EFFECT OF DIFFERENT FERTILIZER PACKAGES ON THE PERFORMANCE OF JHUM CROPS

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CERTIFICATE

This is to certify that thesis entitled, **"EFFECT OF DIFFERENT FERTILIZER PACKAGES ON THE PERFORMANCE OF JHUM CROPS"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN SOIL SCIENCE,** embodies the result of a piece of *bona fide* research work carried out by **TARUN KUMAR BALA, REGISTRATION NO. 08-02871** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:
Place: Dhaka, Bangladesh

……………………………………
(Dr. Alok Kumar Paul)
Professor
Supervisor

Dedicated To My

Beloved Parents

And Respected Teacher

Prof. Dr. Alok Kumar Paul

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EFFECT OF DIFFERENT FERTILIZER PACKAGES ON THE PERFORMANCE OF JHUM CROPS

ABSTRACT

The experiment was conducted at Hill Agricultural Research Station, Bangladesh Agricultural Research Institute, Khagrachari, Bangladesh during Kharif season May, 2014 to January, 2015 to study the effects of different fertilizer on the performance of jhum crops. Jhum rice (Locally called 20 number), marpha, maize, sweet gourd, sesame, turmeric and arhar were used as the test crop in this experiment. The experiment was laid out in Latin Square Design (LSD), where the experimental area was divided into four blocks representing the replications to reduce soil heterogenetic effects. The treatments consisted of 4(four) levels of NPK fertilizers i.e. T_1: no fertilizer (Control), T_2: 40 kg N + 25 kg P_2O_5 + 30 kg K_2O ha^{-1}, T_3: 80 kg N + 50 kg P_2O_5 + 60 kg K_2O ha^{-1} and T_4: 120 kg N + 75 kg P_2O_5 + 90 kg K_2O ha^{-1}. The yield parameters and yields were significantly affected by fertilizer. Yield contributing characters and yields of jhum rice were significantly affected by different levels of NPK fertilizer. The highest plant height of jhum rice (132.8 cm), effective tillers hill^{-1} (14.38), panicle length (30.80 cm), highest number of filled grain per panicle (132.7), 1000 grain weight (25.17 gm), straw yield (4.18 ton/ha) and grain yield (3.34 ton/ha) were found from T_4 treatment receiving 120 kg N + 75 kg P_2O_5 + 90 kg K_2O ha^{-1} and for all cases lowest results were found in T_1 treatment receiving no fertilizer (control). NPK fertilizer plays a significant role on the yield of marpha, maize, sesame, sweet gourd, turmeric and arhar. The highest yield of marpha (984.8 kg ha^{-1}), maize (951.3 kg ha^{-1}), sweet gourd (1418.0 kg ha^{-1}), sesame (331.3 kg ha^{-1}), turmeric (680.2 kg ha^{-1}) and arhar (349.9 kg ha^{-1}) were found in T_4 treatment receiving 120 kg N + 75 kg P_2O_5 + 90 kg K_2O ha^{-1} and for all cases lowest results were found in T_1 treatment receiving no fertilizer.

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Introduction

INTRODUCTION

Jhum cultivation is an age-old, rain-fed cultivation method, practiced by the indigenous people on the hills and slopes of the Chittagong Hill Tracts, because of the lack of flat land suitable for farming. This system involves cutting back and clearing large areas of the hill side through fire. Jhum cultivation also called slash and burn agriculture, shifting cultivation or swiddan cultivation. This agricultural system is practiced by the individual or family.

This traditional cultivation practice has been the only way of subsistence agriculture practice for many of the CHT people specially who are living in remote places. It is estimated that about 40,000 households are engaged with jhum cultivation in CHT (Ullah *et al.*, 2012). Typically it involves clearing land (often forest) for the growing of crops and then moving on to new sites, leaving the earlier ground fallow to regain its soil fertility. In the past, land was left fallow for between 15 to 20 years, which allowed the soil time to regenerate its fertility. These days however population pressure, coupled with acute land scarcity has forced that time frame to be reduced to a rotation cycle of between 2 to 3 years (CARE, 2000). This is widely recognized as not being sufficient for soil to regain its productivity.

Seeds of different crops are mixed together and sown in the field after the first rain shower has fallen, usually during the months of April to May. Typically, upland rice and vegetables are harvested within a few months after sowing, whereas cotton, turmeric and arhar are harvested after 8 or 9 months, during December. 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. Rice is the most common crop in jhum farming and cultivated in rain fed 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}) (BBS, 2009). Rasul and Thapa (2002) reported that poverty is widespread in the CHT particularly in rural areas. Many rural families suffer from chronic food shortages. On average, per household per annum food (rice) shortage was found higher (0.87 ton) for non-ethnic and lower for ethnic households (0.49 ton) which constitutes 84.5% and 45.9% respectively (Uddin *et al.*, 2010).

The Chittagong Hill Tract (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 (hill), 20% undulating bumpy land and 3% plain with high potential for agriculture development (BBS, 2008). Indigenous hill people are generally very poor, not enough educated and their livelihood depends mostly on wage earnings and Jhum cultivation. For the well-being of human life, food security as well as livelihood security is a matter of concern. CHT is completely different in physical features, agricultural practices and soil conditions from rest of the country. Food insecurity is a great concern in CHT where it is sometimes becomes very difficult to arrange three meals particularly for medium or big families. As the world food prices have hit the record highs recently and the uptrend is still continuing, the household of Chittagong Hill Tracts (CHTs) are highly vulnerable to food security due to their limited access to food (The News Today, 2012).

Now a day's, the shrinkage of jhum fields and reducing yields has created a challenge for the Jumia families. Compared to this low return from the jhum, still many of the people either partly or fully depend on jhum for their livelihoods (Borggaard *et al.,* 2003). Degradation of upland soils is widespread in CHT and continues to accelerate due to gradual intensification of crop production without applying balanced fertilizers or manures (Miah *et al.,* 2008).

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). Though the practice is ecologically harmful and economically unviable, it is still only sensible means to make a living in the more inaccessible areas of Chittagong Hill Tracts. These days it is gradually evolving and becoming more market oriented, which is also adding pressure for shorter land rotation. Ironically it seems possible fertilizer will become more and more necessary, and come to play an important role in this process, in stark contrast to the purely organic practice of the past.

The depleted soil fertility is a major constraint to higher crop production in Chittagong Hill Tracts, Bangladesh (Farid *et al.*, 2009). The increasing land use intensity has resulted in a great exhaustion of nutrients in soils. Continuous cultivation of this highly exhaustive cropping sequence in most of the lands has resulted in the decline of soil physico-chemical condition. For that reason scientists are trying to improve the production systems with the help of application of fertilizers. The improvement of soil physico-chemical properties by using fertilizers are supply for essential plant nutrient for higher yield. The applications of different fertilizer packages affect the yield, nutrient accumulation and quality of jhum crops.

Crops in jhum are usually planted after the onset of monsoon rain. When heavy rains occur in May-June, the crops have not yet formed a cover to protect the newly cultivated slopes from splash erosion. As the soil surface is uncovered and land is sloppy, the intensity of rain exceeds the infiltration rate of soil causing large quantities of run-off that carries fertile top soil and rendering the land unproductive. With the rapidly growing population, the fallowing period has started to shrink and it is now reduced to 2-3 years or less (CARE, 2000). This shorter fallow period is not sufficient for replenishment of natural soil fertility. As a result, the productivity of jhum is declining day by day.

So, to restore the soil fertility and to increase the productivity of jhum, a judicious application of fertilizer is a must. Little or no research information on fertilizer management of jhum crops is available. Considering these facts as stated, the present study was undertaken to identify the fertilizer package for increasing the yield of jhum crops.

This detailed study was under taken with the following objectives:

I. To develop a suitable dose of fertilizer for increasing the productivity of jhum

II. To evaluate the effects of fertilizer on the yield and quality of jhum crops.

III. To create awareness about the use of fertilizer for jhum in farmers

Chapter 2

Review of Literature

REVIEW OF LITERATURE

Fertilizer is the essential factor for sustainable soil fertility and crop productivity because it is the store house of plant nutrients. Optimum fertilizer dose are the most important factors for maximizing crop yield. 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 fertilizer. However, the requirement of fertilizer for any crop varies with the cultivars, season and soil types in different agro ecological zones. A few numbers of works has so far been done pertaining to the influence of fertilizer dose on the yield and yield contributing components of jhum crops in the world and considerable extent in Bangladesh. Since review of literature forms a bridge 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 "**EFFECT OF DIFFERENT FERTILIZER PACKGES ON THE PERFPRMANCE OF JHUM CROPS**" are reviewed below-

2.1 Effect of NPK fertilizer on the growth and yield of rice

Satyanarayana *et al.* (2010) reported significant influence of different inorganic fertilizer levels on grain and straw yield, tiller numbers, filled grains per panicle and 1000-grain weight of rice. Application of 120 : 75 : 90 kg N: P_2O_5 : K_2O ha^{-1} produced significantly greater grain yield (3.37 t ha^{-1}) as compared to that obtained with lower fertilizer levels of N: P_2O_5 : K_2O ha^{-1} (3.11 t ha^{-1}).

Nyalemegbe *et al.* (2009) observed that application of higher fertilizer level of 160: 90: 100 kg N: P_2O_5: K_2O ha^{-1} produced grain yield of 3.46 t ha^{-1}, which was statistically similar to that obtained with application of 120: 75: 90 kg N: P_2O_5: K_2O ha^{-1}. Similar effects were also observed for straw yield, number of tillers, filled grains per panicle and 1000-grain weight.

Singh *et al.* (2003) reported that crop growth rate, such as plant height, dry mater production averaged across treatments, was significantly influence by NPK fertilizers.

Khan *et al.* (2004) conducted an experiment to evaluate the effect of increased plant density and fertilizer dose on yield of rice variety IR-6. He found that increased fertilizer dose of NPK increase plant height.

Islam *et al.* (2010) conducted an experiment to determine the response and the optimum rate of nutrients (NPK) for Chili- Fallow- T. *aman* cropping pattern. He found that grain yield influenced significantly due to application of different rates of nutrients and 120-70-90 kg ha^{-1} NPK maximized the yield of T. *aman* rice varieties in respect of yield and economics.

Asif *et al.* (2000) reported that NPK levels significantly increase the panicle length, number of primary and secondary branches $panicle^{-1}$ when NPK fertilizer applied in 130-90-90 kg ha^{-1} this might be attributed to the adequate supply of NPK.

Haq *et al.* (2002)[a] reported that the number of panicles increased with increase in the nitrogen rates and that number of panicles per plant increased with increase in NPK rates.

Shen *et al.* (2003) reported that the effect of different NP levels i.e., 0-0, 25-0, 50-25, 75-50, 100-75 and 125-100 kg ha^{-1} on yield and yield attributes of rice Bas-385. Yield attributes (No. of effective tillers per hill, spikelet per panicle, normal kernels per panicle, 1000-grain weight) were improved linearly with increasing NP levels up to 100-75 kg ha^{-1}. The NP level of 100-75 kg ha^{-1} resulted in the highest grain yield of 4.53 t ha^{-1} with minimum kernel abnormalities (Sterility, abortive kernels and opaque kernels) as against the minimum of 2.356 t ha^{-1} in the control (0-0) followed by 25-0 kg NP ha^{-1} with maximum kernel abnormalities.

Singh *et al.* (2003) also reported that crop growth rate and relative growth rate such as total dry matter production was significantly influenced by NPK. The tiller number and total dry matter production were closely correlated with yield depending on the rice cultivar (Tanaka, 1968) which can be greatly enhanced by applying proper nutrient.

Bahmanyar and Mashaee (2009) found that maximum grain yield (87.43 g pot^{-1}) was found @ 110 kg N ha^{-1} in Aus rice.

Singh *et al.* (2006) showed that the nitrogen application significantly increased plant height.

Saha *et al.* (2007) conducted an experiment in 2002-2003 to create and compare a suitable fertilizer recommendation model for rice. Five different fertilizer recommendation models were tested and compared with one check plot. Results showed that the application of different packages estimated by different fertilizer models significantly influence panicle length, panicle numbers, spikelet number per panicle, total grains panicle^{-1}, number of filled grain and unfilled grain per panicle. The combination of NPK that gave the highest result was 120-70-80-20 kg ha^{-1} NPKS.

Salahuddin *et al.* (2009[a]) conducted an experiment to study the effect of nitrogen levels and plant spacing on the yield and yield contributing characters of T. aman rice (var. BRRI dhan31) and found that panicle length increased with the increase of nitrogen rate up to 150 kg N ha^{-1} and thereafter declined. The longest panicle (24.50 cm) was observed when 150 kg N ha^{-1} was applied and the shortest (18.15 cm) from control. Nitrogen nutrient takes part in panicle formation as well as panicle elongation and for this reason, panicle length increased with the increase of N-fertilization up to 150 kg N ha^{-1}.

Reddy (2009) reported that the highest number of grains panicle^{-1} (109.79) was obtained with 150 kg N ha^{-1}, which was significantly different from other N levels. Nitrogen helped in proper filling of seeds which resulted higher produced plump seeds and thus the higher number of grains panicle^{-1}. The lowest number of grains panicle^{-1} (99.41) was obtained from 0 kg N ha^{-1}.

Alam *et al.* (2006) reported that straw yield increased with increasing N levels in rice.

Chaudhary *et al.* (2011) conducted an experiment on 3 rice cultivars in 1933-96 in Mahara by applying 25-100 kg N ha^{-1} or no fertilizers or 12 t ha^{-1} farmyard manures. They observed that the grain yield was the highest with applying 100kg N ha^{-1}.

