeding.

Pest managements: Among the insect pests rice bugs (*Leptocorisa acuta*),rice hispa(*Dicladispa armigera*), are reported to be major pest. This kind of pest controlled by spraying Cuberil 85WP,Melathion 57EC,Diazinon 60EC, Aktara, Darsban etc.But vertebrate pests such as rat, wild pig, monkeys and jungle fowl also cause considerable damage. Thus, cultivators built small house locally called Tong ghor in the Jhum field for guarding the crop against these vertebrate pests. On the other hand rats, monkeys and jungle fowl cause serious damage to ripening crop. Now a day the most notable change is the use of pesticide and chemical fertilizers by some farmer to improve production.

General observation of the experimental field

The field was observed time to time to identify visual difference among the treatment and any kind of infestation by weeds, insects and diseases so that considerable damages by pest should be minimized. The field appearence nice with normal green color plants. In panicle initiation stage incidence of stem borer, green leaf hopper was observed. Otherwise any bacterial and fungal disease was not pragmatic. In the flower blooming stage,therefore it was jhum cultivation flowering was not same time of crops. Due to heavy rainfall with gusty winds lodging did not occur in during the heading stage.

Plant sampling collection at harvest

In each of the plot plants were collected from $1m^2$ randomly to record the yield contributing characters like plant height (cm), number of tillers $hill^{-1}$, panicle length (cm), number of grains $panicle^{-1}$, and 1000-grain weight (g) for rice and in case of other crops (Marpha, Maize, Sweet gourd, Chili etc) grain yield were recorded. Before harvesting the selected hills were collected. On sundry basis grain yields of all crops and straw yields of rice were recorded plot-wise and expressed at t ha^{-1}.

Harvesting and post harvest operation

Maturity of crop was determined when 90% of the grains become golden yellow in color. Harvesting begins at the ripe. The first crop to ripe is maize in mid-July, followed by different varieties of vegetables. Rice and other grains are ready for harvest in September and October.

The rice panicles are harvested and brought to the temporary house in the Jhum field. A special kind of knife locally called chari is used for harvesting rice panicles. Rice straws are cut from the base and leave in the Jhum field for few days.

The crop of each plot was collected and harvested separately, bundled, properly tagged and then brought to the threshing floor. Threshing was done by pedal thresher. The grains were cleaned and sun dried to moisture content of 12%. Straw was also sun dried properly. Finally grain and straw yields plot-1 were recorded and converted to t ha-1.

In this experiment harvesting field -1, of Maize was done on 14 August, 2017, Marpha 10 August,2017, Chili on 22 August,2017 Sweet gourd on 28 August,2017. In case of Field-2 harvesting of Maize was done on 17 August,2017, Marpha on 23 August,2017, Chili on 18 August,2017 Sweet gourd on 2 September,2017.In field -1 harvesting of rice was done on 18 September,2017 and Field-2 harvesting of rice was done on 5 0ctober,2017.In case of field-1 and 2 harvesting of Turmeric was done on 22 December,2017. Straw yields of rice and Grain yields of all crops were recorded separately plot-wise and moisture percentage was calculated after sun drying. Dry weight for both grain and straw were also recorded.

Data collection

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

For rice:

i) Plant height (cm)

ii) Number of effective and ineffective tillers hill^{-1}

iii) Panicle length (cm)

iv)Total number of grain per panicle

v) Number of unfilled and filled grains panicle^{-1}

vi)1000-grain weight (g)

vii) Grain and straw yields (t ha^{-1})

Plant height (cm)

From the ground level to the top of the panicle the plant height was measured. Plant heights of 10 hills (1 m) were measured and averaged for each plot.

Number of tillers hill^{-1}

At randomly from each plot Ten hills were taken and the numbers of tillers hill^{-1} were counted. The numbers of effective and ineffective tillers hill^{-1} were also determined.

Panicle length (cm)

Measurement was taken from basal node of the rachis to apex of each panicle randomly. Each observation was an average of 10 panicles.

Filled and unfilled grains panicle^{-1}

Each of the treatment ten panicles were taken at random to count unfilled and filled grains and averaged.

1000 grain weight

The weight of 1000-grains from each plot was taken after sun drying by an electric balance.

Grain and straw yields

Grain and straw yields were recorded separately plot-wise and expressed as t ha^{-1} on 14% moisture basis.

For marpha, maize, sweet gourd, chili, and turmeric :

i) Yields (kg ha^{-1})

Chemical analysis of soil samples

Both physical and chemical properties of soil samples were analyzed in the soil science laboratory of Sher-e-Bangla Agricultural University, Dhaka and Soil Research Development Institute (SRDI) Farmgate, Dhaka. The properties studied included soil texture, pH, organic matter, organic carbon, total N, available P, exchangeable K and available Zn. The initial soil physical and chemical properties have been presented in Table 2. The soil was analyzed by standard methods:

Particle size analysis

Hydrometer Method was used in particle size analysis of soil (Bouyoucos, 1926) 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.

Soil pH

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

Organic matter

Soil organic matter (SOM), which is usually estimated by total organic C content, can be understood as the collection of organic substances and complexes present in the soil. Mebius methods that allowed the determination of SOM by spectrophotometry, increasing functionality. The mass of 500 mg was reduced to 200 mg, generating a mean of 60 % saving of reagents and a decrease of 91 % in the volume of residue generated for the methods without compromising accuracy and precision.

Organic carbon

Walkley and Black (1934) observed that organic carbon in soil was determined by 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 excess of $K_2Cr_2O_7$ solution with 1N $FeSO_4$ solution. The amount of organic carbon was multiplied by the Van Bemmelen factor, 1.73 for obtaining the organic matter content. The result was expressed in percentage.

Total nitrogen

Micro Kjeldahl method was used to determine the total nitrogen of soil where soil was digested with 30% H_2O_2, conc. H_2SO_4 and catalyst mixture (K_2SO_4: $CuSO_4.5H_2O$: Si powder in the ratio of 100:10:1). (Bremner and Mulvaney, 1982)showed that nitrogen in the digest was estimated by distillation with 40% NaOH followed by titration of the distillate trapped in H_3BO_3 with 0.01N H_2SO_4

Available phosphorus

(Olsen *et al.,* 1954) observed that available phosphorus was extracted from soil by shaking with 0.5 M $NaHCO_3$ solution of pH 8.5. Ascorbic acid reduction of phosphomolybdate complex was used to determine the phosphorus in the extract by developing blue color. At 660 *nm* wave length by Spectrophotometer was used for absorbance of the molybdophosphate blue color which was measured and available P was calculated with the help of standard curve.

Exchangeable potassium

Flame photometer was used to determine the exchangeable potassium by 1N NH_4OAc (pH 7.0) extract of the soil (Black, 1965).

Available sulphur

By extracting the soil samples with 0.15% CaCl2 solution available sulphur in soil was determined (Page *et al.,* 1982).

3.1.20 Statistical analysis

Different characters of jhum crops and N, P, K, S content in post harvest soil of jhum cultivation were done following the ANOVA technique and the mean results in case of significant F-values were adjusted by the Least Significant Difference (LSD) (Gomez *et. al.,* 1984).

RESULT AND DISCUSSION

Two experiments were conducted to examine the influence of NPK and USG briquette levels on the growth and development of Jhum crops in hilly areas. The experiments results were conducted under field conditions which are presented in several Tables and Figures. Treatments effect of NPK briquette on all the studied parameters have been presented and discussed under the observation of field 1 and field 2. Summary of mean square values of different parameters are also given in appendices.

Effect of NPK briquette on growth and yield components of jhum rice

Plant height

When NPK briquettewe were applied in Jhum rice cultivation plant height was significantly influenced. In field 1, the plant height of Jhum rice was significantly influenced by the application different levels of NPK briquette. The highest plant height of Jhum rice ranged over control was observed (Treatment 1) from 124.73 to 137.13 cm.. The tallest plant height of Jhum rice (137.13cm) was found in treatment T_5 which was statistically different from all other treatments. The shortest plant height (124.73cm) of Jhum rice was found in T_1 treatment where no fertilizer was applied i.e control treatment **(**Fig.).The plant height was ranked in field 1,$T_5>T_3>T_6>T_2>T_4>T_1>T_{7.}$

In field 2, the plant height of Jhum rice was significantly influenced by the application different levels of NPK briquette. The highest plant height of Jhum rice ranged over control was observed (Treatment 1) from 109.27 to 139.23cm.. The tallest plant height of Jhum rice (139.23cm) was found in treatment T_5 which was statistically different from all other treatments. The shortest plant height (109.27cm) of Jhum rice was found in T_1 treatment where no fertilizer was applied i.e control treatment **(**Fig.).

Results were reported by Ahammed (2008).Urea Super Briquette (USG) and NPK briquette fertilizers provide a better effect on LAI and Dry matter production. The plant height ranked in field 2,$T_5>T_4>T_6>T_7>T_2>T_4>T_{1.}$

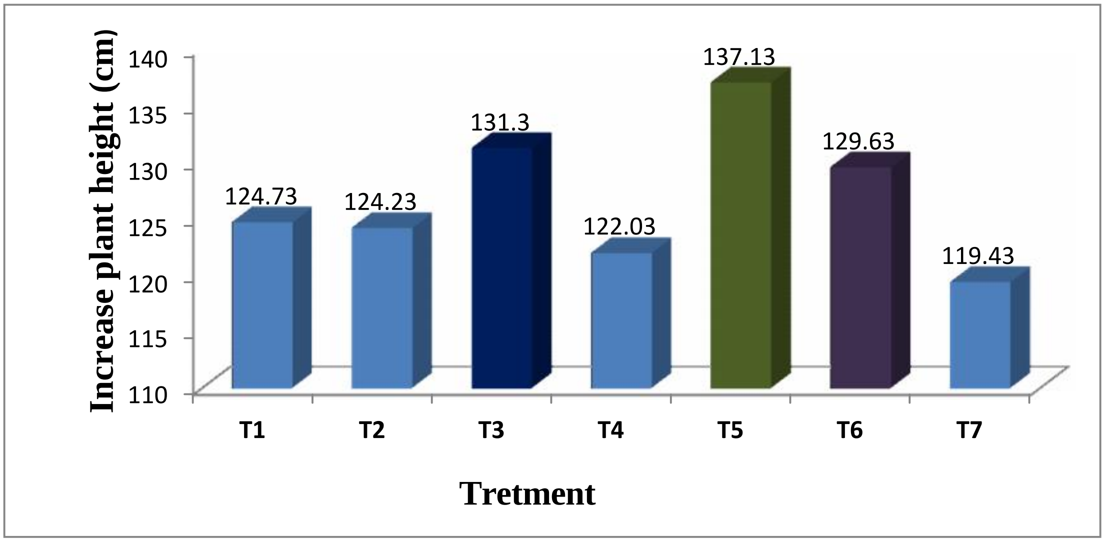


Fig.4. Effects of NPK and USG briquette increase plant height over control of jhum rice (Field 1)

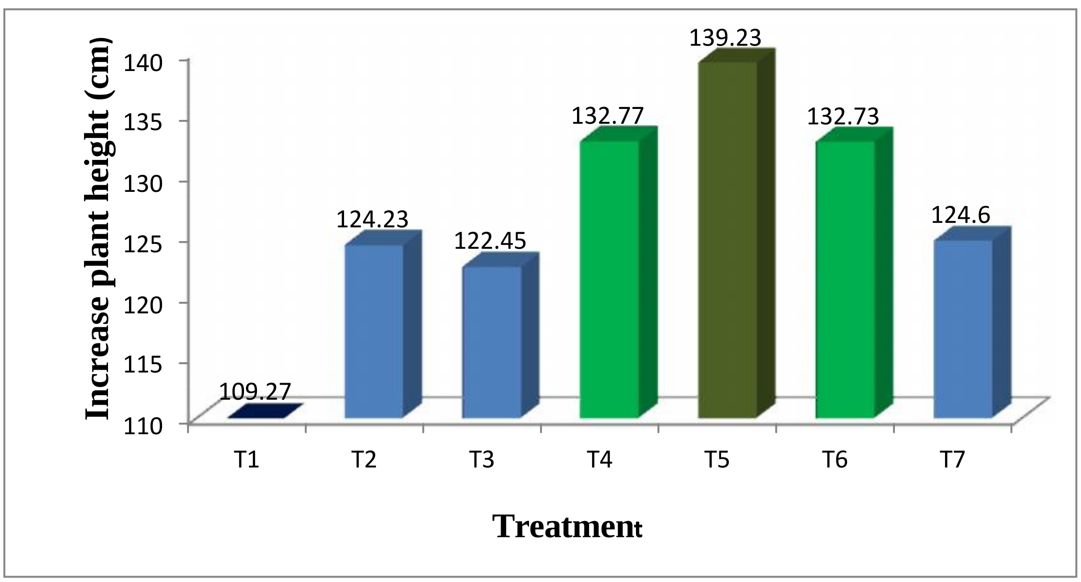


Fig.5. Effects of NPK and USG briquette increase plant height over control of jhum rice (Field 2)

Effective tillers hill^{-1}

In field 1effective tiller hill^{-1} range from 11.53 to 15.267. The highest number of effective hill^{-1} was 15.267over control (Treatment 1). In field 1 the highest number of effective tiller hill^{-1} was found T_5 treatment. The lowestnumber of 11.53 cm was found in T_1 (control) treatment having no fertilizer(Fig). The number of effective tiller hill^{-1} was ranked in field 1,$T_5>T_4>T_7>T_2>T_3>T_6>T_{1.}$Jahan et al. (2014) reported that application of USG was more effective in producing higher rice effective tiller.