Mazumder *et al.* (2005) reported that different levels of nitrogen influenced grain, straw and biological yields with the application of 100% recommended dose (RD) of N (120 kg N ha^{-1}) which was statistically followed by other treatments in descending order. The highest grain yield (4.86 t ha^{-1}) was obtained with 100% RD of N and the lowest (3.80 t ha^{-1}) from no application of nitrogen.

Moula (2005) conducted an experiment on T. aman rice with different phosphorus rates. He found that when four treatments (P_0, 75 kg ha^{-1} phosphate rock, 75 kg ha^{-1} TSP and 210 kg ha^{-1} phosphate rock) were applied, 75 kg phosphate rock (PR) showed better performance on yield contributing characters and nutrient content as well as nutrient uptake by rice over other treatments.

Wang *et al.* (2011) carried out a field experiment to study the effects of N, P and K fertilizer application on grain yield, grain quality as well as nutrient uptake and utilization of rice to elucidate the interactive effects among N, P and K in a field experiment with four levels of nitrogen (N), phosphorus (P) and potassium (K) fertilizers. The results showed that the application of N, P and K fertilizer significantly increased grain yield, and the highest yield was found under the combined application of N, P and K fertilizer.

Wan *et al.* (2010) conducted an experiment to evaluate the effects of application of fertilizer, pig manure (PM), and rice straw (RS) on rice yield, uptake, and usage efficiency of potassium, soil K pools, and the non-exchangeable K release under the double rice cropping system. The field treatments included control (no fertilizer applied), NP, NK, NPK, and NK + PM, NP + RS, NPK + RS. The application of K fertilizer (NPK) increased grain yield by 56.7 kg ha^{-1} over that obtained with no K application (NP).

Muangsri *et al.* (2008) reported that the effect of rice straw and rice hull in combination with nitrogen, phosphorus and potassium fertilizer on yield of rice grown on Phimai soil series. The investigation carried out in pots. A completely randomized design with 3 replications was used. The treatments consisted of the control (without fertilizer) NPK fertilizer, rice straw at the rate of 0.75, 1.5 and 3.0 g kg^{-1} soil in combination with NPK fertilizer, and rice hull at the rate of 0.75, 1.5, 3.0 and 4.5 g kg^{-1} soil in combination with NPK fertilizer. The results showed that the growth, yield and nutrient uptake of rice plant grown on Phimai soil series without fertilizer were the lowest. Application of rice hull in combination with NPK fertilizer increased nutrient absorption and rice yield better than with NPK alone, especially at the rate of 1.5 g kg^{-1} soil. Yield of rice plant grown on the soil amended with rice straw in combination with NPK fertilizer tended to be higher than that of rice plant grown on the soil amended with only NPK fertilizer.

Mostofa *et al*. (2009) conducted a pot experiment in the net house at the Department of Soil Science, Bangladesh agricultural University, Mymensingh. Four levels of potassium (0, 100, 200, and 300 kg ha^{-1}) were applied. They observed that the yield contributing characters like plant height, tiller number, and dry matter yield were the highest in 100 kg ha^{-1} of K.

Bhuiyan *et al*. (2003) studied the effects of N and K fertilizer on the yield and quality of rice. Potassium fertilizer significantly improved all quality parameters and yield at 150 kg N ha^{-1} and 90 kg ha^{-1} K fertilizer applied to rice fields are optimum to obtain high yield.

Sarkar and Singh (2002) conducted a field experiment to determine the effect of NPKS on growth and yield of rice (*Oryza sativa* L.). They observed that the number of tillers m^{-2}, 1000-grain weight, paddy and straw yield significantly increased with the application of N, P, K and S.

Singh *et al.* (2000) evaluated the effect of different levels of K application on rice at different places. Results indicated that K application significant enhanced the growth and yield of rice over no application. The highest grain and straw yields of rice was obtained at 90 kg K_2O ha^{-1} in all the cropping seasons.

Leharia and Zaad (2004) conducted a field experiment during Kharif in Jammu, India to investigate the effect to NPK application on growth and yield of rice cv. PC-19. Results indicated that application of NPK @ 120:70:90 kg ha^{-1} gave highest grain and straw yield over other treatments.

Rajarathinam *et al.* (1999) found in an experiment with plant population and different levels of N on the growth and yield of rice that plant height was increased with increasing up to application of 120 kg N ha^{-1}.

BRRI (1989) conducted a field trial in Pirojpur entitled the effect of two rates of N and other fertilizer elements (P. K. S. Zn) on grain yield of BR 3. The results showed that 3.10 and 3.73 t ha^{-1} grain yield was obtained when N was applied at rate of 80 and 120 kg ha^{-1}.

2.2 Effect of NPK fertilizer on yield of marpha (cucumber)

Ubeiz (2009) conducted a field experiment to determine the effect of NPK on the yield of cucumber. He observed that NPK at the rate of 120:80:90 kg ha^{-1} gives higher fruit yield than the control.

Rehamn *et al.* (1995) conducted a field experiment and observed that NPK@ 140-70-90 kg ha^{-1} exhibited better results for highest germination percentage, more fruits per vine, maximum fruit diameter and weight and total yield.

Phu (2010) reported that N and K fertilizer applications had significant effect on the yield of cucumber variety Poung. Nitrogen and Potassium rate at 100–100 kg ha^{-1} gave promising for number of fruits, main stem length, number of branches and yield.

Choudhari and More (2002) applied 120:90:90 kg NPK ha^{-1} through fertigation and found maximum number of fruits per vine, fruit weight (g), yield per plant (kg) and yield ha^{-1} of cucumber plant.

Naeem *et al.* (2002) reported that different dozes of NPK exerted significant influence on days to flowering, days to fruiting, number of fruits per plant, length of fruit (cm) and total yield (kg ha^{-1}).

Abdel-Mawgoud *et al.* (2005) reported that increasing the level of NPK resulted in a positive response in the vegetative growth and increased yield.

Watcharasak and Thammasak (2005) found that fertigation of 150 mg N L^{-1} gave the highest leaf number, leaf area, fresh and dry weight of shoot and roots, in cucumber.

Ahmed *et al.* (2007) reported that an increase in nitrogen application resulted in maximum fruit length, fruit weight, vine length and yield of cucumber.

Din *et al.* (2007) reported that NPK level of 120-70-90 kg ha^{-1} significantly performed better with regard to yield of cucumber.

Waseem et al. (2008) also reported that 100 kg N ha^{-1} had significantly maximized cucumber fruit length, fruit weight and vine length, which are indirectly related to the yield, but 80 kg N ha^{-1} was the most economical dose for minimizing the days to flowering, days to fruit setting and days to fruit maturity and getting higher number of fruits and ultimately higher yield.

2.3 Effect of NPK fertilizer on yield of maize

Halim *et al.* (2004) carried out an experiment on the effect of different doses of NPK on the growth and yield of maize at Jamalpur. Nitrogen was applied at 0, 60, 90 or 120 kg ha^{-1}, P at 0, 25, 50 or 75 kg P_20_5/ha and K at 0, 30, 60, or 90 kg K_20/ha in 12 combinations. Gross yield were maximum with 120 kg N_2 + 70 kg P_20_5 + 90 kg K_20 combination.

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

Syed *et al.* (2002) reported that grain yield and biological yield of maize were significantly affected by different variation and fertilizer (NP) levels. Plots treated with NP levels of 120:90 kg NP ha^{-1} produced maximum number of grains cob^{-1}, number of cobs $plant^{-1}$, harvest index, grain yield and biological yield.

Sani *et al.* (2011) conducted an experiment to identify the combined effects of NPK on growth and yield of maize. They found that NPK @ 130:70:90 kg ha^{-1} gives the higher yield than other.

Albinet (1998) reported that Maize cv. HD208 was given 0-160 kg N, 0-128 kg P_20_5 and 0-96 kg K_20 $ha^{'1}$. Optimum yield was obtained with 120 kg N ha^1, and with 96 kg P_20_5 ha^{-1}. There was a positive interaction between N and P_20_5 in increasing CP content (up to 96 kg P_20_5 ha^{-1}) and yield. Application of 64-160 kg N + 64 kg P_2O_s + 64 kg K_20 ha^{-1} gave the most positive interactions to increase CP content and yield.

Talukder *et al.* (2011) reported K and P responses on maize (*Zea mays* L.) grown under rainfed condition in soils treated with different levels of P as TSP and K as MoP along with basal doses of N @ 120 kg ha^{-1}. They found that K responses were significant with all P treatments and the highest grain and straw yields were obtained due to the combined effect of 70 kg P_20_5 ha^{-1} and 90 kg K ha^{-1}. Increasing rates of P and/or K increased seed protein, P and K contents.

Ramazanova (2007) carried out an experiment to see the effects with four levels of NPK fertilizer on growth and yield of maize. Optimum yield was obtained with NPK @ 110:60:80 kg ha^{-1}.

Abro and Abbasi (2010) conducted a field experiment in randomized complete block design with six replications on maize at Agriculture Research Institute, Dokri. The result indicated that highest grain yield was obtained when NPK fertilizer applied at the rate of 130-90-90 kg ha^{-1}.

Sharma *et al.* (2000) conducted field studies at Diphu during Kharif season to find out the optimum level of N and P for composite maize (*Zea mays* L.) cv. Vijoy under rainfed condition. They found that maize responded up to 120 kg N ha^{-1} significantly.

2.4 Effect of NPK fertilizer on yield of sweet gourd

The response of gourd cultivars to the application of 0, 60, 80, 100 and 120 kg N ha^{-1} was studied by Ali *et al.* (2005). They found that the highest number of female flowers (36.13) and fruit set (34.49) was recorded with 120 kg N ha^{-1}.

The influences of N, P and K fertilizers on yield and seed quality of sweet gourd were studied by Nmanop (1997). Sweet gourd was grown and treated with the combination of 3 rates of nitrogen (0, 60 and 120 kg N ha^{-1}), 3 rate of phosphorus (0, 50 and 70 kg P_20_5 ha^{-1}) and 2 rates of potassium (0 and 70 kg K_20 ha^{-1}) fertilizers. The results showed that N, P and K fertilizers had no significant effects on the first bloom of male and female flower (earliness), total number of fruits, weight per fruit, number of seeds per 7 square meter (6 plants), number of seeds per fruit, total seed weight and 100 seeds weight. However, the high rates of N, P and K gave the highest germination (92.9 %) and germination index (23.2) and the best combination was 120, 70 and 70 kg N, P_20_5 and K_20 ha^{-1} respectively.

Krishnan (2001) conducted a field experiment with sweet gourd at Kerala, India during kharif season. Considering the total yield, marketable yield and size of fruits, the treatment T_7 which receive a fertilizer dose of 120:75:90 kg NPK ha^{-1} was found superior to all other treatments.

Bacha *et al.* (2005) conducted an experiment on the effects of P rate (0, 40, 50, 60 or 70 kg ha^{-1} as P_2O_5) and sowing date (15 May, 30 May, 20 June and 5 July) on the growth and yield of sweet gourd were studied in Mingora during 2001-02. The increase in the rate of P_2O_5 rate resulted in early germination, flowering and harvesting, but had no effect on growth and yield. Also found that sowing on 15 May is optimum for sweet gourd production in the region.

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

Lingaiah *et al.* (1988) stated that the highest yield of gourd was obtained in coastal region at N: P_2O_5: K_2O at 90:70:90 kg ha^{-1}.

Makal *et al.* (2007) studied the effect of NPK on yield of gourd. It was reported that N, P_2O_5 and K_2O at the rate of 110, 70 and 90 kg ha^{-1} enhanced the yield.

Alom (2005) conducted an experiment with five levels of NPK such as 0-0-0, 120-0-0, 120-70-90, 240-0-0 and 240-70-90 kg ha^{-1} on gourd crops. He observed that plots treated with N alone at the rate of 120 kg ha^{-1} improved the vegetative growth of gourd as manifested by an increase number and length of vines, diameter of stem, length and diameter of leaves. The inclusion of P and K to N significantly reduced the above parameters, except the number of lateral vines and diameter of stem, which remains unaffected. However, application of NPK significantly increased the number of fruits per plant, size and weight of fruits and the fruit yield compared to plots treated with N alone. The same trend of result was noted for yield and quality where plants fertilized with 120-70-90 kg ha^{-1} produced the highest yield. Moreover, the above treatment produced seeds with the highest percentage of germination (99.00) and seed vigor index (20.03%).

2.5 Effect of NPK fertilizer on yield of sesame

Satyanarayana *el al.* (2011) conducted a pot experiment to study the effects of N, P and K fertilization on the yield of sesame. The experiment comprised 4 nitrogen rates (0, 60, 90 and 120 kg N ha^{-1}), 3 phosphorus rates (0, 30 and 60 kg P_2O_5 ha^{-1}) and 3 rates of potassium (0, 45 & 90 kg K_2O ha^{-1}). Optimum number of capsule and seed yield was obtained at 120 kg N + 60 kg P_2O_5 + 90 kg K_2O ha^{-1}.

Sezol (2010) conducted a field trial with sesame and reported that seed yield (1.3 t ha^{-1}) was the highest with 80 kg P_2O_5 ha^{-1} along with 120 kg N and 90 kg K_20 ha^{-1}.

Pauste and Maiti (1990) carried out a field experiment to determine the optimum level of phosphorus for sesame cultivation with 0, 40 and 80 kg P_2O_5 ha^{-1}. They found that yield increase with increase the rate of P_2O_5.

Deshmukh *et al.* (1990) carried out a field experiment in India with four phosphorus levels 0, 25, 50 and 75 kg ha^{-1} on sesame crop. They observed that 75 kg P_2O_5 ha^{-1} significantly increased number of capsules $plant^{-1}$ and seed yield.

An experiment on sesame was conducted by Mahalonabis (1999) with different phosphorus levels 0, 25, 50 and 75 kg P_20_5 ha^{-1}. They found that 75 kg P_20_5 ha^{-1} was most effective in increasing the number of capsule $plant^{-1}$, seeds $capsule^{-1}$ and seed yield.

Ali *et al.* (1997) carried out a field experiment during the *kharif* season. They observed that number of branches $plant^{-1}$, capsule $plant^{-1}$ and seed yield ha^{-1} were significantly improved by phosphorus application up to 60 kg ha^{-1} P_2O_5 and it was statistically identical with 80 kg P_20_5 ha^{-1} with 120 kg N and 90 kg K_2O applied as basal dose. Such type of variable response of sesame to phosphorus application has also been demonstrated by Sangar and Roy (1990).

Jadhav *el al.* (1992) stated that seed yield and protein content of sesame increased with increasing nitrogen rate up to 120 kg ha^{-1} in sesame variety cv. Punjab 1.

Tiwari and Namdeo (1997) observed that application of nitrogen at the rate of 90 kg ha^{-1} produced the highest seed yield. Seed oil content was also increased with increasing nitrogen rate.

Mondol *el al.* (1997) conducted a field trials at Kalyani, West Bengal with five levels of nitrogen (0, 30, 60, 90 or 120 kg ha^{-1}) on sesame and observed that plant height, dry matter accumulation, number of capsules $plant^{-1}$, number of capsules $plant^{-1}$, number of seeds capsules'$^{-1}$, 1000 seed weight, seed yield and protein yields were increased significantly with increasing nitrogen rates but harvest index and oil content were not significantly affected.

Kavita (2010) carried out an experiment to study the response of 2 cultivars (TMV-3 and TMV-4) of sesame *(S. indicum*) of different fertilizer levels (control, 100% recommended NPK of 120:70:90 kg ha^{-1} and 150% recommended NPK of 180:105:135 kg ha^{-1}) on a sandy loam soil. He found that 100% recommended dose of nutrient significantly increase seed yield during summer than lower nutrient level.

Probin *et al.* (1996) stated that the seed yield of sesame was highest with 120 kg N + 70 kg P_2O_5 + 90 kg K_2O ha^{-1}. Uptakes of nitrogen, phosphorus and potassium were positively correlated with yield.

2.6 Effect of NPK fertilizer on yield of turmeric

Paul (2008) conducted an experiment with turmeric cv. PTS 9 on a sandy loam soil at G. Udayagiri, India. It was sown in a raised seed bed before the onset of rain and supplied with different rates of N, P and K fertilizers. He reported that rhizome yield and plant growth were increased consistently as the application rates of N, P and K were increased, but all treatments significantly increased yield and yield components compared to the control. The highest yields were recorded with N : P : K at 120 : 75 : 90 kg ha^{-1}.

Uthaiah (2004) investigated the yield of *Curcuma longa* cv. Co-1 in Karnataka, India in relation to different rates of NPK fertilizer. They reported that growth parameters and rhizome yields were significantly influenced by fertilizer application. The best growth and yield of *Curcuma longa* were observed at an NPK rate of 120:75:90 kg ha^{-1}.

Meerabai *et al.* (2000) conducted a two year field study in Kerala, India on turmeric intercropped under partial shade of coconut. They noticed that turmeric responded to higher nitrogen (N) and potassium (K) fertilizer application rates than recommended for open field conditions. Application of 120 kg N and 120 kg K_20 ha^{-1} gave the maximum economic yield.

Tarafder *et al.* (1998) carried out an experiment with turmeric grown with or without P fertilizer at Dinajpur, Bangladesh. They found that phosphorus increased root growth due to the production of numerous lateral roots, and increased water use efficiency and yield.

Behura and Swain (1997) carried out a field trial with turmeric with 0, 50, 100, 150 kg N and 0, 60, 120, 180 kg K_20 ha^{-1}. They mentioned that rhizome yield was increased with up to 100 kg N and 60 kg K_20 per hectare.

Pal *et al.* (1993) conducted an experiment on fertilizer application to turmeric grown as an alley crop between *Leucaena leucocephala* trees (spaced 1 m apart in rows 4 m apart) for two years. They revealed that turmeric respond to N (both as urea and as urea with *L. leucocephala* leaves). Average yield over the two years was the greatest when 120 kg N (half as urea and half as leaves) + 90 kg K_20 was applied and lowest was in the unfertilized control.

Yamgar and Pawar (1991) conducted an experiment on turmeric with seven fertilizer treatments which were applied with different sources and rates of NPK (kg ha^{-1} N: P_2O_s: K_20) as follows: 60:40:40, 45:30:30 and 120:60:90 (recommended dose) as conventional fertilizers, 60:40:40 and 45:30:30 as suphala, and 60:40:40 and 45:30:30. The highest mean yield was obtained with 120:60:90 kg NPK ha^{-1}.

Mohankumar and Sadanandan (1990[b]) studied with three levels of N, P, K and two time of application of N and K on *Curcuma longa L.* They found that NPK @ 120 kg, 70 kg and 90 kg ha^{-1} respectively give maximum yield over other treatments.

Haroon *et al.* (1997) found in a field study on farmers fields in Kushtia, Bangladesh in 1991-93, on turmeric and mentioned that rhizome yield was increased with NPK @ 120kg, 80 kg and 120 kg ha^{-1} respectively.

Venkatesha *et al.* (2010) conducted a field trail on turmeric with three levels of NPK i.e 0-0-0, 60-45-45 and 120-90-90 kg ha^{-1} respectively. Optimum rhizome was found from the application of NPK at the rate of 120 kg N, 90 kg P_2O_5 and 90 kg K_2O ha^{-1}.

2.7 Effect of NPK fertilizer on yield of arhar (pigeon pea)

Pachauri *el al.* (2008) in a 2 years trial with pigeon pea applied N at 0, 60 or 120 kg ha^{-1}, P_20_5 at 0, 30 and 60 kg ha^{-1} and K_20 at 0, 50 and 100 kg ha. The highest seed yield was obtained on the plots receiving N: P_20_5: K_20 at 120: 60: 100 kg ha^{-1} respectively.

Koylijarvi (1990) investigated the effect of different N fertilizer rates (0-120 kg N ha^{-1}) on peas and pea oat mixture. He reported that increased in N rate up to 120 kg ha^{-1} increased seed yield and the highest yield was obtained with 120 kg N.

Sinha *et al.* (1996) conducted an experiment with a pea/maize cropping sequence, seed inoculation with *Rhizobium* and application of 30-90 kg P_20_5 ha^{-1} to peas increased the N fixation in soil and yield of crop.

Saimbhi and Grcwal (1989) conducted a field experiment with a pigeon pea by applying N at the rates of 0, 50, 75 and 100 kg ha^{-1} and P_2O_5 at 30 and 60 kg ha^{-1} in all possible combinations with N. They observed that the rate of N and P at 100:60 kg ha^{-1} gave the highest yield compared with control.

Naik (1989) also found that, the closest spacing and N and P at the highest rates resulted in the highest yields but no appreciable response to K was observed.

Singh *et al.* (2000) conducted an experiment with pigeon pea received N at the rate of 0, 40, 80 and 120 kg ha^{-1} and P_2O_5 at 0, 50, 75 and 100 kg ha^{-1} with K_20 at 80 kg ha^{-1}. They concluded that the mean green pod yield increased with increasing N rates up to 80 kg ha^{-1} with 75 kg P_2O_5 and 80 kg K_20 ha^{-1}. Vigorous vegetative growth was attributed at the highest N rates.

Vijai (1996) carried out an experiment with pigeon pea showed that increasing rates of N or P application significantly increased growth and pod yield. At the highest rates of N and P_20_5 application (70 and 110 kg ha^{-1}, respectively) showed the best performance in terms of yield and yield attributes of pigeon pea.

Kushwaha (2001) conducted a field study involving four rates of K (0, 30, 60 and 90 kg ha^{-1}) and reported that the highest potassium use efficiency was with the application of 90 kg K_2O ha^{-1}.

Chapter 3

Materials and Methods

MATERIALS AND METHODS

The experiment was conducted at Hill Agricultural Research Station, Khagrachari Hill District in Chittagong Hill Tracts (CHT), Bangladesh under the Agro Ecological Zone of Northern and Eastern Hills, AEZ-29 during the *Kharif* season of 2014. For better understanding the site, it is shown in the Map of AEZ of Bangladesh (Fig. 1). This chapter presents a brief description of the soil, crop, experimental design, treatments, and cultural operations, collection of soil and plant samples and analytic methods followed in the experiment. This chapter has been divided into a number of sub-heads describe as below:

3.1 Experimental details of site

3.1.1 Soil

The experiment was carried out in hill soil at Hill Agricultural Research Station (HARS), Khagrachari Hill Districts, during *Kharif* season of 2014. It belongs to the General soil type, "Brown Hill Soils". The land was above flood level, sloppy and sufficient sunshine was available during the experimental period. The morphological, physical and chemical characteristics of initial soil are presented in Tables 1 and 2.

Table 1. Morphological characteristics of the experimental field

Morphology	Characteristics
Location	Hill Agricultural Research Station, Khagrachari.
Agro-ecological zone	Northern and Eastern Hills (AEZ-29)
General Soil Type	Brown Hill Soil
Topography	Sloppy
Slope %	12-15
Drainage	Well drained
Flood level	Above flood level

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

Characteristics		Value
Particle size analysis	% Sand	23.12
	% Silt	55.62
	% Clay	21.35
Textural class		Silt Loam
pH		5.3
Bulk Density (g/cc)		1.45
Particle Density (g/cc)		2.52
Organic carbon (%)		1.83
Organic matter (%)		3.18
Total N (%)		0.07
Available P (ppm)		14.1
Exchangeable K (meq/100g soil)		0.76
Available S (ppm)		19.69

3.1.2 Crop

In jhum cultivation selection of crops depend on farmers' demand that is required for their daily life. In general, farmers cultivate more than 40 species in their fields, while approximately 50 wild plant species are collected by women. In this way, farmers meet all their day-to-day demands except for salt. In jhum cultivation rice cover about 90-95% of total area and other crops cover 5-10% area of the land. Rice, Marpha, Maize, Sweet Gourd, Sesame, Turmeric and Arhar were used as test jhum crop.

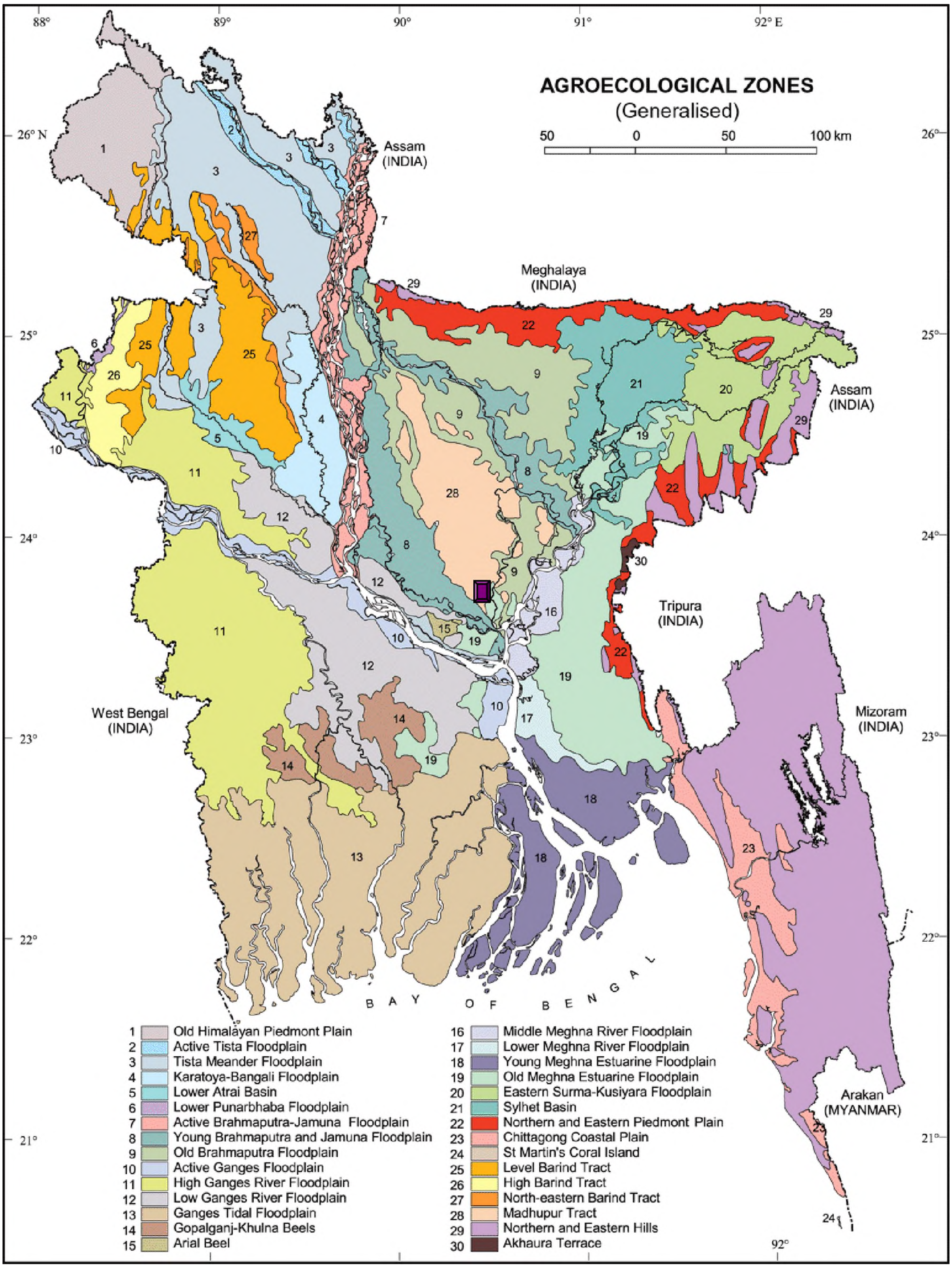


Figure 1. Map showing the experimental site under study

3.1.3 Land preparation

The selected land was slashed and burned and partially burnt plant parts were cleaned during land preparation and no tillage was given. All kinds of weeds and residues were removed from the field. The experimental plots were laid out as per treatment and design.