In field 2,effective tiller hill^{-1} range from 10.63 to 16.6. The highest number of effective hill^{-1} was 16.6 over control (Treatment 1). In field 2 the highest number of effective tiller hill^{-1} was found T_5 treatment. The lowestnumber of 10.63 cm was found in T_1 (control) treatment having no fertilizer (Fig). The number of effective tiller hill^{-1} was ranked in field 2,$T_5>T_7>T_4>T_6>T_2>T_3>T_{1.}$In rice production, nitrogen fertilizers provide the most essential nutrient – Nitrogen (N), which enhances the crop’s vegetative growth and development, and yield (Naznin*et al*., 2014).

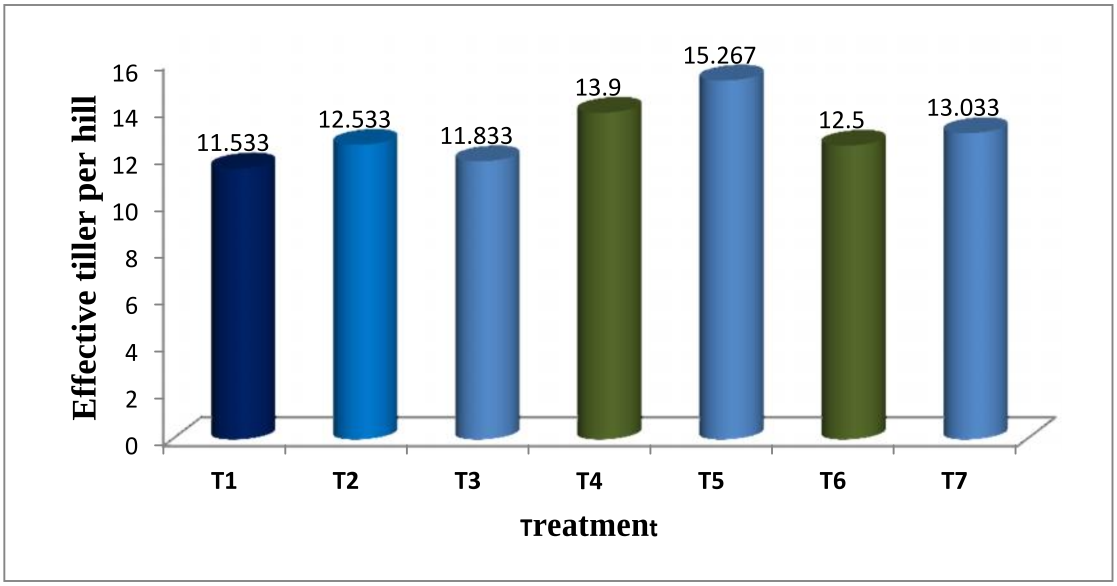


Fig.6. Effects of NPK and USG briquette increase effective tiller per hill over control of jhum rice (Field 1)

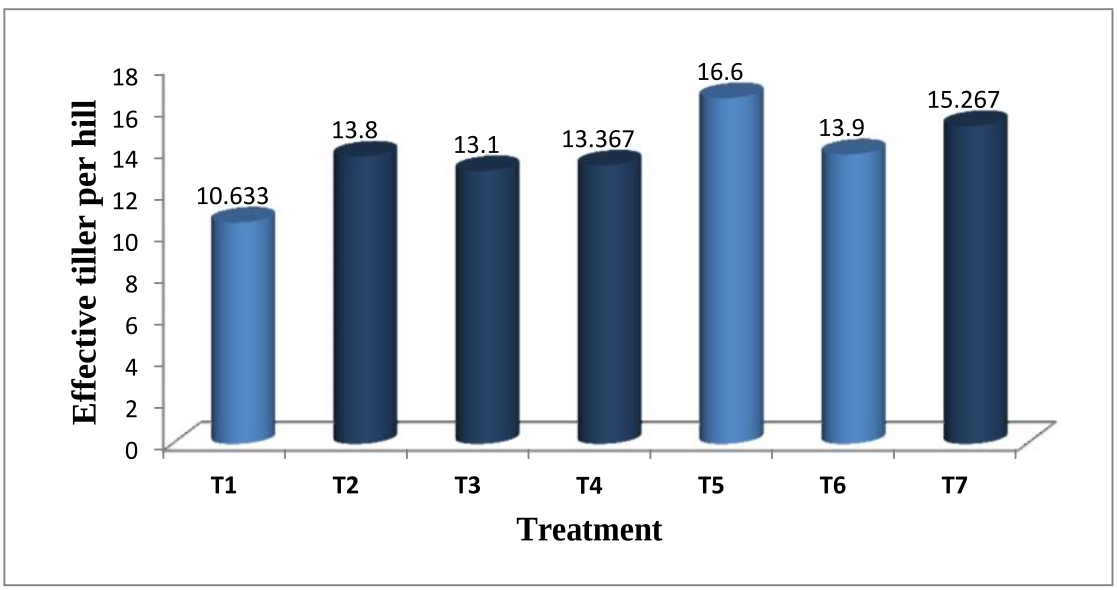


Fig.7. Effects of NPK and USG briquette increase effective tiller per hill over control of jhum rice (Field 2)

Non-effective tillers hill^{-1}

There is also some effect of NPK and USG briquette treatments significantly influenced non-effective tiller per hill compared with normal recommended fertilizer dose. In field 1 non-effective tiller hill^{-1} range from 0.9. to2.13. The highest number of non-effective hill^{-1} was 2.13 over control (Treatment 1). In field 1 the highest number of no-effective tiller hill^{-1} was found T_1 treatment having no fertilizer (Fig).The lowestnumber of 0.9 was found T_5 treatment. The number of non-effective tiller hill^{-1} was ranked in field 1,$T_1>T_3>T_7>T_6>T_4>T_2>T_5$.Alam (2002) observed that total tillers hill^{-1} and effective tillers hill^{-1}increased significantly with the increase of level of USG, when USG was applied as one, two, three and four briquettes/4 hills during the boro season.

In field 2 non-effective tiller hill^{-1}range from 2.06. to 0.86. The highest number of non-effective hill^{-1} was 2.06 over control (Treatment 1). In field 1 the highest number of no-effective tiller hill^{-1} was found T_1 treatment having no fertilizer (Fig). The lowestnumber of 0.86 was found T_5 treatment. The number of non-effective tiller hill^{-1} was ranked in field 1,$T_1>T_2>T_6>T_7>T_4>T_3>T_5$Rahman (2003) also observed that different level of USG did not affect the non effective tiller.

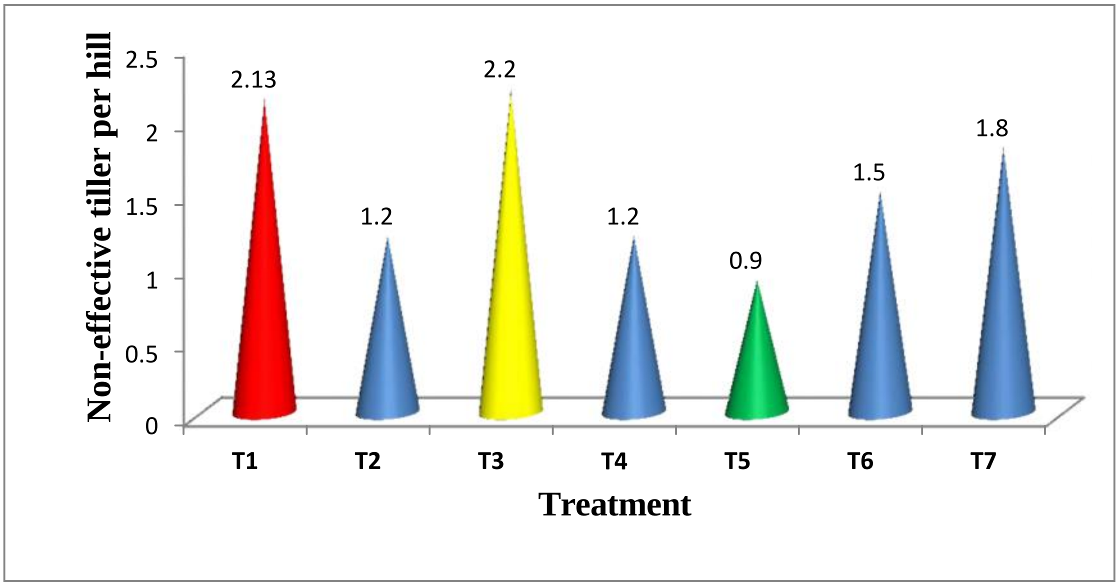


Fig.8. Effects of NPK and USG briquette increase non-effective tiller per hill over control of jhum rice (Field 1)

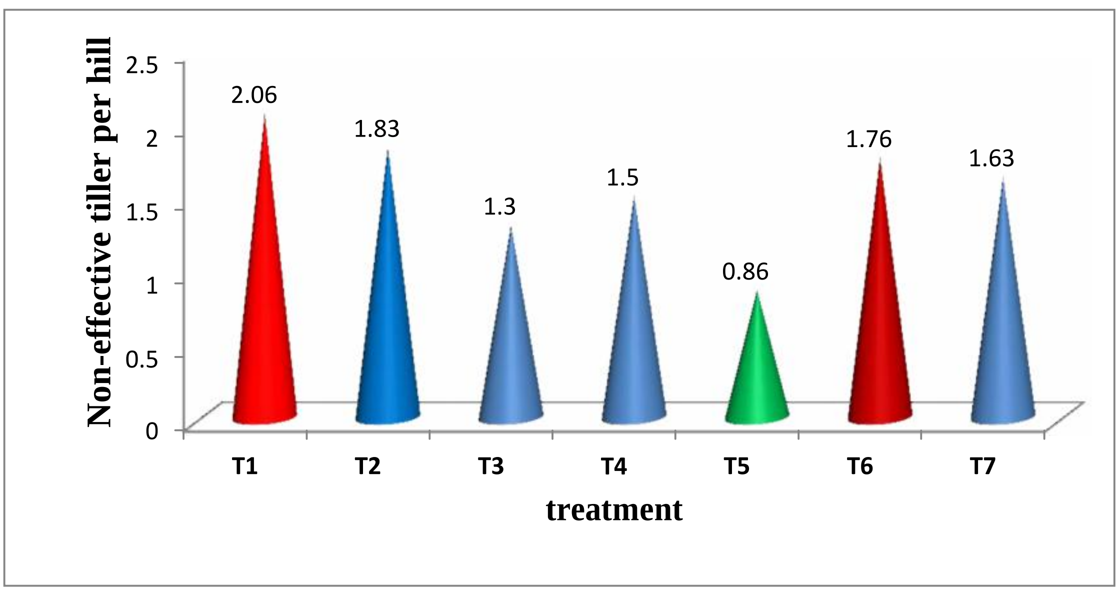


Fig. 9. Effects of NPK and USG briquette increase non-effective tiller per hill over control of jhum rice (Field 2)

Panicle length

There were a different effects of treatments on panicle length which are shown in Table.In field 1, the panicle length of Jhum rice was significantly influenced by the application different levels of NPK briquette.The highest panicle length of Jhum rice ranged over control was observed (Treatment 1) from 22.353 to 30.23 cm. The highest panicle length of Jhum rice (30.23 cm) was found in treatment T_5 which was statistically different from all other treatments. The lowest panicle length (22.353 cm) of Jhum rice was found in T_1 treatment where no fertilizer was applied i.e control treatment **(**Fig.). The panicle length was ranked in field 1,$T_5>T_7>T_6>T_3>T_4>T_2>T_{1.}$

In field 2, the panicle length of Jhum rice was significantly influenced by the application different levels of NPK briquette.The highest panicle length of Jhum rice ranged over control was observed (Treatment 1) from 22.03 to 29.0 cm. The highest panicle length of Jhum rice (29.0 cm) was found in treatment T_5 which was statistically different from all other treatments. The lowest panicle length (22.03 cm) of Jhum rice was found in T_1 treatment where no fertilizer was applied i.e control treatment **(**Fig.). The panicle length was ranked in field 2,$T_5>T_7>T_6>T_3>T_4>T_2>T_{1.}$Wani AR, *et al.* (1999) The use of USG and Mixed fertilizer has often been advocated to minimize nitrogen losses because organic manures act as a great source of plant nutrients, especially of N, P, K and S, and also prevents leaching loss of the nutrients. USG @ 120 kg N ha^{-1} was the best in producing the yield and yield attributes of rice spikelet number per plant thus reduces the number of engorged pollen grains per anther and leading into increased spikelet sterility.