Figure 2. Land preparation

3.1.4 Experimental design

Design: Latin Square

Treatment: 4

Replication: 4

Total number of plots: 16

Plot size: 5 m × 4 m

Block to block distance: 1 m

Plot to plot distance: 1 m

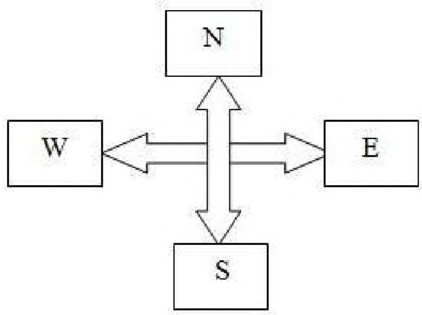
3.1.5 Layout of the experiment

The experiment was laid out in a Latin Square Design (LSD) with four replications. The total number of plots was 16 (4×4). The unit plot size was 5 m × 4 m. Block to block distance was 1 m and plot to plot distance was 1 m. The layout of the experiment has been shown in Fig. 2.

Plot size: 5 m x 4 m

Plot to plot distance: 1 m

Block to block distance: 1 m



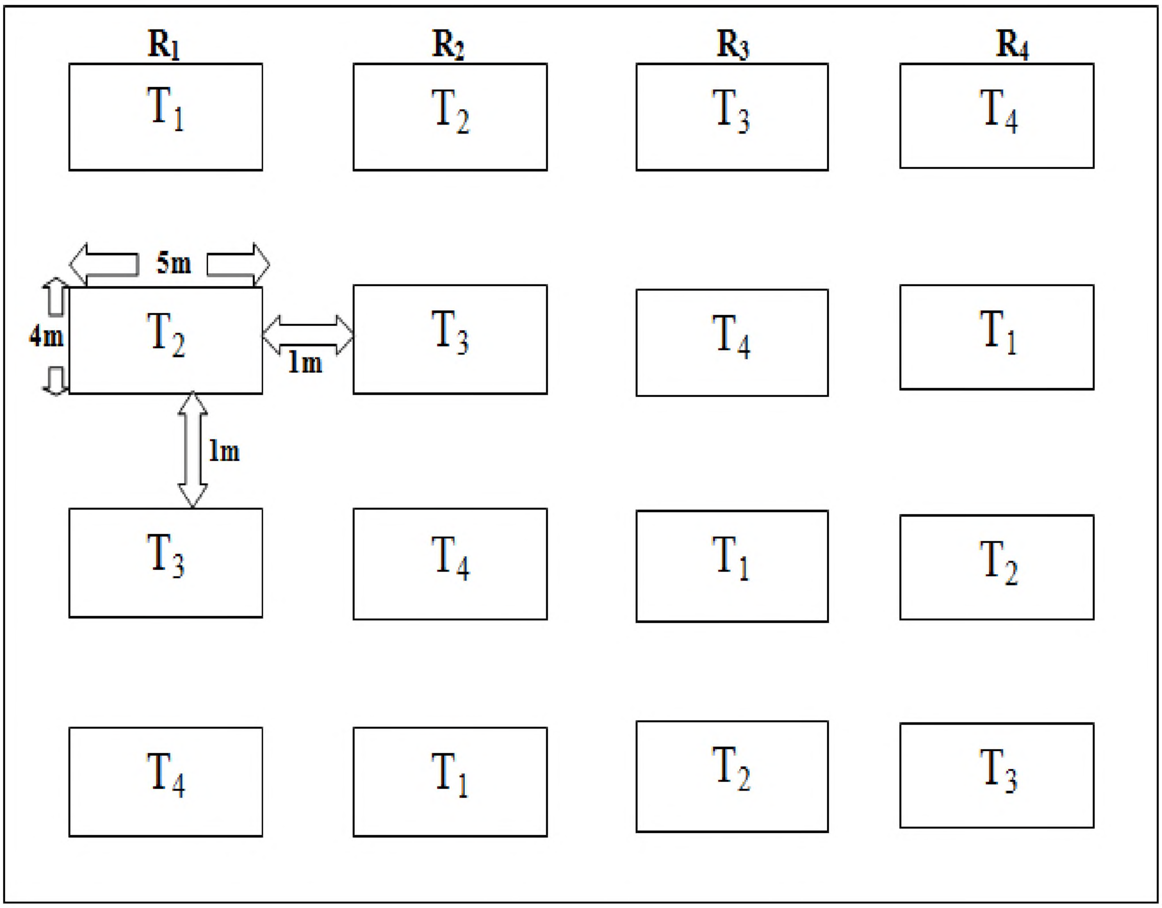


Figure 3. Layout of the experimental field

3.1.6 Seed sowing

Seeds are sown by dibbling method with the help of *Da.* Seeds are sown directly on the soil. Before sowing, seeds of different jhum crops except turmeric and sesame were mixed together. Turmeric was sown before seeding of rice and other seed mixture. Sesame seed was broadcasted over the soil surface after sowing of rice and other crops.

Figure 4. Seed sowing

3.1.7 Collection and preparation of initial soil sample

The initial soil samples were collected before land preparation from a 0-15 cm soil depth. The samples were drawn by means of an auger from different location covering the whole experimental plot and mixed thoroughly to make a composite sample. After collection of soil samples, the plant roots, leaves etc. were picked up and removed. Then the samples were air-dried and sieved through a 10-mesh sieve and stored in a clean plastic container for physical and chemical analysis.

3.1.8 Treatments

There were 4 treatment combinations. The treatment combinations were as follows:

T_1: No fertilizer (Control)

T_2: 40 kg N + 25 kg P_2O_5 + 30 kg K_2O ha^{-1}

T_3: 80 kg N + 50 kg P_2O_5 + 60 kg K_2O ha^{-1}

T_4: 120 kg N + 75 kg P_2O_5 + 90 kg K_2O ha^{-1}

Table 3. Sources of different fertilizer elements in the experiment

Elements	Source
N	Urea
P	TSP
K	MoP

3.1.9 Application of fertilizers

Urea, TSP and MoP were used as a source of N, P and K respectively. The amounts of nitrogen, phosphorus and potassium fertilizers required per plot were calculated from fertilizers rate per hectare. Half urea and full amount of TSP and MoP were applied at the time of final land preparation by dibbling method. Rest of the urea was top dressed in two splits- one at vegetative and another at maximum tillering stage of rice.

3.1.10 Intercultural operations

The following intercultural operations were done for ensuring the normal growth of the crop. Top dressing of urea was done as per schedule and the normal cultural practices including weeding and insecticides spray were done as and when necessary. There were some incidence of insect attack specially rice hispa, rice bug, which were controlled by spraying Diazinon Aktara, Darsban, and Malathion.

3.1.11 Plant sampling at harvest

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

3.1.12 Harvesting

The crop was harvested at maturity. Harvesting of Marpha was done on 04 August, 2014, Maize on 09 August, 2014, Sweet Gourd on 18 August, 2014. Harvesting of rice was done on 19 September, 2014. In case of Arhar and Turmeric, harvesting was done on 15 January, 2015. The harvested crop was threshed plot-wise.

Grain yields of all crops and straw yields of rice were recorded separately plot-wise and moisture percentage was calculated after sun drying. Dry weight for both grain and straw were also recorded.

3.1.13 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})

For marpha, maize, sweet gourd, sesame, turmeric and arhar:

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

3.1.13.1 Plant height (cm)

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

3.1.13.2 Number of tillers hill^{-1}

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

3.1.13.3 Panicle length (cm)

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

3.1.13.4 Filled and unfilled grains panicle^{-1}

Ten panicles were taken at random to count unfilled and filled grains and averaged.

3.1.13.5 1000 grain weight

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

3.1.13.6 Grain and straw yields

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

3.1.14 Chemical analysis of soil samples

Soil samples were analyzed for both physical and chemical properties in the soil science laboratory of Sher-e-Bangla Agricultural University, Dhaka and Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur. The properties studied included soil texture, pH, organic matter, total N, available P and exchangeable K. The physical and chemical properties of the initial soil have been presented in Table 2. The soil was analyzed by standard methods:

3.1.14.1 Particle size analysis

Particle size analysis of soil was done by Hydrometer Method (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.

3.1.14.2 Soil pH

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

3.1.14.3 Organic carbon

Organic carbon in soil was determined by Walkley and Black (1934) Wet Oxidation Method. The underlying principle is to oxidize the organic carbon with an excess of 1N $K_2Cr_2O_7$ in presence of conc. H_2SO_4 and to titrate the excess of $K_2Cr_2O_7$ solution with 1N $FeSO_4$ solution. To obtain the organic matter content, the amount of organic carbon was multiplied by the Van Bemmelen factor, 1.73. The result was expressed in percentage.

3.1.14.4 Total nitrogen

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

3.1.14.5 Available phosphorus

Available phosphorus was extracted from soil by shaking with 0.5 M $NaHCO_3$ solution of pH 8.5 (Olsen *et al.*, 1954). The phosphorus in the extract was then determined by developing blue color using ascorbic acid reduction of phosphomolybdate complex. The absorbance of the molybdophosphate blue color was measured at 660 *n*m wave length by Spectrophotometer and available P was calculated with the help of standard curve.

3.1.14.6 Exchangeable potassium

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

3.1.14.7 Available sulphur

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

3.1.15 Statistical analysis

The statistical analyses for 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).

Chapter 4

Results and Discussion

RESULTS AND DISCUSSION

The results of the experiment conducted under field conditions are presented in several Tables and Figures. The experiment was conducted to study the effect of different fertilizers (NPK) on the growth and yield of jhum crops. The results are presented and discussed under the following parameters.

4.1 Growth and yield components of jhum rice

4.1.1 Plant height

Plant height of rice (locally called 20 number) was significantly influenced by NPK fertilizers (Table 4). All the treatment recorded significantly higher plant height over the control (T_1 treatment). Plant height ranged from 116.1 to 132.8 cm. The tallest plant of 132.8 cm was found in T_4 treatment receiving 120 kg N, 75 kg P_2O_5 and 90 kg K_2O ha^{-1}, which was statistically identical with T_3 treatment receiving 80 kg N, 50 kg P_2O_5 and 60 kg K_2O ha^{-1}. The shortest plant height of 116.1 cm was found in T_1 (control) treatment having no fertilizer, which was statistically identical with T_2 treatment receiving 40 kg N, 25 kg P_2O_5 and 30 kg K_2O ha^{-1}. Treatment T_4 receiving 120 kg N, 75 kg P_2O_5 and 90 kg K_2O ha^{-1} produced 14.38% higher plant height compared to control treatment (Fig.5). The treatments may be ranked in the order of $T_4>T_3>T_2>T_1$ treatments. Amim *et al.* (2004) found that increased fertilizer dose of NPK increase plant height. Rajarathinam *et al.* (1999) observed that the yield contributing characters like plant height was the highest in 120 kg ha^{-1} of N. Similar result also found by Leharia and Zaad (2004) and BRRI (1989).