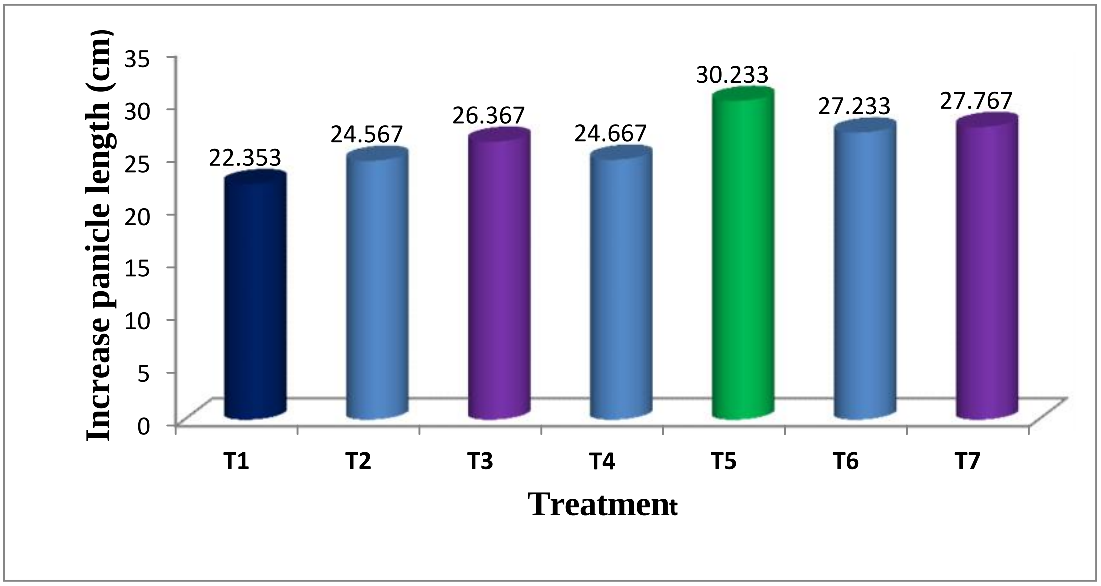


Fig.10. Effects of NPK and USG briquette increase panicle length (cm) over control of jhum rice (Field 1)

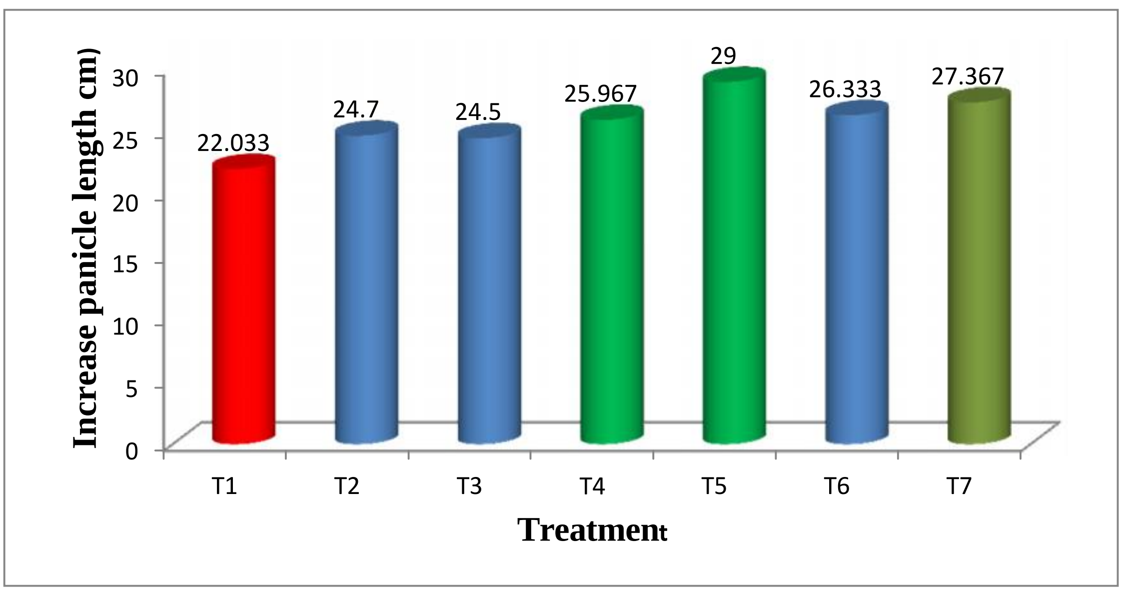


Fig.11. Effects of NPK and USG briquette increase panicle length (cm) over control of jhum rice (Field 2)

Filled grains panicle^{-1}

In field 1 number of filled grain was ranged from 105.23 to 254.23. The highest number of filled grain panicle^{-1} was 254.23 over control (Treatment 1). In field 1 the highest number of filled grain panicle^{-1} was found T_5 treatment. The lowestnumber of (105.23/panicle) was found in T_1 (control) treatment having no fertilizer(Fig). The number of filled grain panicle^{-1} was ranked in field 1,$T_5>T_6>T_7>T_4>T_3>T_2>T_1$.Higher number of filled grain was found in applying fertilizer treatment compared with control but it reached maximum number of filled grain in the treatment (T_5) of NPK briquette compared over control. Nori *et al*. (2008)conducted that the effect of fertilizer management on number of filled grain per panicle

In field 2 number of filled grain was ranged from 109.03 to 232.57. The highest number of filled grain panicle^{-1} was 232.57 over control (Treatment 1). In field 2 the highest number of filled grain panicle^{-1} was found T_5 treatment. The lowestnumber of (109.23/panicle) was found in T_1 (control) treatment having no fertilizer (Fig). The number of filled grain panicle^{-1} was ranked in field 2,$T_5>T_6>T_7>T_4>T_2>T_3>T_1$.Singh *et al*. (1986) reported that placement of urea superbriquettes increased N use efficiency. The highest grain yield was obtained with 150 kg N ha^{-1} as urea superbriquettes with 489 panicles m-2 and 122 grains panicle^{-1}.

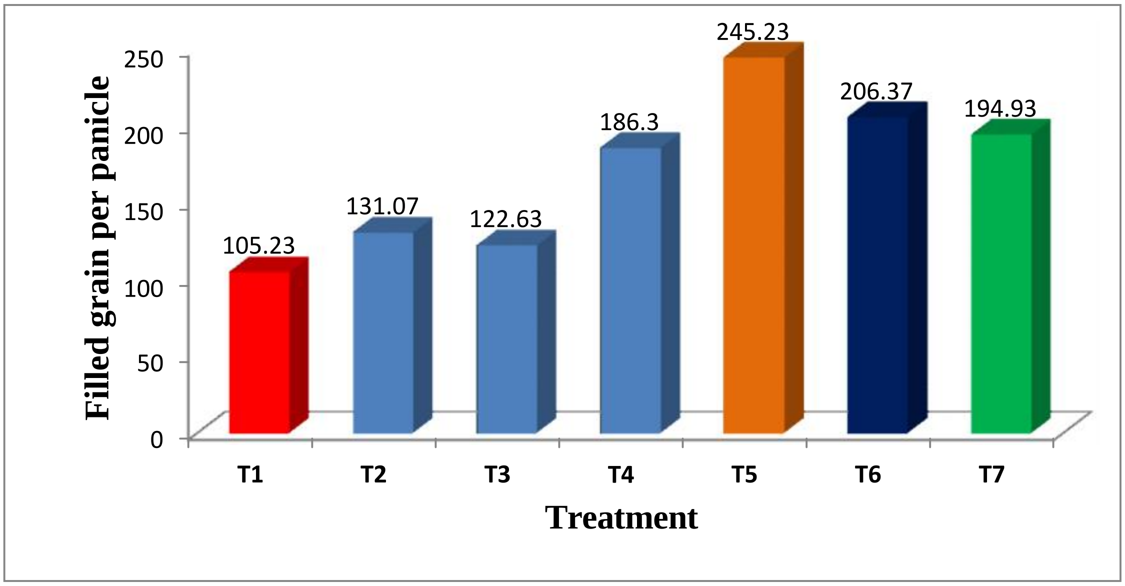


Fig.12. Effects of NPK and USG briquette increase Filled grain per panicle over control of jhum rice (Field 1)

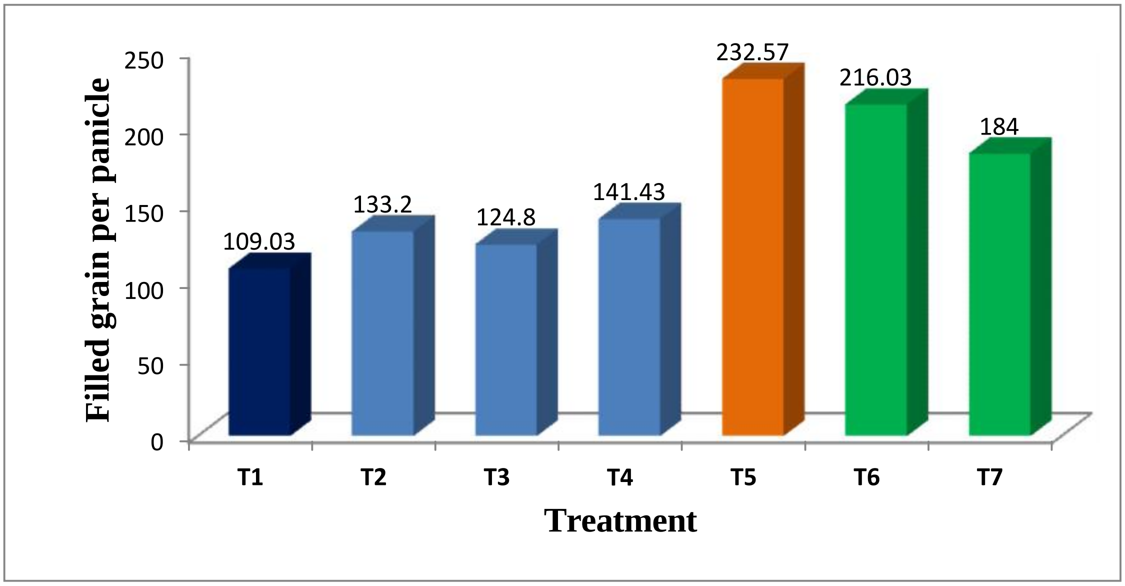


Fig.13. Effects of NPK and USG briquette increase Filled grain per panicle over control of jhum rice (Field 2)

Unfilled grains panicle^{-1}

In field 1 number of unfilled grain was ranged from 44.86 to 20.26. The highest number of unfilled grain panicle^{-1} was 44.26over NPK briquette(Treatment 5). In field 1 the highest number of unfilled grain panicle^{-1} was found T_1 treatment (control). The lowestnumber of (20.26/panicle) was found in T_5treatment having 100% NPK briquette(Fig). Theunfilled grain panicle^{-1} was identical in stastistically T_1,T_2, T_6 and T_7 treatment .The number of unfilled grain panicle^{-1} was ranked in field 1,$T_1>T_2>T_3>T_6>T_7>T_4>T_5$.Higher number of unfilled grain was found T_7 treatment due to some environmental factor and over dose of NPK briquette compared with control and T_5 treatment.Afroz*et al*. (2013) conducted a field experiment at the Soil Science Field Laboratory of Bangladesh Agricultural University, Mymensingh during Boro season to investigate the effects of PU, USG, and NPK briquettes on growth and yield of BRRI dhan28 and found that USG performed better in increasing grain yield of rice compared to PU

In field 2 number of unfilled grain was ranged from 48.66 to 19.53. The highest number of unfilled grain panicle^{-1} was 48.66 over NPK briquette(Treatment 5). In field 2 the highest number of unfilled grain panicle^{-1} was found T_1 treatment (control). The lowestnumber of (19.53/panicle) was found in T_5treatment. The number of unfilled grain panicle^{-1} was ranked in field 2,$T_1>T_2>T_3>T_6>T_7>T_4>T_5$.

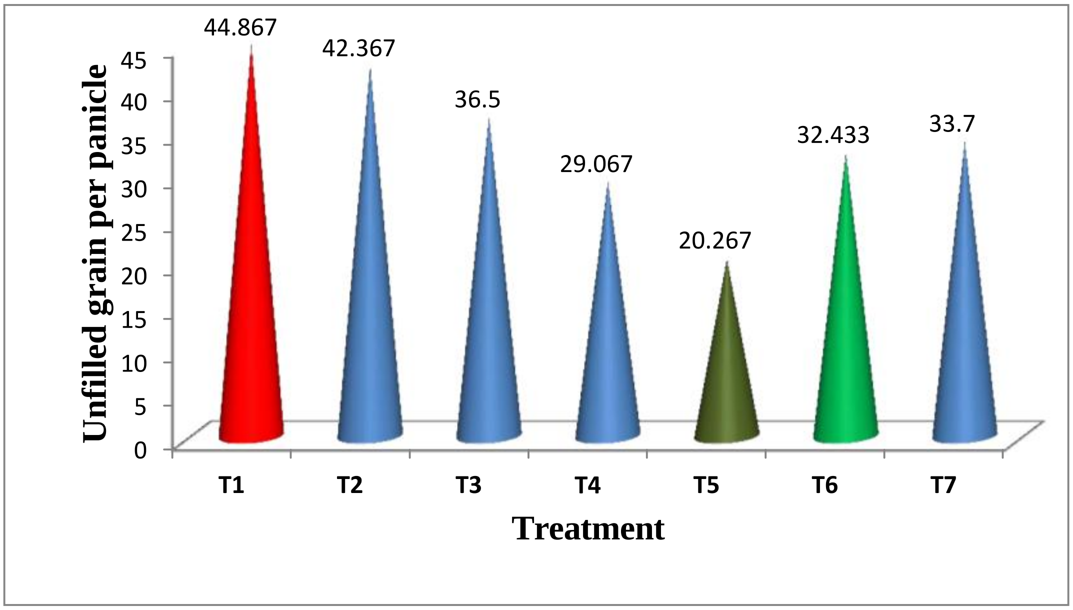


Fig.14. Effects of NPK and USG briquette increase unFilled grain per panicle over control of jhum rice (Field 1)

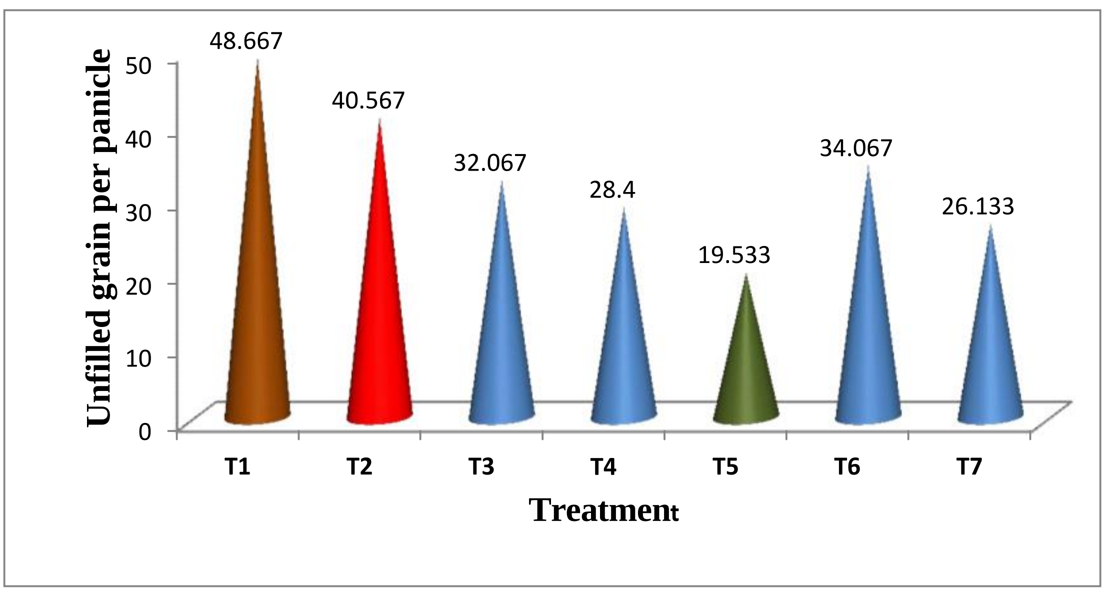


Fig.15. Effects of NPK and USG briquette increase unfilled grain per panicle over control of jhum rice (Field 2)

1000 grain weight

The effects of NPK briquette on 1000 grain weight were insignificant in case of field and field 2. In field 1 the highest 1000 grain weight was found T_5 treatment. The lowestgrain weight of 21.6gm was found in T_3 treatment.(Fig).1000 grain weight per treatment was ranked in field 1,$T_5>T_7>T_6>T_2>T_4>T_3>T_{1.}$Jeng *et al*. (2006) found the similar result in respect of 1000 grain weight. Filled grain per panicle was highest in USG and BRRIdhan48 (67.83) andlowest in no fertilizer with BRRIdhan55. And in case of 1000 seed weight USG and BRRIdhan27 (30.10 g) provide the highest result and lowest in absolute control with BRRIdhan55 (21.77 g).

In field 2 1000 grain weight was ranged from 22.33 to 28.0 gm. The highest 1000 grain weight was 28.0gmover control (Treatment 1). In field 2 the highest 1000 grain weight was found T_5 treatment. The lowestgrain weight of 22.33gm was found in T_1 (control) treatment.(Fig**)**. 1000 grain weight per treatment was ranked in field 1,$T_5>T_6>T_7>T_4>T_3>T_2>T_{1.}$Hasan (2007) found the effect of level of USG significantly influences all the yield attributes except 1000 grain weight.

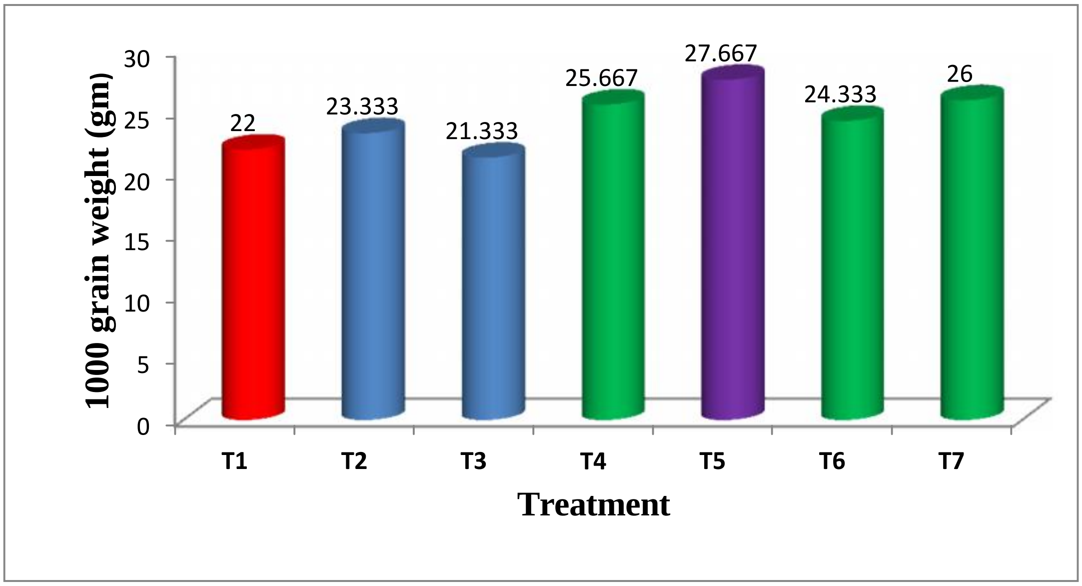


Fig.16. Effects of NPK and USG briquette increase 1000 grain weight (gm)over control of jhum rice (Field 1)

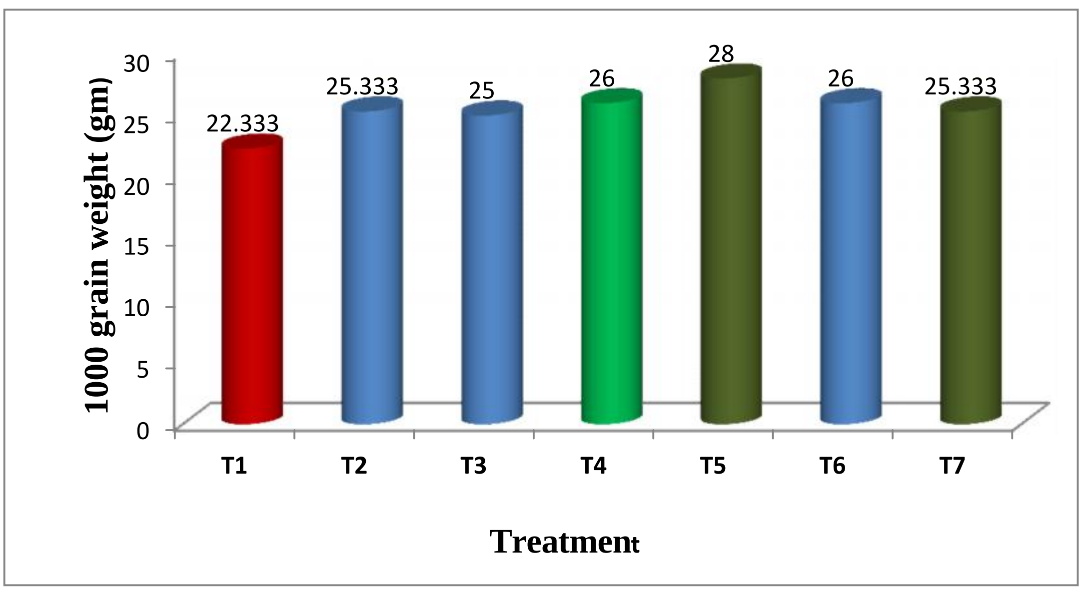


Fig.17. Effects of NPK and USG briquette increase 1000 grain weight(gm)over control of jhum rice (Field 2)

Table 4. Effects of NPK granule on plant height, effective tillers hill^{-1}, non-effective tillers hill^{-1}, panicle length, filled grains panicle^{-1}, unfilled grains panicle^{-1} and 1000 grain weight of jhum rice (Field 1)

Treatments	Plant Height (cm)	Effective Tiller Hill^{-1}	Non – Effective Tiller Hill^{-1}	Panicle length (cm)	Filled grain Panicle^{-1}	Unfilled Grain panicle^{-1}	1000 grain wt (gm)
T_1	124.73^{c}	11.53^{d}	2.13^{a}	22.35^{e}	105.23^{g}	44.86^{a}	22.0
T_2	124.23^{c}	12.53^{cd}	1.20^{d}	24.56^{d}	131.07^{e}	42.36^{b}	23.3
T_3	131.30^{b}	11.83^{d}	2.20^{a}	26.36^{c}	122.63^{f}	36.50^{c}	21.3
T_4	122.03^{d}	13.90^{b}	1.20^{d}	24.66^{d}	186.30^{d}	29.06^{e}	25.6
T_5	137.13^{a}	15.26a	0.90^{e}	30.23^{a}	245.23^{a}	20.26^{f}	27.6
T_6	129.63^{b}	12.50^{cd}	1.50^{c}	27.23^{bc}	206.37^{b}	32.43^{d}	24.3
T_7	119.43^{d}	13.03^{bc}	1.80^{b}	27.76^{b}	194.93^{c}	33.70^{d}	26.0
LSD	1.28	0.54	0.11	0.51	1.66	0.82	0.50
CV%	1.24	5.13	8.95	2.40	1.19	2.94	2.56

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

T_1=Control

T_2=100%USG and PK(RFD)

T_3=80%USG and PK(RFD)

T_4=120%USG and PK (RFD)

T_5 =100%NPK briquette

T_6=80%% NPK briquette

T_7=120% NPK briquette

Table 5. Effects of NPK granule on plant height, effective tillers hill^{-1}, non-effective tillers hill^{-1}, panicle length, filled grains panicle^{-1}, unfilled grains panicle^{-1} and 1000 grain weight of Jhum rice (Field 2)

grain w

Treatments	Plant Height (cm)	Effective Tiller Hill^{-1}	Non – Effective Tiller Hill^{-1}	Panicle length (cm)	Filled grain Panicle^{-1}	Unfilled Grain panicle^{-1}	1000 grain wt (gm)
T_1	109.27^{d}	10.63^{d}	2.06^{a}	22.03^{e}	109.03^{g}	48.66^{a}	22.3
T_2	124.23^{c}	13.80^{c}	1.83^{b}	24.70^{d}	133.20^{e}	40.56^{b}	25.3
T_3	122.45^{c}	13.10^{c}	1.30^{e}	24.50^{d}	124.80^{f}	32.06^{c}	25.0
T_4	132.77^{b}	13.36^{c}	1.50^{d}	25.96^{c}	141.43^{d}	28.40^{d}	26.0
T_5	139.23^{a}	16.60^{a}	0.86^{f}	29.00^{a}	232.57a	19.53^{e}	28.0
T_6	132.73^{b}	13.90^{c}	1.76^{b}	26.33^{c}	216.03^{b}	34.06^{c}	26.0
T_7	124.60^{c}	15.26^{b}	1.63^{c}	27.36^{b}	184.00^{c}	26.13^{d}	25.3
LSD	1.55	0.47	0.60	039	3.39	1.22	0.77
CV%	1.51	4.22	4.76	1.90	2.55	4.56	3.74

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

T_1=Control

T_2=100%USG and PK(RFD)

T_3=80%USG and PK(RFD)

T_4=120%USG and PK (RFD)

T_5 =100%NPK briquette

T_6=80%% NPK briquette

T_7=120% NPK briquette

NPK briquette increase the yield of Jhum rice

Grain yield

The grain yield of Jhum rice was significantly influenced by the application of different levels of NPK briquette. In field 1 grain yield ranged over control was observed from 1.63 t ha^{-1} to 3.56 t ha^{-1}. The highest grain yield of Jhum rice (3.56 t ha^{-1}) was found in treatment T_5, which was statistically different from all other treatments. The lowest grain yield of Jhum rice (1.63 t ha^{-1}) was found in T_1 treatment where no fertilizer was applied i.e control treatment (Fig.21). The grain yield of rice per treatment was ranked in $T_5>T_7>T_6>T_2>T_3>T_4>T_1$.Uddin *et al*. (2010) and Sohel *et al*. (2009) reported that the variations in yield might be due to genetic makeup of the varieties.