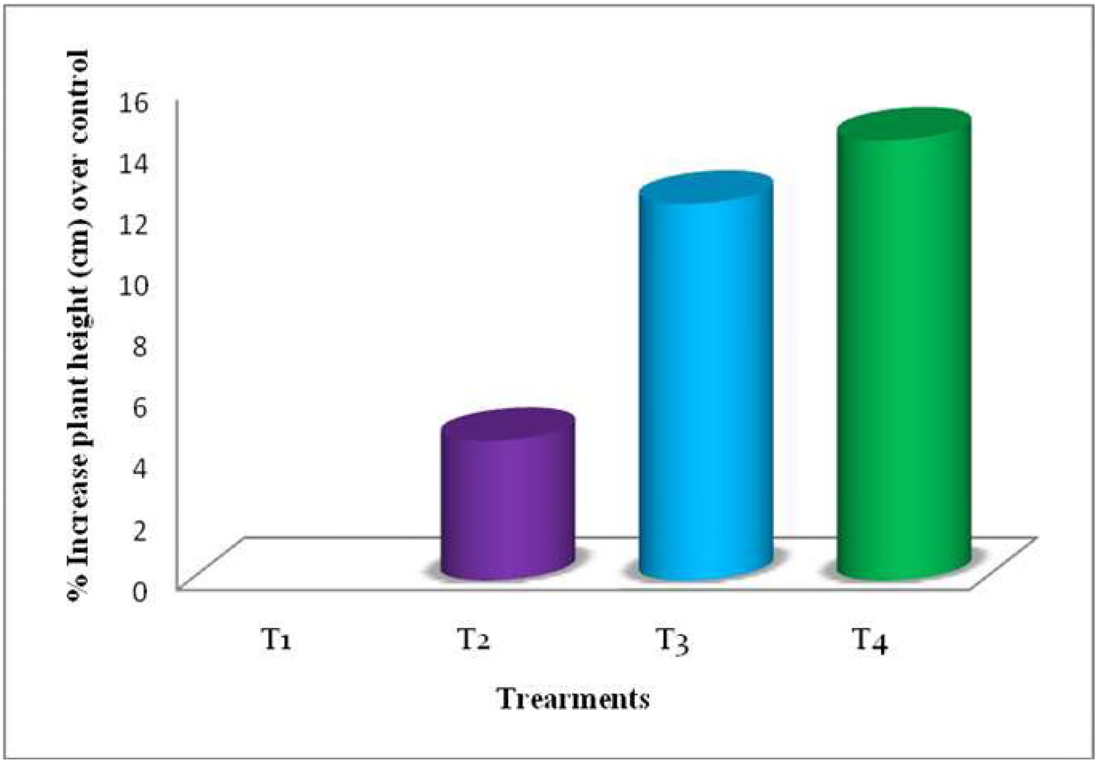


Fig. 5. Effect of NPK fertilizer on percent increase in plant height over control of jhum rice

4.1.2 Panicle length

Application of NPK fertilizers had a significant effect on panicle length. The effects of different treatments on panicle length are shown in Table 4. The tallest panicle (30.80 cm) was found in T_4 treatment. The shortest panicle (26.70 cm) was observed in T_1 (control). Panicle length of T_2 treatment was statistically identical with T_3 treatment. The treatments may be ranked in the order of $T_4>T_3>T_2>T_1$ in terms of panicle length. Morteza *et al.* (2011) also observed that the panicle length was increased with the application of inorganic fertilizers. Saha *et al.* (2007) reported that combined application of NPK fertilizer significantly influence the panicle length. Treatment T_4 produced 15.35% higher panicle length than control treatment (Fig. 6).

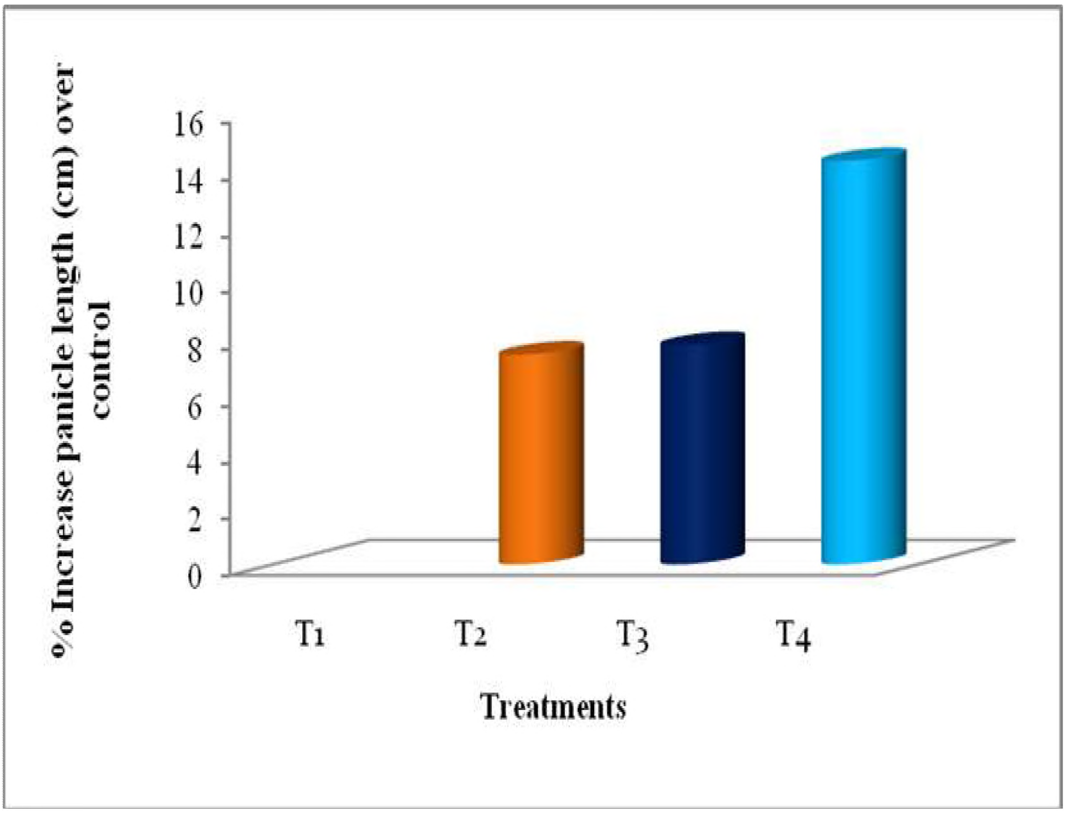


Fig. 6. Effect of NPK fertilizer on percent increase panicle length over control of jhum rice

4.1.3 Effective tillers hill^{-1}

There was a significant effect of the treatments on number of effective tillers per hill (Table 4). The effective tillers per hill range from 9.05 to 14.38. The highest number of effective tillers hill^{-1} (14.38) was found in T_4 receiving 120 kg N, 75 kg P_2O_5 and 90 kg K_2O ha^{-1} and the lowest was found in T_1 (9.05) treatment receiving no fertilizer (Fig. 7). The treatments may be ranked in the order of $T_4 > T_3 > T_2 > T_1$ in terms of effective tillers hill^{-1}. Pandey (2009) cited that application of NPK fertilizers increases the effective tillers hill^{-1}.

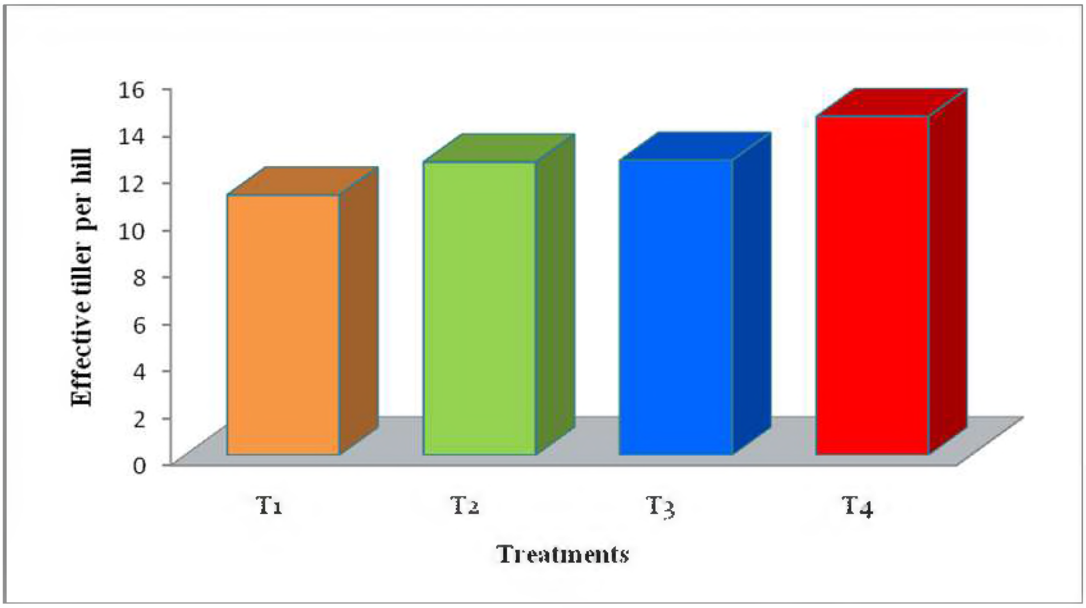


Fig. 7. Effect of NPK fertilizer on effective tillers hill^{-1} of jhum rice

4.1.4 Non-effective tillers hill^{-1}

In terms of non-effective tillers hill^{-1} no statistically significant variation was recorded for the effect of fertilizer (Table 4). The non-effective tillers per hill range from 1.41 to 1.98. The highest number of non-effective tiller hill^{-1} (1.98) was found in T_1 receiving no fertilizers and the lowest was found in T_4 (1.41) treatment receiving 120 kg N, 75 kg P_2O_5 and 90 kg K_2O ha^{-1} (Fig. 8). Amim *et al.* (2004) and Asif *et al.* (2000) found the similar results.

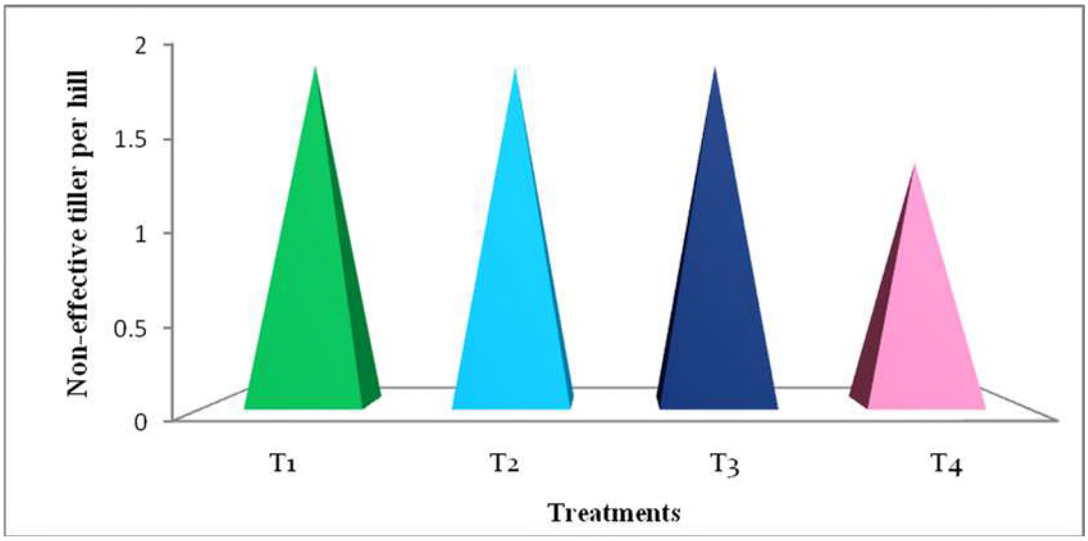


Fig. 8. Effect of NPK fertilizer on non-effective tillers hill^{-1} of jhum rice

4.1.5 Filled grains panicle^{-1}

There was a significant effect of the treatments on number of filled grains per panicle (Table 4). The number of filled grains panicle^{-1} ranged from 109.5 to 132. The maximum number of filled grains per panicle (132/panicle) was noted in T_4 treatment with the application of 120 kg N, 75 kg P_2O_5 and 90 kg K_2O ha^{-1}. The minimum number of filled grains per panicle (109.5 /panicle) was recorded in T_1 treatment receiving no chemical fertilizer (Fig. 9). The treatments may be ranked in the order of $T_4 > T_3 > T_2 > T_1$ with respect of the number of filled grains panicle^{-1}. Wang *et al*. (2011) showed that the application of N, P and K fertilizer significantly increased the number of filled grains panicle^{-1}and the highest number of filled grains panicle^{-1} was found under the combined application of N, P and K fertilizer.

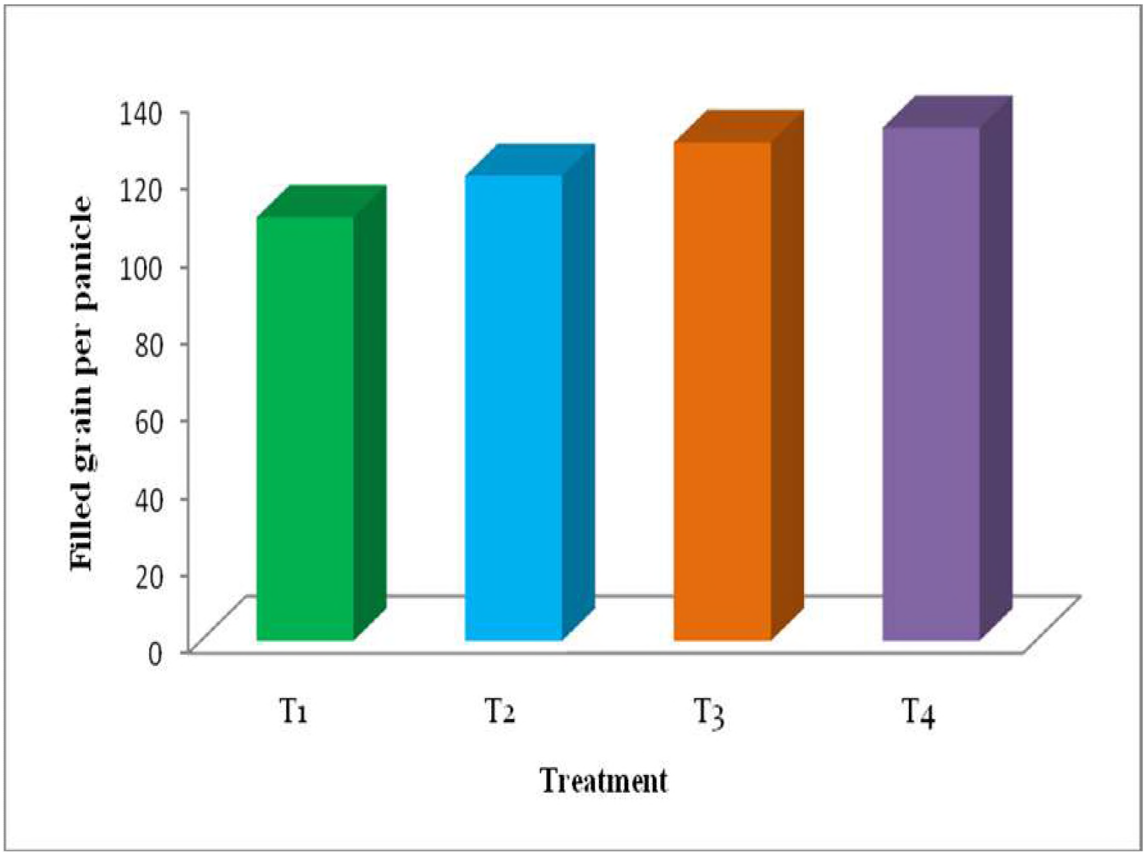


Fig. 9. Effect of NPK fertilizer on the number of filled grains panicle^{-1} of jhum rice