In field 2 grain yield was ranged from 1.84 t ha^{-1} to 3.54 t ha^{-1}. The highest grain yield was 3.54 t ha^{-1}over control (Treatment 1). In field 2 the highest grain yield was found T_5 treatment. The lowestgrain yield of 1.84 t $ha^{-1}$was found in T_1 (control) treatment having no fertilizer(Fig).Second highest grain yield was found in T_7 treatment. The grain yield of rice per treatment was ranked in $T_5>T_7>T_6>T_2>T_3>T_4>T_1$.VibhuKapoor*et al*.(2013) recorded that deep placed N–P briquettes gave significantly higher grain yield

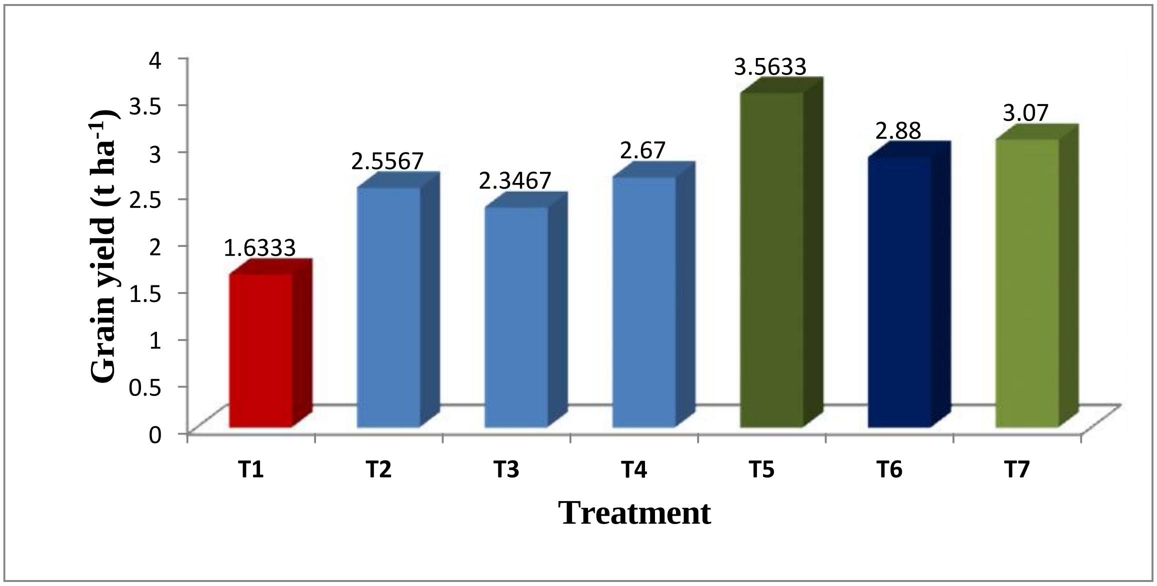


Fig.18. Effects of NPK and USG briquette increase grain yield over control of jhum rice (Field 1)

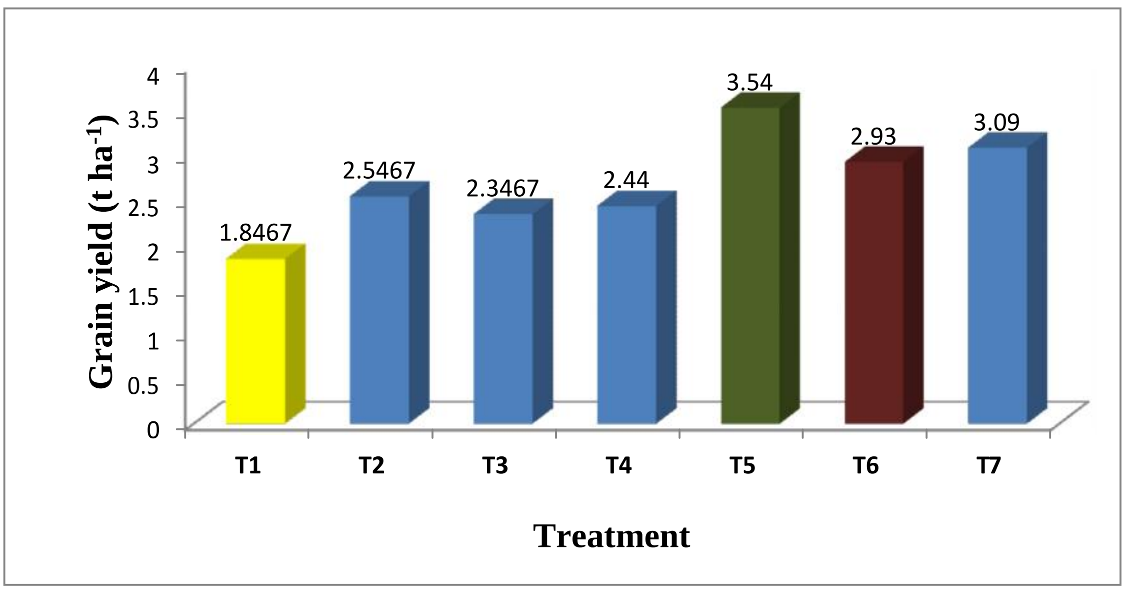


Fig.19. Effects of NPK and USG briquette increase grain yield over control of jhum rice (Field 2)

Straw yield

The straw yield of Jhum rice was significantly influenced by the application of different levels of NPK briquette. In field 1 straw yield ranged over control was observed from 2.62 t ha^{-1} to 4.15 t ha^{-1}. The highest straw yield of Jhum rice (4.15 t ha^{-1}) was found in treatment T_5, which was statistically different from all other treatments. The lowest straw yield of Jhum rice (2.62 t ha^{-1}) was found in T_1 treatment where no fertilizer was applied i.e control treatment (Fig.23). The straw yield of rice per treatment was ranked in $T_5>T_7>T_3>T_6>T_4>T_2>T_1$.

In field 2 straw yield was ranged from 2.6 t ha^{-1} to 4.08 t ha^{-1}. The highest straw yield was 4.08 t ha^{-1}over control (Treatment 1). In field 2 the highest straw yield was found T_5 treatment.The straw yield of rice per treatment was ranked in $T_5>T_7>T_3>T_6>T_4>T_2>T_1$.Fertilizer management differences regarding grain yield and Straw yield were also reported by Qiao *et al*. (2011).

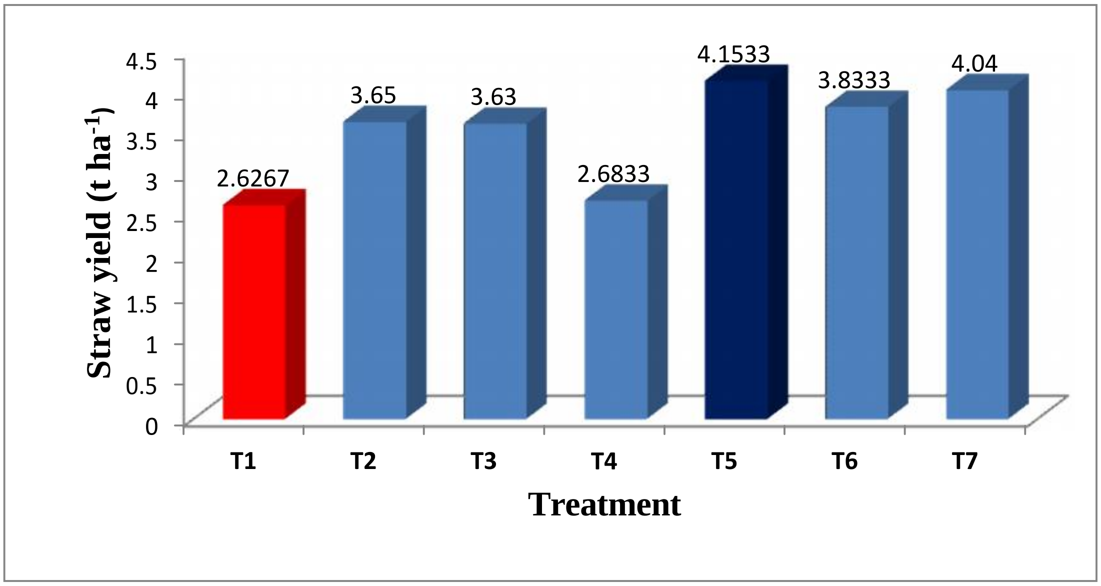


Fig.20. Effects of NPK and USG briquette increase straw yield over control of jhum rice (Field 1)

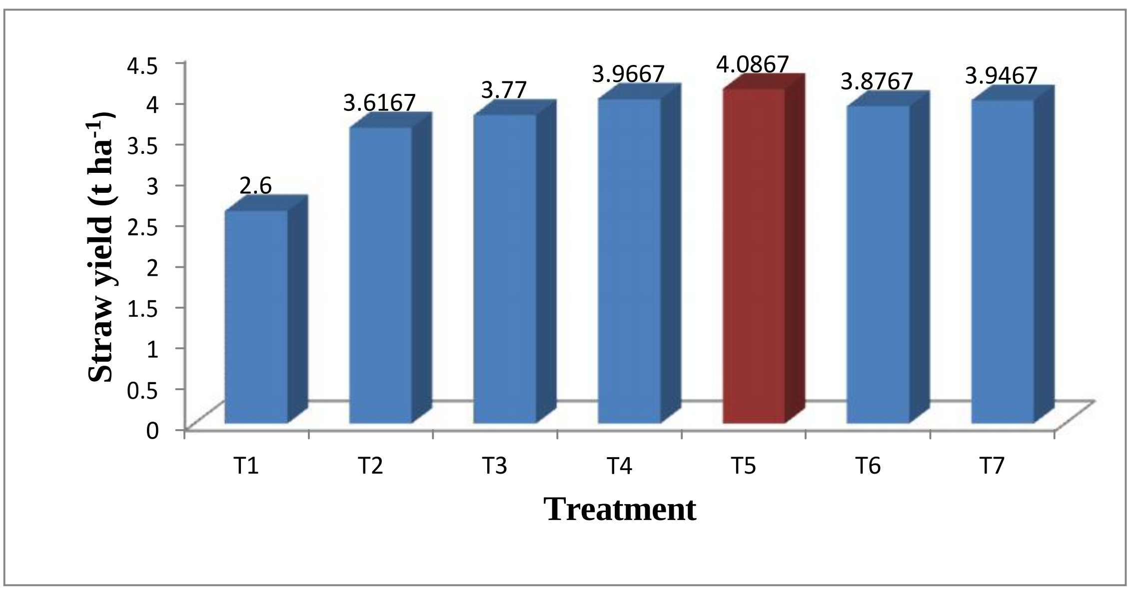


Fig. 21. Effects of NPK and USG briquette increase straw yield over control of jhum rice (Field 2)

Table 6. Effects of NPK and USG briquette on the grain and straw yields (t ha^{-1}) of jhum rice (Field 1)

Treatments	Grain yield (t ha $^{-1}$)	Straw yield (t ha $^{-1}$)
T_1	1.63^{g}	2.62^{d}
T_2	2.55^{e}	3.65^{c}
T_3	2.34^{f}	3.63^{c}
T_4	2.67^{d}	2.68^{d}
T_5	3.56^{a}	4.15^{a}
T_6	2.88^{c}	3.83^{bc}
T_7	3.07^{b}	4.04^{ab}
LSD $_{(0.01\%)}$	**0.03**	**0.07**
CV%	**1.49**	**2.76**

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

T_1=Control

T_2=100%USG and PK(RFD)

T_3=80%USG and PK(RFD)

T_4=120%USG and PK (RFD)

T_5 =100%NPK briquette

T_6=80%% NPK briquette

T_7=120% NPK briquette

Table 7. Effects of NPK and USGbriquette on the grain and straw yields (t ha^{-1}) of jhum rice (Field 2)

Treatments	Grain yield (t ha $^{-1}$)	Straw yield (t ha $^{-1}$)
T_1	1.84^{g}	2.60^{e}
T_2	2.54^{d}	3.61^{d}
T_3	2.34^{f}	3.77^{c}
T_4	2.44^{e}	3.96^{ab}
T_5	3.54^{a}	4.08^{a}
T_6	2.93^{c}	3.87^{bc}
T_7	3.09^{b}	3.94^{b}
LSD $_{(0.01\%)}$	**0.02**	**0.04**
CV%	**1.21**	**1.46**

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

T_1=Control

T_2=100%USG and PK(RFD)

T_3=80%USG and PK(RFD)

T_4=120%USG and PK (RFD)

T_5 =100%NPK briquette

T_6=80%% NPK briquette

T_7=120% NPK briquette

Effect of NPK briquette on the yield of Jhum crops other than rice

Yield of marpha

In field 1 fruit yield of marpha ranged over control was observed from 185.64 kg ha^{-1} to 727.46 kg ha^{-1}. The highest fruit yield of Jhummarpha (727.46 kg ha^{-1}) was found in treatment T_5, which was statistically different from all other treatments. The lowest fruit yield of Jhummarpha (185.64 kg ha^{-1}) was found in T_1 treatment where no fertilizer was applied i.e control treatment (Fig).The fruit yield of marpha per treatment was ranked in $T_5>T_7>T_6>T_4>T_2>T_3>T_1$. Krishna *et al*. (1995) showed that the effect of different fertilizer briquette, showed the significant results with respect to number of branches per plant at various stages except 30 DAS.

In field 2 fruit yield of marpha ranged over control was observed from 167.6 kg ha^{-1} to 734.48 kg ha^{-1}. The highest fruit yield of Jhummarpha (734.48 kg ha^{-1}) was found in treatment T_5, which was statistically different from all other treatments. The lowest fruit yield of Jhummarpha (167.6 kg ha^{-1}) was found in T_1 treatment where no fertilizer was applied i.e control treatment (Fig). The fruit yield was statistically identical T6 and T_7treatment .The fruit yield of marpha per treatment was ranked in $T_5>T_7>T_6>T_4>T_2>T_3>T_1$. Bulbule*et al*. (2008) showed increase in phosphorus uptake due to deep placement of briquettes containing NPK in different levels. Whereas the significantly highest uptake of K by cucumber (3.86 kg ha^{-1}) was recorded.

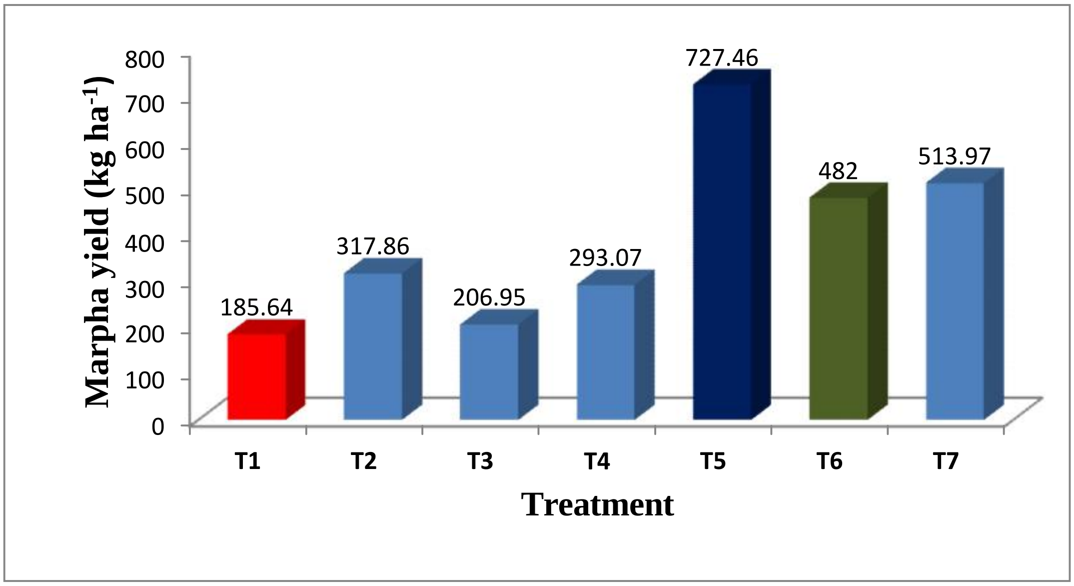


Fig.22. Effects of NPK and USG briquette increase marpha yield over control of jhum rice (Field 1)

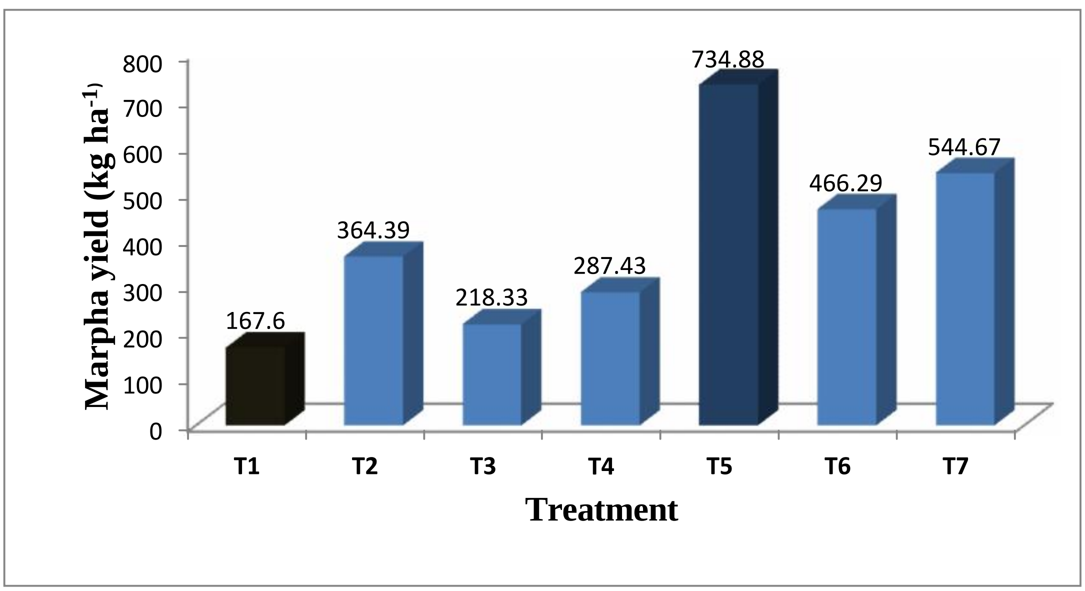


Fig.23. Effects of NPK and USG briquette increase marpha yield over control of jhum rice (Field 2)

Yield of maize

In field 1, Maize yield was ranged from 124.59 kg ha^{-1} to 674.45 kg ha^{-1}. The maximum grain yield was 674.45 kg ha^{-1} over control (Treatment 1). In field 1, the maximum grain yield was found T_5 treatment. The second highest grain yield of maize also obtained from NPK briquette treatment (T_7). The lowest yield of 124.59 kg ha^{-1} was found in T_1 (control) treatment having no fertilizer (Fig).The grain yield was statistically identical T_3, and T_6 treatment. The grain yield of maize per treatment was ranked as$T_5>T_7>T_6>T_4>T_2>T_3>T_1$.Kamal *et al.* (1991) used different forms of urea and level of nitrogen @ 29, 58, 87 kg N ha^{-1} in maize.

In field 2, Maize yield was ranged from 128.14 kg ha^{-1} to 642.49 kg ha^{-1}. Themaximum grain yield was 642.49 kg ha^{-1} over control (Treatment 1). In field 2, the maximum grain yield was found T_5 treatment. The second highest grain yield of maize also obtained from NPK briquette treatment (T_7). The lowest yield of 128.14 kg ha^{-1} was found in T_1 (control) treatment having no fertilizer (Fig.) The grain yield of maize per treatment was ranked as$T_5>T_7>T_6>T_4>T_2>T_3>T_1$. Amin M., *et al*. (2006) Nitrogen (N) is a vital plant nutrient and a major determining factor required for maize production.

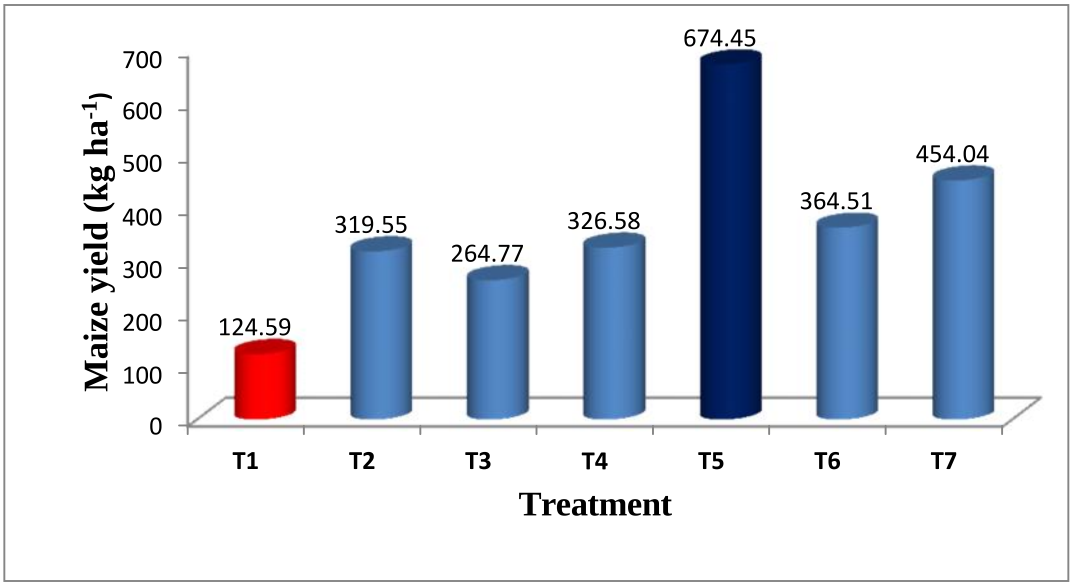


Fig.24. Effects of NPK and USG briquette increase maize yield over control of jhum rice (Field 1)

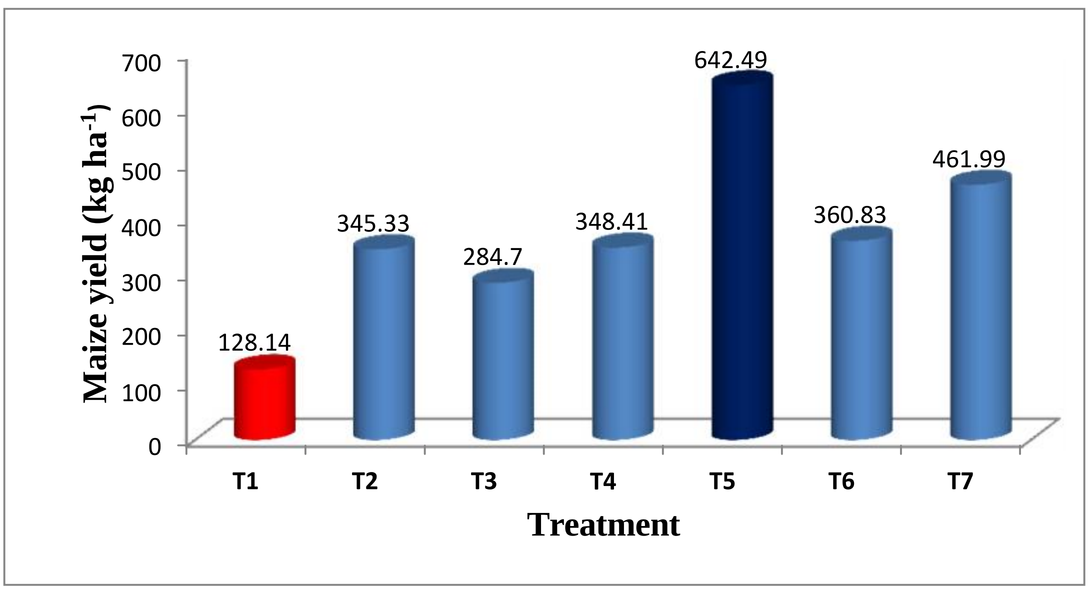


Fig.25. Effects of NPK and USG briquette increase maize yield over control of jhum rice (Field 2)

Yield of sweet gourd

In field 1, sweet gourd yield was ranged from 286.5 kg ha^{-1} to 1236.4 kg ha^{-1}. The highest fruit yield was 1236.4 kg ha^{-1} over control (Treatment 1). In field 1, the maximum fruit yield was found T_5 treatment. The lowest fruit yield of 286.5 kg ha^{-1} was found in T_1 (control) treatment having no fertilizer (Fig.)The fruit yield was statistically identical T_2 and T_4 treatment. The fruit yield of sweet gourd per treatment was ranked in $T_5>T_6>T_7>T_2>T_4>T_3>T_1$.Gaudin (2012) carried out an experiment on the kinetics of ammonia disappearance from deep-placed urea super briquettes (USG) in sweet gourd the effects of deep placement USG application and PU fertilizer.

In field 2, sweet gourd yield was ranged from 281.1 kg ha^{-1} to 1368.5 kg ha^{-1}. Thehighest fruit yield was 1368.5 kg ha^{-1}over control (Treatment 1). In field 2, the maximum fruit yield was found T_5 treatment. The lowest fruit yield of 281.1 kg ha^{-1}was found in T_1 (control) treatment having no fertilizer**(**Fig.)The fruit yield was statistically identical T_2 and T_4 treatment. The fruit yield of sweet gourd per treatment was ranked in $T_5>T_6>T_7>T_2>T_4>T_3>T_{1.}$Shukla and Prabhakar (1987) observed that the Sweet gourd with the spacing of plants at 300×45 cm gave the highest average yield of 384.54 q ha^{-1}.