4.1.6 Unfilled grains panicle^{-1}

The effects of different treatments on number of unfilled grains per panicle are shown in Table 4. The number of unfilled grain per panicle ranged from 11.57 to 23.08. The highest number of unfilled grains per panicle (23.08) was noted in treatment T_1 (Control). The lowest number of unfilled grains per panicle (11.57) was recorded in T_4 treatment receiving 120 kg N, 75 kg P_2O_5 and 90 kg K_2O ha^{-1}, which was statistically identical with T_2 and T_3 received 40 kg N + 25 kg P_2O_5 + 30 kg K_2O ha^{-1} and 80 kg N + 50 kg P_2O_5 + 60 kg K_2O ha^{-1} respectively (Fig. 10). These results were corroborated with the findings of Sarkar and Singh (2002) who found increased number of filled grains per panicle and decreased number of unfilled grains per panicle significant increased with the application of N, P, K and S.

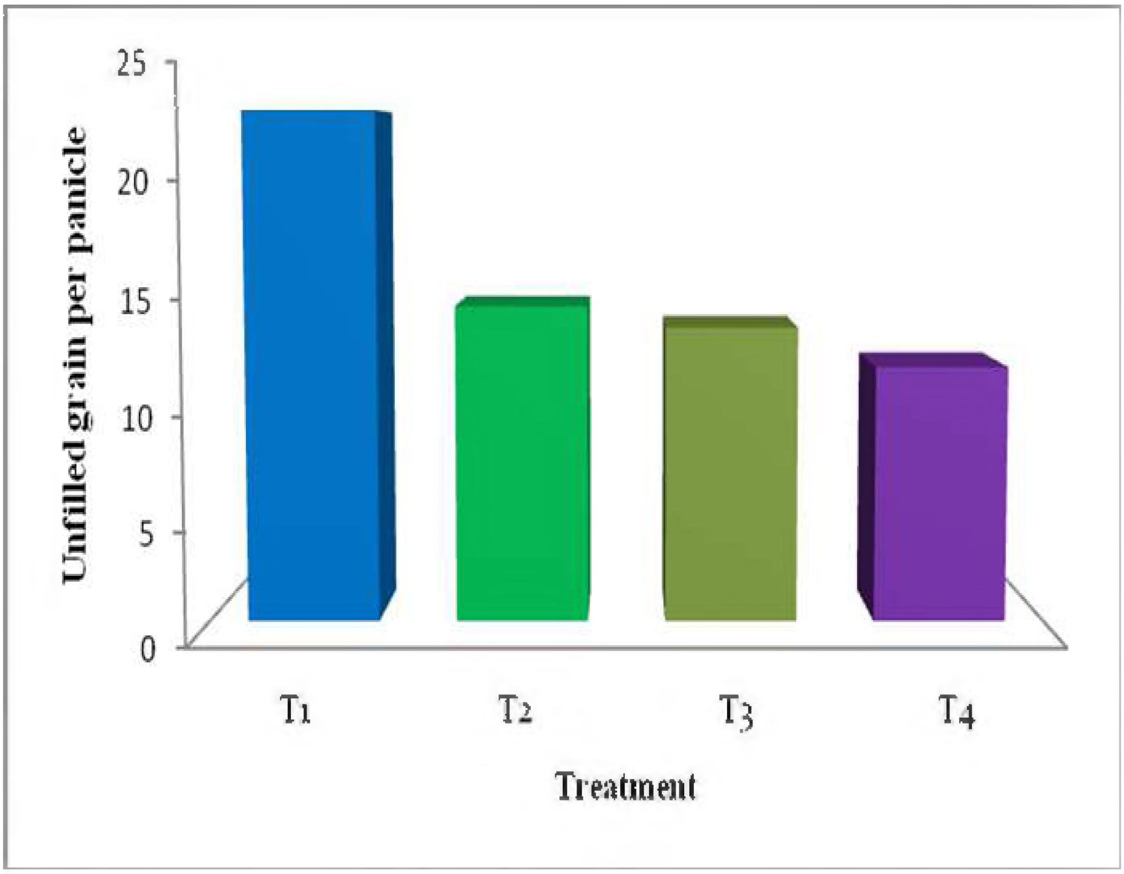


Fig. 10. Effect of NPK fertilizer on the number of unfilled grains panicle^{-1} of jhum rice

4.1.7 1000 grain weight

A significant difference in 1000-grain weight was observed at different levels of NPK fertilizers (Table 4). The 1000-grain weight ranged from 22.62 to 25.17 g. The highest weight of 1000-grain weight (25.17 g) was observed in T_4 treatment receiving 120 kg N, 75 kg P_2O_5 and 90 kg K_2O ha^{-1} and the lowest weight of 1000-grain weight (22.62 g) was observed in T_1 treatment receiving no fertilizers (Fig. 11). Statistically identical 1000-grain weight were found in T_2 (40 kg N + 25 kg P_2O_5 + 30 kg K_2O ha^{-1}) and T_3 (80 kg N + 50 kg P_2O_5 + 60 kg K_2O ha^{-1}) treatment. The treatments may be ranked in the order of $T_4 > T_3 > T_2 > T_1$ with respect of 1000-grain weight. Debiprasad *et al.* (2010) found that application of NPK fertilizers increased 1000-grain weight. Sarkar and Singh (2002) and BRRI (1989) also cited that application of NPK fertilizers increased the 1000-grain weight of rice.

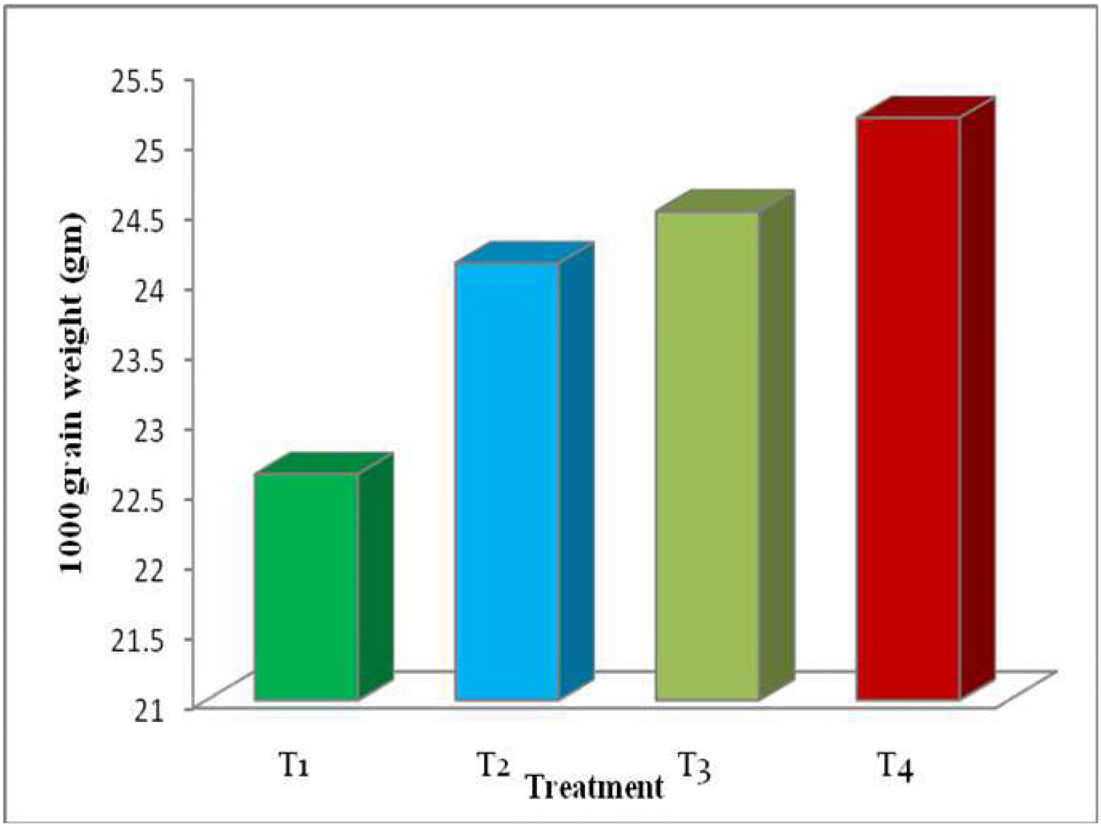


Fig. 11. Effect of NPK fertilizer on 1000 grain weight of jhum rice

Table 4. Effect of NPK fertilizers 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

Treatments	Plant height (cm)	Effective tillers hill^{-1}	Non-effective tillers hill^{-1}	Panicle length (cm)	Filled grains panicle^{-1}	Unfilled grains panicle^{-1}	1000 grain wt (gm)
T_1	116.1^{c}	11.05^{c}	1.98^{a}	26.70^{c}	109.5^{d}	23.08^{a}	22.62^{c}
T_2	121.4^{bc}	12.50^{b}	1.97^{a}	28.68^{b}	120.3^{c}	14.30^{b}	24.13^{b}
T_3	130.4^{ab}	12.52^{b}	1.98^{a}	28.77^{b}	128.9^{b}	13.35^{b}	24.50^{b}
T_4	132.8^{a}	14.38^{a}	1.41^{a}	30.80^{a}	132.7^{a}	11.57^{b}	25.17^{a}
LSD Value	**9.25**	**1.39**	**1.37**	**1.27**	**2.26**	**3.34**	**0.50**
CV %	**3.22**	**4.88**	**32.84**	**1.92**	**0.80**	**9.55**	**3.01**

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

T_1: No fertilizer (Control)

T_2: 40 kg N + 25 kg P_2O_5 + 30 kg K_2O ha^{-1}

T_3: 80 kg N + 50 kg P_2O_5 + 60 kg K_2O ha^{-1}

T_4: 120 kg N + 75 kg P_2O_5 + 90 kg K_2O ha^{-1}

4.2 Yield of jhum rice

4.2.1 Grain yield

The grain yield of jhum rice (locally called 20 number) varied significantly due to application of different rates of NPK fertilizer treatments (Table 5). The grain yield ranged from 1.67 to 3.34 t ha^{-1}. The highest grain yield (3.34 t ha^{-1}) was found in T_4 treatment receiving 120 kg N + 75 kg P_2O_5 + 90 kg K_2O ha^{-1}. The lowest value (1.67 t ha^{-1}) was recorded in T_1 (control) treatment. The treatment T_4 produced the highest grain yield than other treatments. Second highest yield (2.93 t ha^{-1}) was found in T_3 treatment receiving 80 kg N + 50 kg P_2O_5 + 60 kg K_2O ha^{-1}. The treatments may be ranked in the order of $T_4 > T_3 > T_2 > T_1$ with respect of grain yield. The percent increase in grain yield over control ranged from 45.50 to 100.00% where the highest increase was obtained in T_4 treatment and the lowest was obtained in T_2 treatment (Fig. 12). Satyanarayana *et al.* (2010) reported that grain yield was significantly increased due to application of NPK fertilizers. Nyalemegbe *et al.* (2009) and Islam *et al.* (2010) also cited that increase the rate of NPK fertilizer increase the yield of rice significantly.

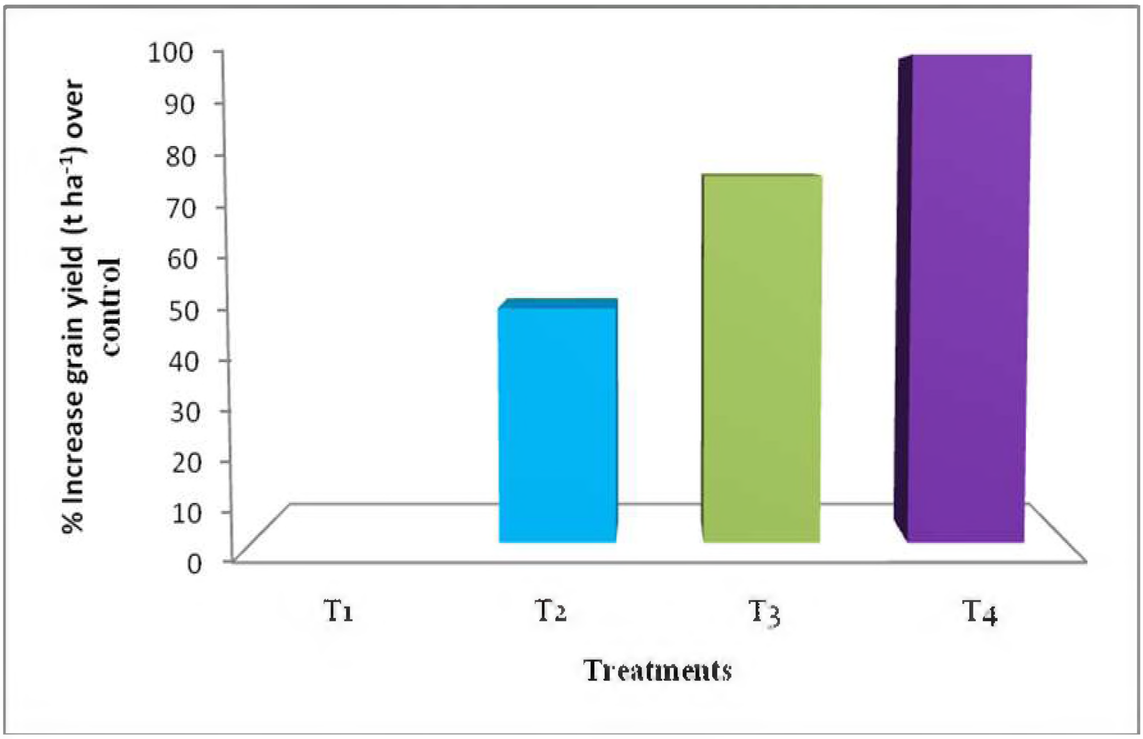


Fig. 12. Effect of NPK fertilizer on percent increase in grain yield (t ha^{-1}) over control of jhum rice

4.2.2 Straw yield

Straw yield of jhum rice (Locally called 20 number) also varied significantly by different treatments under study (Table 5). The yields of straw ranged from 2.45 to 4.18 t ha^{-1}. The highest straw yield of 4.18 t ha^{-1} was obtained in T_4 treatment receiving 120 kg N + 75 kg P_2O_5 + 90 kg K_2O ha^{-1} which was statistically differed with other treatments. The lowest straw yield of 2.45 t ha^{-1} was noted in T_1 (control) treatment. Second highest straw yield of 3.69 t ha^{-1} was found in T_3 treatment receiving 80 kg N + 50 kg P_2O_5 + 60 kg K_2O ha^{-1}. The treatment may be ranked in the order of $T_4>T_3>T_2>T_1$ in terms of straw yield. Maximum straw yield increase over control (70.61%) was noted in T_4 treatment and the minimum (13.47 %) was found in T_2 treatment (Fig. 13). Ravi *et al.* (2007) reported that the straw yield was significantly increased due to application of NPK fertilizers. Nyalemegbe *et al.* (2009) also found the same results in case of straw yield of rice.

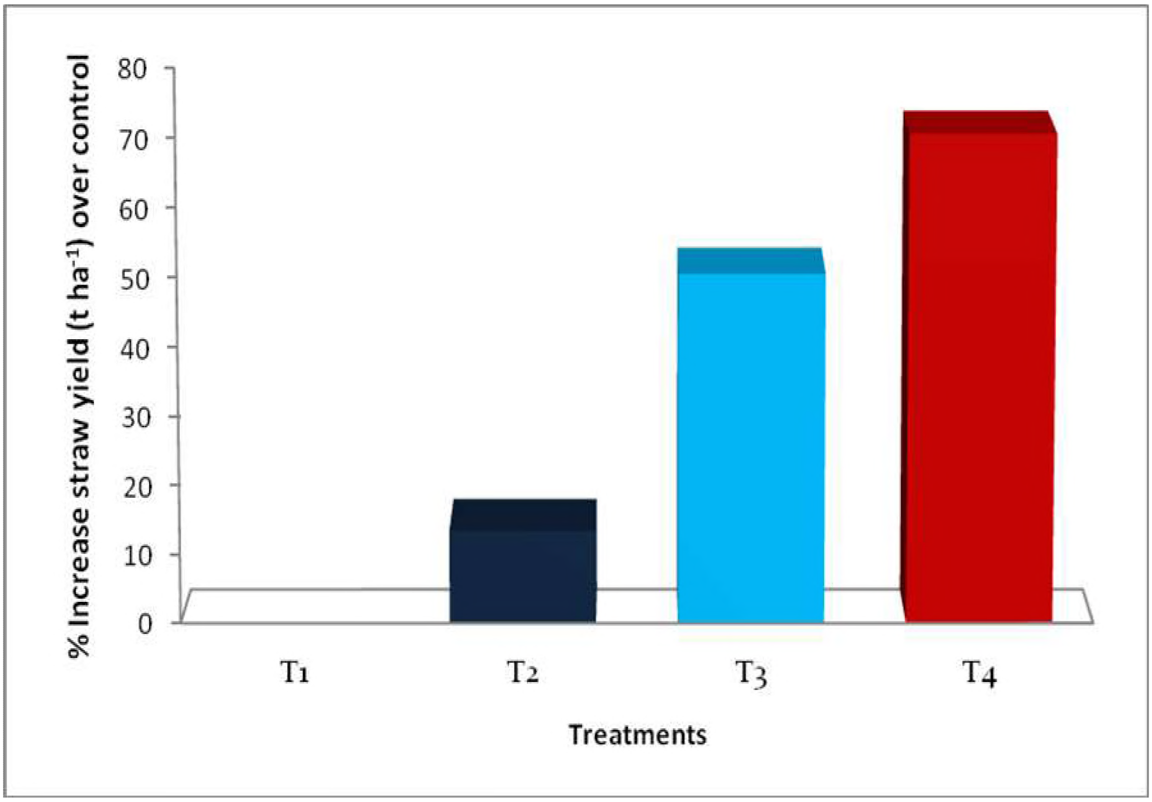


Fig. 13. Effect of NPK fertilizers on percent increase straw yield (t ha^{-1}) over control of jhum rice

Table 5. Effect of NPK fertilizers on the grain and straw yields (t ha^{-1}) of jhum rice (locally called 20 number)

Treatment	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1	1.67^d	2.45^d
T_2	2.48^c	2.78^c
T_3	2.93^b	3.69^b
T_4	3.34^a	4.18^a
LSD $_{(0.01\%)}$	**0.22**	**0.29**
CV%	**3.59**	**3.95**

Means in a column followed by same letter(s) are not significantly different at 1% level of significance by LSD.

T_1: No fertilizer (Control)

T_2: 40 kg N + 25 kg P_2O_5 + 30 kg K_2O ha^{-1}

T_3: 80 kg N + 50 kg P_2O_5 + 60 kg K_2O ha^{-1}

T_4: 120 kg N + 75 kg P_2O_5 + 90 kg K_2O ha^{-1}

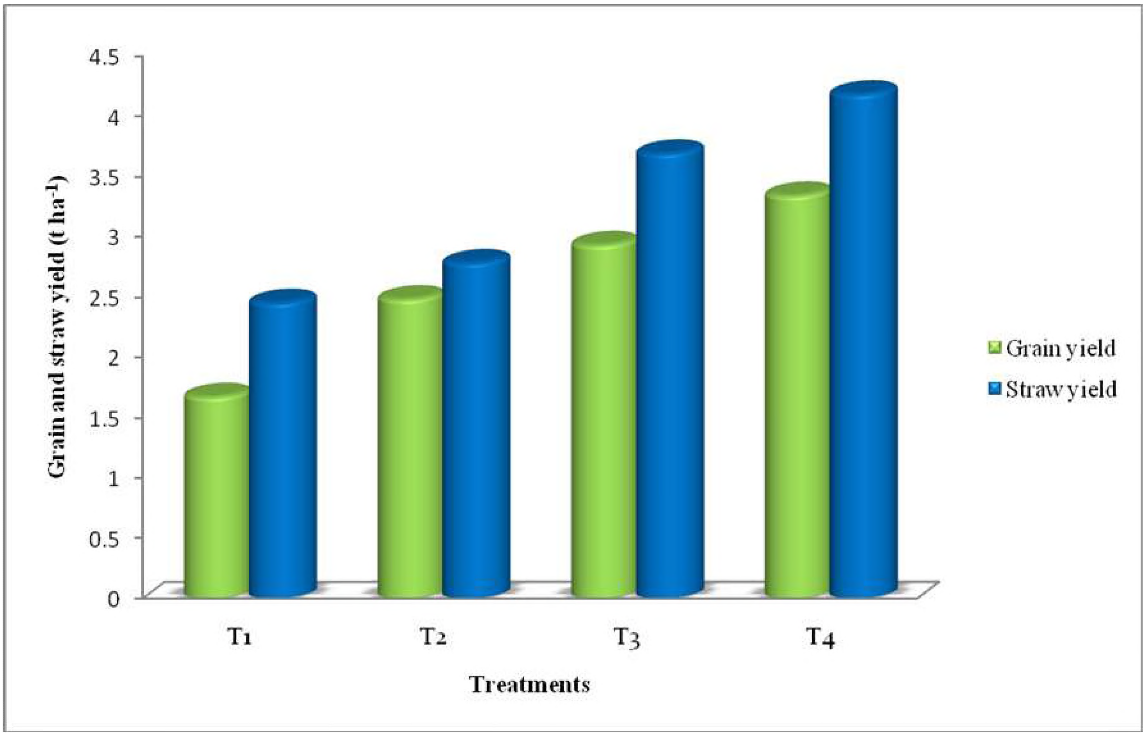


Fig. 14. Effect of NPK fertilizer on grain and straw yield (t ha^{-1}) of jhum rice

4.3 Yield of jhum crops other than rice

Jhumia farmers' use rice as a major crops and use other crops in minor amount. Seeds of different crops are mixed together and sown. The ratio of seed mixture (rice : other crop) is 100 : 1. That rice cover 95% of the total land area and other crops cover 5% of rest of the land. Yield of jhum crops other than rice got from that 5% are represented here.

4.3.1 Yield of marpha

Different levels of NPK fertilizer showed statistically significant variation on fruit yield of marpha (Table 6). The maximum yield 984.8 kg ha^{-1} was recorded from T_4 treatment receiving 120 kg N + 75 kg P_2O_5 + 90 kg K_2O ha^{-1} which was highly significant than other treatments. Second highest yield 683.5 kg ha^{-1} was recorded from T_3 treatment receiving 80 kg N + 50 kg P_2O_5 + 60 kg K_2O ha^{-1}. The lowest yield 453.8 kg ha^{-1} was observed in T_1 treatment receiving no fertilizer which was statistically identical with T_2 treatment receiving 40 kg N + 25 kg P_2O_5 + 30 kg K_2O ha^{-1} (Fig. 15). The treatment may be ranked in the order of $T_4>T_3>T_2>T_1$ in terms of marpha yield. Ravikumar (2009) recorded highest fruit yield of cucumber with the application of 120:70:90 kg NPK ha^{-1}. Ubeiz (2009), Rehamn *et al.* (1995) and Abdel-Mawgoud *et al.* (2005) reported that NPK fertilizer have a positive response in the vegetative growth and increased yield of cucumber. Din *et al.* (2007) reported that with increase levels of NPK cucumber significantly performed better with regard to yield.

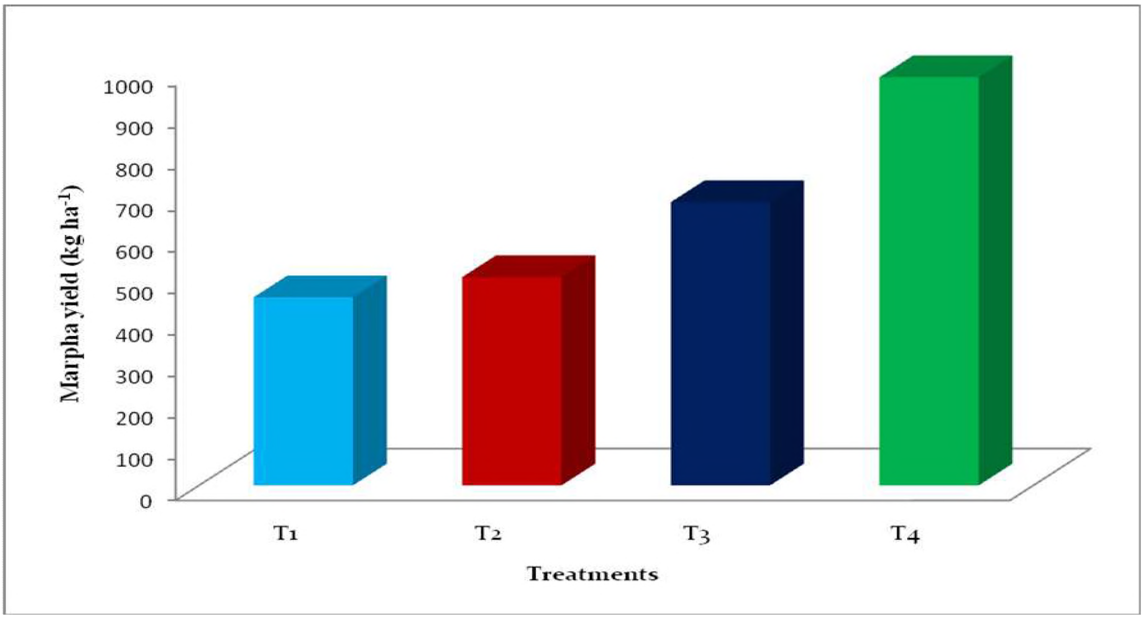


Fig. 15. Effect of NPK fertilizer on yield of marpha (kg ha^{-1})

4.3.2 Yield of maize

The grain yield of maize was significantly influenced by different levels of NPK fertilizer (Table 6). The yields of maize ranged from 517.5 to 951.3 kg ha^{-1}. The highest maize yield of 951.3 kg ha^{-1} was obtained in T_4 treatment receiving 120 kg N + 75 kg P_2O_5 + 90 kg K_2O ha^{-1} which was statistically differed with other treatments. The lowest maize yield of 517.5 kg ha^{-1} was recorded in T_1 (control) treatment receiving no fertilizer. Second highest maize yield of 749.3 kg ha^{-1} was found in T_3 treatment receiving 80 kg N + 50 kg P_2O_5 + 60 kg K_2O ha^{-1} which was statistically identical with T_2 treatment receiving 40 kg N + 25 kg P_2O_5 + 30 kg K_2O ha^{-1} (Fig. 16). The treatment may be ranked in the order of $T_4 > T_3 > T_2 > T_1$ in terms of maize yield. Halim *et al.* (2004) found increased maize yield with combined application of NPK fertilizer. Talukder *et al.* (2011) reported that increasing rates of P and/or K increased seed protein and grain yield of maize with 120 N kg ha^{-1} as a basal dose.