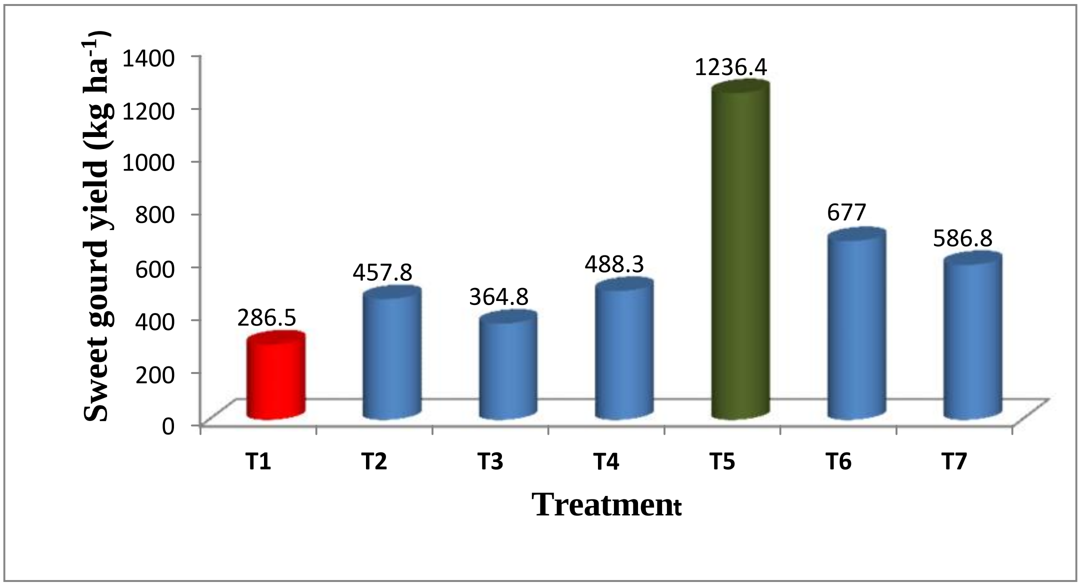


Fig.26. Effects of NPK and USG briquette increase sweet gourd yield over control of jhum rice (Field 1)

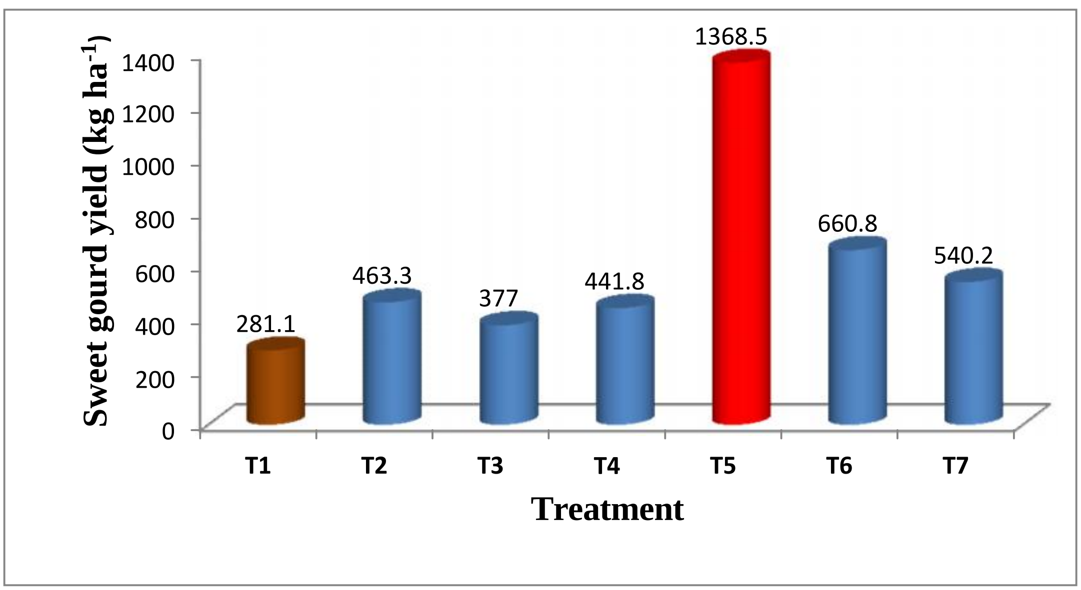


Fig.27. Effects of NPK and USG briquette increase sweet gourd yield over control of jhum rice (Field 2)

Yield of chili

In field 1 fruit yield of chili ranged over control was observed from 24.33 kg ha^{-1} to 155.5 kg ha^{-1}. The maximumt fruit yield of chili (155.5kg ha^{-1}) was found in treatment T_5, which was statistically different from all other treatments. The minimum fruit yield of chili (24.33 kg ha^{-1}) was found in T_1 treatment where no fertilizer was applied i.e control treatment (Fig).The fruit yield of chili per treatment was ranked in $T_5>T_6>T_7>T_2>T_3>T_4>T_{1.}$Brohi*et al*. (1997) also conducted an experiment to identify the effect of N and P fertilization on the yield and nutrient status of chili.

In field 2, chili yield was ranged from 19.7 kg ha^{-1} to 156.04 kg ha^{-1}. Thehighest fruit yield was 156.04 kg ha^{-1}over control (Treatment 1). In field 2, the maximum fruit yield was found T_5 treatment. The lowest fruit yield of 19.7 kg $ha^{-1}$was found in T_1 (control) treatment having no fertilizer(Fig.).The fruit yield of chili per treatment was ranked in $T_5>T_7>T_6>T_2>T_3>T_4>T_{1.}$Pandey and Tiwari (1996) evaluated the rate of 87 kg N ha^{-1} as a basal application of USG and to dressing as PU and observed that pod yield of chili and N use efficiency were the highest with N applied as a basal application of USG

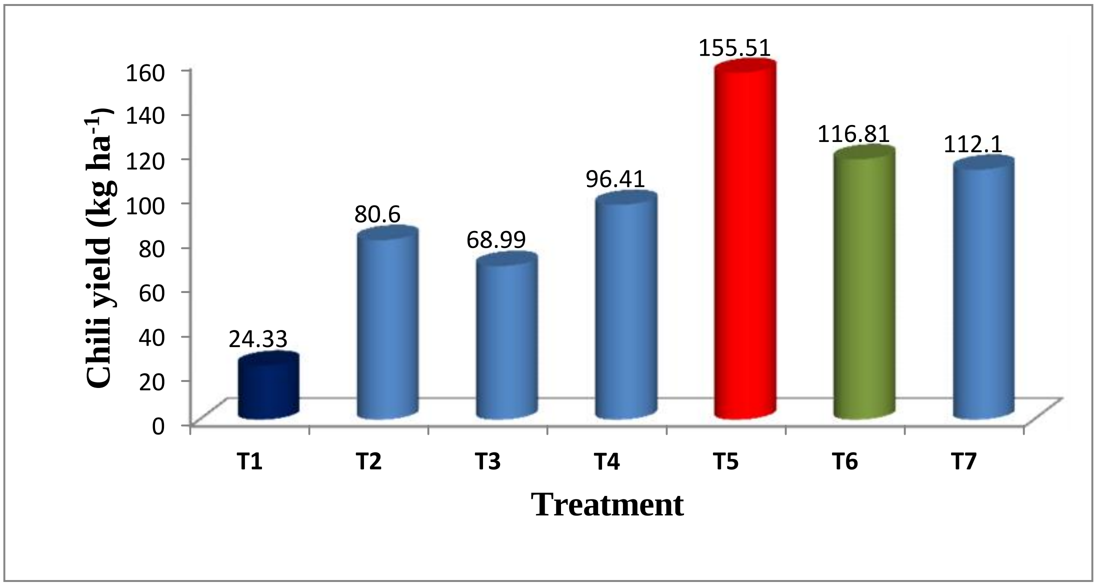


Fig.28. Effects of NPK and USG briquette increase chili yield over control of jhum rice (Field 1)

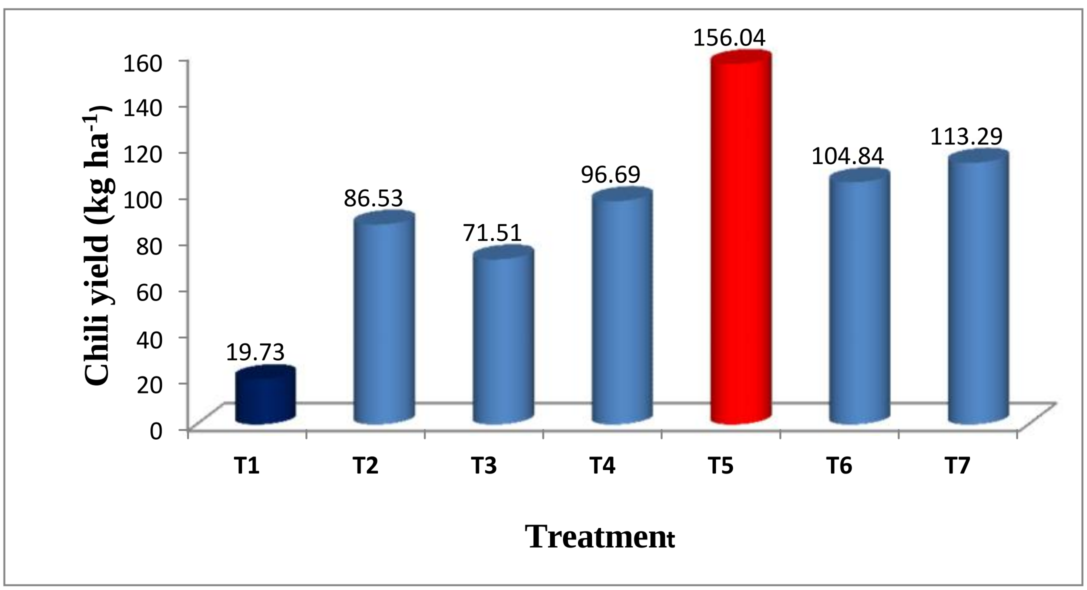


Fig.29. Effects of NPK and USG briquette increase chili yield over control of jhum rice (Field 2)

Table.8. Effects of NPK and USG briquette on the yield (kg ha^{-1}) marpha, maize, sweet gourd and chili (Field 1)

Treatments	Marpha (kg ha^{-1})	Maize (kg ha^{-1})	Sweet Gourd (kg ha^{-1})	Chili (kg ha^{-1})
T_1	185.64^{g}	124.59^{g}	286.5^{g}	19.73^{g}
T_2	317.86^{d}	319.55^{e}	457.8^{e}	86.53^{e}
T_3	206.95^{f}	264.77^{f}	364.8^{f}	71.51^{f}
T_4	293.07^{e}	326.58^{d}	488.3^{d}	96.69^{d}
T_5	727.46^{a}	674.45^{a}	1236.4^{a}	156.04^{a}
T_6	482.00^{c}	364.51^{c}	677.0^{b}	104.84^{c}
T_7	513.97^{b}	454.04^{b}	586.8^{c}	113.29^{b}
LSD $_{(0.05\%)}$	**1.82**	**1.33**	**1.67**	**1.23**
CV%	**0.57**	**0.45**	**0.35**	**1.63**

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

T_1=Control

T_2=100%USG and PK(RFD)

T_3=80%USG and PK(RFD)

T_4=120%USG and PK (RFD)

T_5 =100%NPK briquette

T_6=80%% NPK briquette

T_7=120% NPK briquette

Table.9. Effects of NPK and USG briquette on the yield (kg ha^{-1}) marpha, maize, sweet gourd and Chili (Field 2)

Treatments	Marpha (kg ha^{-1})	Maize (kg ha^{-1})	Sweet Gourd (kg ha^{-1})	Chilli (kg ha^{-1})
T_1	167.60^{g}	128.14^{e}	281.1^{f}	24.33^{f}
T_2	364.39^{d}	345.33^{c}	463.3^{d}	80.60^{d}
T_3	218.33^{f}	284.70^{d}	377.0^{e}	68.99^{e}
T_4	287.43^{e}	348.41^{c}	441.8d	96.41^{c}
T_5	734.88^{a}	642.49^{a}	1368.5^{a}	155.51^{a}
T_6	466.29^{c}	360.83^{c}	660.8^{b}	116.81^{b}
T_7	544.67^{b}	461.99^{b}	540.2^{c}	112.10^{b}
LSD (0.05%)	12.51	7.82	20.99	4.05
CV%	3.85	2.61	4.35	5.31

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

T_1=Control

T_2=100%USG and PK(RFD)

T_3=80%USG and PK(RFD)

T_4=120%USG and PK (RFD)

T_5 =100%NPK briquette

T_6=80%% NPK briquette

T_7=120% NPK briquette

Nutrient content in post harvest soil of Jhum cultivation

4.4.1 pH

Most of the soil pH was ranged in this areas from 4.0 to 4.5.In jhum crops cultivation, variation was observed in post harvest soil pH due to the application of different levels of NPK briquette(Table).In field 1, the pH of post harvest soilhighest 4.6 was found from T_4 treatment. The lowest pH in post harvest soil 4.1 was observed from T_2 treatment.In field 2, the pH of post harvest soilhighest 4.6 was found from T_5 treatment receiving 100% NPK briquette. The lowest pH in post harvest soil 4.3 was observed from T_1 treatment (control) receiving no fertilizer.

Organic matter

In post harvest soil organic matter was varied with different levels of NPK fertilizer for jhum cultivation (Table). In field 1,the organic matter of post harvest soil maximum 2.67 was found from T_5 treatment. The minimum organic matter in post harvest soil 2.52 was observed from T_1 treatment receiving no fertilizer (control). In field 2, the organic matter of post harvest soil maximum 2.67 was found from T_5treatment.The minimum organic matter in post harvest soil 2.62 was observed from T_1 treatment receiving no fertilizer (control).

Organic carbon

In field 1,the organic carbon of post harvest soil maximum 1.66 was found from T_5 treatment receiving 100% NPK briquette. The minimum organic carbon in post harvest soil 1.61 was observed from T_1 treatment receiving no fertilizer (control). In field 2, the organic carbon of post harvest soil maximum 1.65 was found from T_6 treatment. The minimum organic carbon in post harvest soil 1.62 was observed from T_2 treatment.

Total nitrogen

In field 1, the total nitrogen of post harvest soil highest 0.084% was found from T_5 treatment receiving 100% NPK briquette. The minimum total nitrogen in post harvest soil 0.083% was observed from T_1 treatment receiving no fertilizer (control). In field 2, the total nitrogen of post harvest highest 0.095 was found from T_6 treatment. The minimum total nitrogen in post harvest soil 0.091 was found from T_1 treatment receiving no fertilizer (control).

Available phosphorus

In field 1,the available P of post harvest soil highest11.33(μg/g)was found from T_6 treatment. The lowest available P in post harvest soil 9.76(μg/g)was observed from T_1 treatment receiving no fertilizer (control). Available P in post harvest soil was greatly influenced by different level of NPK briquette treatment Table**.**In field 2,the available P of post harvest soil highest11.56(μg/g)was found from T_4 treatment. The lowest available P in post harvest soil 10.16(μg/g)was observed from T_1 treatment receiving no fertilizer (control).

Exchangeable potassium

In field 1, the exchangeable K of post harvest soil highest 0.15 (meq/100g) was found from T_5 treatment receiving 100% NPK briquette (267.8 kg ha^{-1}). The lowest exchangeable K in post harvest soil 0.12(meq/100g) was observed from T_1 treatment receiving no fertilizer (control). In field 2, the exchangeable K of post harvest soil highest 0.14 (meq/100g) was found from T_6 treatment. The lowest exchangeable K in post harvest soil 0.11(meq/100g) was observed from T_1 treatment receiving no fertilizer (control).

Available sulphur

In field 1, the available S of post harvest soil maximum6.56 (µg/g) was found from T_5 treatment receiving 100% NPK briquette (267.8 kg ha^{-1}). The minimumavailable S in post harvest soil 5.73 (µg/g) was observed from T_1 treatment receiving no fertilizer (control)**.**In field 2, the available S of post harvest soil maximum6.86 (µg/g) was found from T_5 treatment receiving 100% NPK briquette (267.8 kg ha^{-1}). The minimumavailable S in post harvest soil 5.66 (µg/g) was observed from $T_{1.}$

Table 10. Effects of NPK briquette on pH, organic matter,organic carbon N, P, K and S in post harvest soil of jhum cultivation (Field 1)

Treatments	pH	Organic Matter (%)	Organic Carbon (%)	Total N (%)	Available P (µg/g)	Exchangeable K (meq/100g)	Available S (µg/g)
T_1	4.3	2.52	1.61	0.081	9.76c	0.12	5.73
T_2	4.1	2.57	1.64	0.083	10.73^{b}	0.14	6.13
T_3	4.2	2.55	1.62	0.083	10.56^{b}	0.14	6.23
T_4	4.5	2.55	1.65	0.080	10.36^{b}	0.12	5.83
T_5	4.3	2.61	1.66	0.084	11.16^{a}	0.15	6.56
T_6	4.6	2.55	1.64	0.082	11.33^{a}	0.11	6.30
T_7	4.4	2.67	1.60	0.083	10.53^{b}	0.15	6.16
$LSD_{(0.05)}$	NS	NS	NS	NS	0.08	NS	NS
CV (%)	1.00	0.83	1.63	2.24	1.03	4.47	1.48

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

T_1=Control, T_2=100%USG and PK(RFD), T_3=80%USG and PK(RFD), T_4=120%USG and PK (RFD),

T_5 =100%NPK briquette, T_6=80%% NPK briquette, T_7=120% NPK briquette

Table 11.Effects of NPK briquette on pH, organic matter,organic carbon N, P, K,S and Zn content in post harvest soil of jhum cultivation (Field 2)

Treatments	pH	Organic Matter (%)	Organic Carbon (%)	Total N (%)	Available P (µg/g)	Exchangeable K (meq/100g)	Available S (µg/g)
T_1	4.4	2.62	1.63	0.091	10.16[c]	0.11	5.86
T_2	4.3	2.66	1.62	0.091	10.23[c]	0.12	5.66
T_3	4.4	2.62	1.63	0.092	10.56[c]	0.13	6.11
T_4	4.6	2.67	1.64	0.091	11.56[a]	0.11	6.76
T_5	4.6	2.65	1.62	0.093	11.36[b]	0.11	6.86
T_6	4.5	2.63	1.65	0.095	11.16[b]	0.14	6.43
T_7	4.7	2.62	1.62	0.093	11.23[b]	0.11	6.43
$LSD_{(0.05)}$	NS	NS	NS	NS	0.07	NS	NS
CV (%)	0.48	0.08	0.39	0.59	079	5.85	1.04

Means in a column followed by same letter(s) are not significantly different at 5% level of significance by RCBD.
T_1=Control, T_2=100%USG and PK(RFD), T_3=80%USG and PK(RFD), T_4=120%USG and PK (RFD),
T_5 =100%NPK briquette, T_6=80%% NPK briquette, T_7=120% NPK briquette

SUMMARY AND CONCLUSION

Two experiments were conducted at Ramery para, Bandarban sadar, Bandarban hill district in Chittagong under the AEZ 29 (Northern and Eastern Hills Tract) during March 2017 to November 2017 to study the effect of NPK briquette on the growth and development of Jhum crops. In this experiment, Jhum rice, marpha, maize, sweet gourd and chili were used as the test crop.

The experiment was conducted in two field and designed on Randomized Completely Block Design (RCBD). The treatments consisted of 7(seven) levels of NPK briquette i.e. T_1: Control, T_2: 100% USG and PK (RFD), T_3: 80% USG and PK (RFD), T_4: 120% USG and PK (RFD), T_5 :100%NPK briquette (267.5 kg ha^{-1}), T_6: 80% NPK briquette (214.1 kg ha^{-1}), T_7: 120% NPK briquette (320.8 kg ha^{-1}). Ratio in 100 kg NPK briquette contain 50 kg urea:30 kg TSP:20 kg MoP and RFD value was N 60 kgha^{-1}, P 18 kg ha^{-1}, K 30 kg ha $^{-1}$ and S 8 kg ha^{-1}

The growth and yield of Jhum rice were significantly influenced by different levels of NPK briquette. Sometimes soil characteristics also influenced by NPK briquette. The highest plant height of jhum rice (139.23 cm), effective tillers hill^{-1} (16.60), panicle length (30.23 cm), highest number of filled grain panicle^{-1} (245.23), 1000 grain weight (28.0 gm), straw yield (4.15 t/ha) and grain yield (3.56 t/ha) were found from T_5 treatment treatment receiving 100%NPK briquette (267.5 kg ha^{-1})and for all cases lowest results were found in T_1 treatment receiving no fertilizer (control).

Yield of others Jhum crops also significantly influenced by NPK briquette. The highest yield of marpha (734.88 kg ha^{-1}), maize (674.45 kg ha^{-1}), sweet gourd (1368.5 kg ha^{-1}), chili (155.51 kg ha^{-1}) and turmeric (422.82 kg ha^{-1}) were found in T_5 and for all cases lowest results were found in T_1 treatment.

Sometimes post harvest soil characteristics like soil physical and chemical properties also influenced by different levels of NPK briquette. In case of field 1& 2,the highest pH (4.7) was found in T_7 treatment treatment and for all treatment lowest pH (4.1) were found in T_1 treatment and in post harvest soil the highest available phosphorus (11.56 µg/g) and available sulphur (6.86µg/g) were found in T_5 treatment treatment and for all treatment lowest P (9.76µg/g) and S (5.73µg/g) were found in T_1 treatment receiving no fertilizer (control).

Rice production in Bangladesh needs to be increased to feed 215.4 million people in 2050. This can be done in two ways: expanding the rice growing area and increasing productivity, or both. Crop productivity can be increased by supplying nutrients as per crop requirement or soil fertility management. So from the above experimental result we can say that hilly areas is great opportunity to sustain our livelihood and Jhumia communities. So considering the present experiment following recommendations may be suggested:

1. Such kinds of study may be conducted in different sites of Chittagong Hill Tracts.
2. Some other levels of fertilizer management practices may be included in future program.

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Appendix I. Analysis of variance of the data on growth and yield contributing characteristics of Jhum rice (Field 1)

Source Of variation	df	Plant Height (cm)	Effective Tiller $Hill^{-1}$	Non-Effective Tiller $Hill^{-1}$	Panicle Length $(cm)^{1}$	Filled Grain/ Panicle (NO.)	Unfilled Grain/ Panicle (NO.)	1000 Seed Wt (t/ha)	Grain Wt (t/ha)	Straw Wt (t/ha)
Replication	2	3.81	0.19	0.006	0.52	11.88	1.35	2.33	0.001	0.006
Factor A	6	111.3	4.95	0.74	19.81	7911.8	204.8	15.5	1.09	1.14
Error	12	2.47	0.44	0.01	0.39	4.14	1.01	0.38	0.001	0.009
Calculated F value		45.04 *	11.23 *	38.27 *	50.35 *	1911.8 *	202.7 *	40.0 *	693.5 **	121.7 **
Critical T Value		5% at 2.179							1% at 3.055	
		2.79	1.18	0.24	1.11	3.61	1.7	1.10	0.09	0.24

**= Significant at 1% level of probability

***** = Significant at 5% level of probability

NS = Non Significant.

Appendix II. Analysis of variance of the data on yield of marpha, maize, sweet Gourd and chili (Field 1)

Source Of variation	df	Marpha Yield (t/ha)	Maize Yield (t/ha)	Sweet Gourd Yield (t/ha)	Chili Yield (t/ha)
Replication	2	0.778	0.175	0.66	0.38
Factor A	6	113.78	87.48	297.9	52.05
Error	12	5.00	2.70	51.0	2.27
Calculated F value		22.78 *	32.61 *	70.4 *	22.89 *
Critical T value		5% at 2.179			
		3.97	2.91	3.65	2.68

**= Significant at 1% level of probability

***** = Significant at 5% level of probability

NS = Non Significant.

ppendix III. Analysis of variance of the data on growth and yield characteristics of Jhum rice (Field 2)

Source Of variation	df	Plant Height (cm)	Effective Tiller Hill^{-1}	Non-Effective Tiller Hill^{-1}	Panicle Length (cm)^{1}	Filled Grain/ Panicle (NO.)	Unfilled Grain/ Panicle (NO.)	1000 Seed Wt (gm)	Grain Wt (t/ha)	Straw Wt (t/ha)
Replication	2	2.00	0.003	0.006	0.16	30.81	0.23	0.57	0.001	0.009
Factor A	6	181.1	10.35	0.46	15.01	6908.9	277.01	8.52	0.92	0.76
Error	12	3.63	0.33	0.005	0.23	17.30	2.23	0.90	0.001	0.002
Calculated F value		77.4 *	30.50 *	83.80 *	62.84 *	399.4 *	124.01 *	9.42 *	881.46 **	263.8 **
Critical T Value		5% at 2.179							1% at 3.055	
		3.39	1.03	0.13	0.86	7.39	2.65	1.69	0.08	0.13

**= Significant at 1% level of probability

***** = Significant at 5% level of probability

NS = Non Significant.

Appendix IV. Analysis of variance of the data on yield of marpha, maize,sweet gourd and chili (Field 2)

Source Of variation	df	Marpha Yield (t/ha)	Maize Yield (t/ha)	Sweet Gourd Yield (t/ha)	Chili Yield (t/ha)
Replication	2	0.730	0.150	0.855	0.067
Factor A	6	119.9	74.80	396.1	5.14
Error	12	0.23	0.91	0.66	0.024
Calculated F value		507.6 *	814.9 *	599.4 *	208.6 *
Critical T value		5% at 2.179			
		27.25	17.04	45.73	8.83

**= Significant at 1% level of probability

***** = Significant at 5% level of probability

NS = Non Significant.

Appendix V. Abbreviations and acronyms

Abbreviations	**Full word**
AEZ	Agro-Ecological Zone
BARI	Bangladesh Agricultural Research Institute
cm	Centimeter
CV %	Percent Coefficient of Variation
DAS	Days After Sowing
RCBD	Randomized Completely Block Design
et al.,	And others
e.g.	exempli gratia (L), for example
etc.	Etcetera
FAO	Food and Agricultural Organization
g	Gram (s)
i.e.	id est (L), that is
Kg	Kilogram (s)
LSD	Least Significant Difference
m^2	Meter squares
ml	MiliLitre
M.S.	Master of Science
No.	Number
SAU	Sher-e-Bangla Agricultural University
var.	Variety
^oC	Degree Celceous
%	Percentage
NaOH	Sodium hydroxide
GM	Geometric mean
mg	Miligram
P	Phosphorus

K	Potassium
S	Sulphur
L	Litre
µg	Microgram
USA	United States of America
USDA	United States Department of Agriculture
N	Nitrogen
Zn	Zinc
Res.	Research
Kg ha^{-1}	Kilogram per hectare
Sc.	Science
Wt	Weight
BRRI	Bangladesh Rice Research Institute
meq	milliequvalent
BSMRAU	Bangladesh Sheikh MujiburRahman Agricultural University
J.	Journal
ANOVA	Analysis of variance
@	At the rate
RFD	Recommended fertilizer dose
IFDC	Increasing Food Security and Agricultural Sustainability
df	Degree of freedom
CEH	Chemical Economics Handbook
Rep.	Replication
IFPRI	International Food Policy Research Institute
DAT	Day After Transplanting
USG	Urea Super Granule

Appendix -VI: List of plates of the experimental plot

Plate 1.Field view at seedling stage

Plate 2.Field view at growing stage of Jhum rice and other crops

Plate 3.Field view at vegetative stage of Jhum rice and other crops

Plate 4.Field view at reproductive stage of Jhum rice

Plat 5. Field view at ripening and harvesting stage of Jhum rice

Plate 6. Field view after harvesting stage

Plate 6.Field view at collection of data from the field

Plate 11.Post harvest soil test in the laboratory