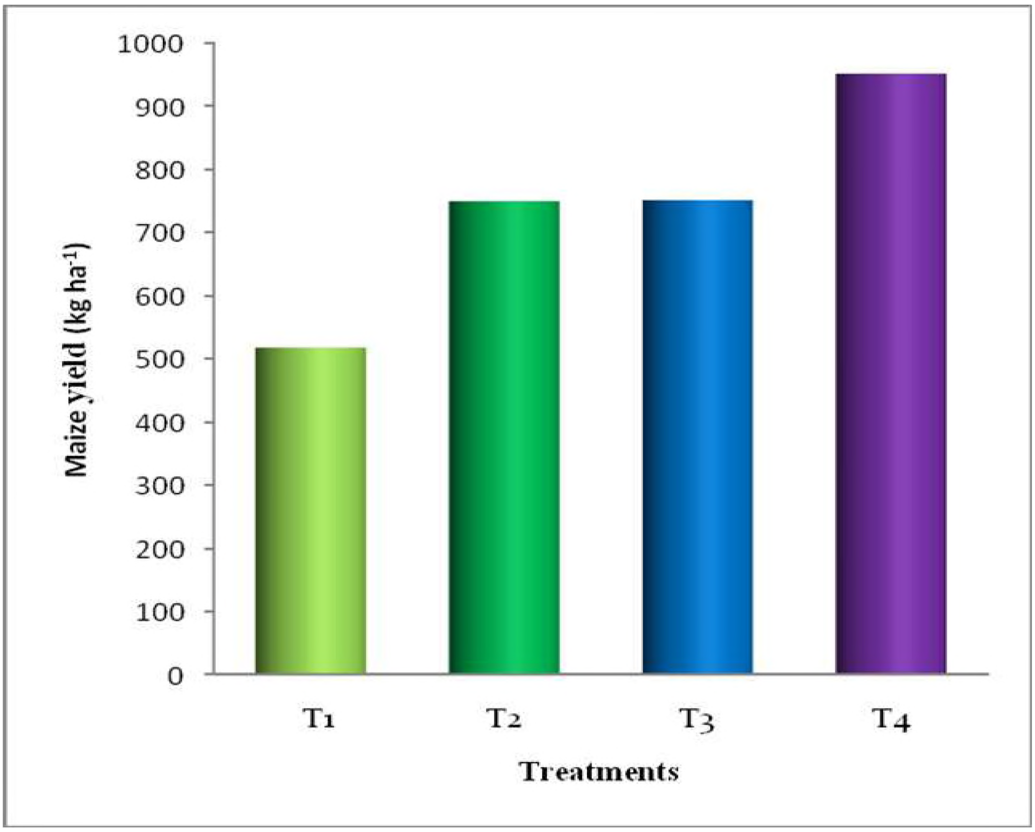


Fig. 16. Effect of NPK fertilizer on yield of maize (kg ha^{-1})

4.3.3 Yield of sweet gourd

NPK fertilizer increases the yield of sweet gourd significantly. Different levels of NPK fertilizer management showed statistically significant variation on yield of sweet gourd (Table 6). The fruit yield ranged from 781.3 to 1418.0 kg ha^{-1}. The maximum yield of 1418.0 kg ha^{-1} was recorded in T_4 treatment receiving 120 kg N + 75 kg P_2O_5 + 90 kg K_2O ha^{-1} that was followed by yield of 1113.0 kg ha^{-1} in T_3 treatment. The minimum yield of 781.30 kg ha^{-1} was recorded in T_1 treatment where no fertilizer was used (Fig. 17). The treatment may be ranked in the order of $T_4>T_3>T_2>T_1$ in terms of sweet gourd yield. Makal *et al.* (2007) and Nmanop (1997) reported that the combination of NPK fertilizers increase the fruit yield of sweet gourd significantly. Alom (2005) found that application of NPK at the rate of 120-70-90 kg ha^{-1} produced the highest yield. Yag (2010) and Oloyede (2008) cited that increase the rate of NPK fertilizer also increase the yield of pumpkin in terms of fruit per plant.

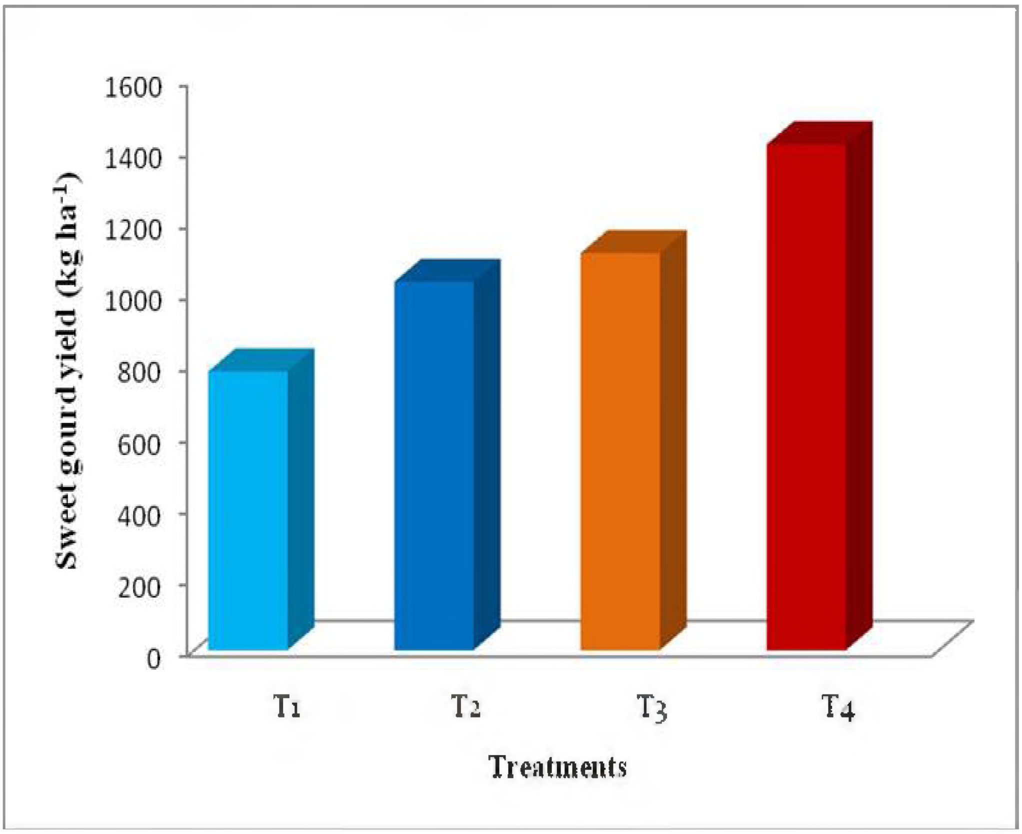


Fig. 17. Effect of NPK fertilizer on yield of sweet gourd (kg ha^{-1})

4.3.4 Yield of sesame

The NPK fertilizer plays a significant role on the seed yield of sesame (*Sesamum indicum*). The seed yield of sesame was significantly influenced by different levels of NPK fertilizer (Table 6). The yield ranged from 107.1 to 331.1 kg ha^{-1}. The highest yield of 331.1 kg ha^{-1} was found in T_4 treatment receiving 120 kg N + 75 kg P_2O_5 + 90 kg K_2O ha^{-1} (Fig. 18). The lowest yield of 107.1 kg ha^{-1} was recorded in T_1 (control) treatment. The treatment T_4 produced the highest grain yield than other treatments. Second highest yield of 245.4 kg ha $^{-1}$ was found in T_3 treatment receiving 80 kg N + 50 kg P_2O_5 + 60 kg K_2O ha^{-1} which was statistically identical with T_2 treatment receiving 40 kg N + 25 kg P-$_2O_5$ + 30 kg K_2O ha^{-1}. The treatments may be ranked in the order of T_4>T_3>T_2> T_1 with respect of seed yield of sesame. Sandabe *el al.* (2011) found that optimum number of capsule and seed yield was obtained with the combined application of NPK fertilizer @ 120:75:90 kg ha^{-1}. Deshmukh *et al.* (1990) and Mahalonabis (1999) found that application of 75 kg P_20_5 ha^{-1} increase the number of capsule plant^{-1}, seeds capsule^{-1} and seed yield of sesame.

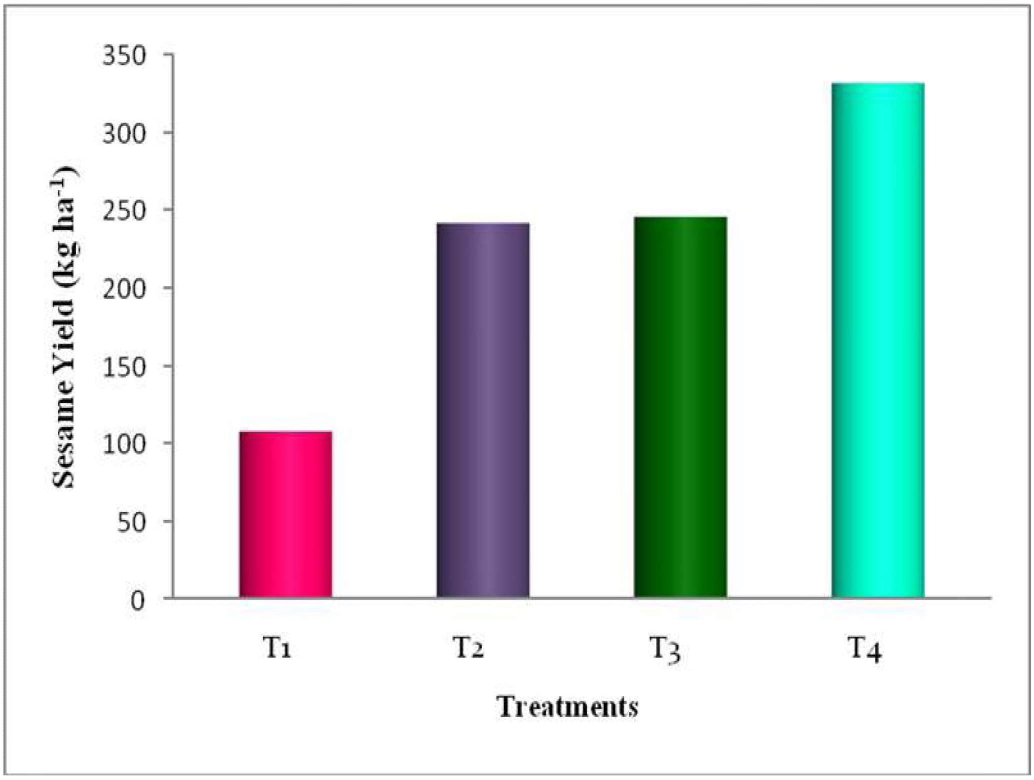


Fig. 18. Effect of NPK fertilizer on yield of sesame (kg ha^{-1})

4.3.5 Yield of turmeric

Fertilizer has a significant effect on the yield of turmeric (*Curcuma longa* L.). Statistically significant variation was recorded for yield of turmeric at different levels of NPK fertilizer (Table 6). The yield of turmeric ranged from 356.5 to 680.2 kg ha^{-1}. The highest yield of 680.2 kg ha^{-1} was found in T_4 treatment receiving 120 kg N + 75 kg P_2O_5 + 90 kg K_2O ha^{-1} (Fig. 19). The lowest yield of 356.5 kg ha^{-1} was recorded in T_1 (control) treatment. The treatment T_4 produced the highest rhizome yield than other treatments. Second highest yield of 554.4 kg ha^{-1} was found in T_3 treatment receiving 80 kg N + 50 kg P_2O_5 + 60 kg K_2O ha^{-1} which was statistically identical with T_2 treatment receiving 40 kg N + 25 kg P_2O_5 + 30 kg K_2O ha^{-1}. The treatments may be ranked in the order of $T_4>T_3>T_2>T_1$ with respect to yield of turmeric. Paul (2008) found that application of NPK fertilizer @ 120:75:90 kg ha^{-1} increase the yield of turmeric significantly. Meerabai *et al.* (2000) cited that application of 120 kg N ha^{-1} gave the maximum economic yield. Mohankumar *et al.* (1990^b) and Vivek (2010) found that increased the amount of NPK fertilizer increased the yield of turmeric significantly.

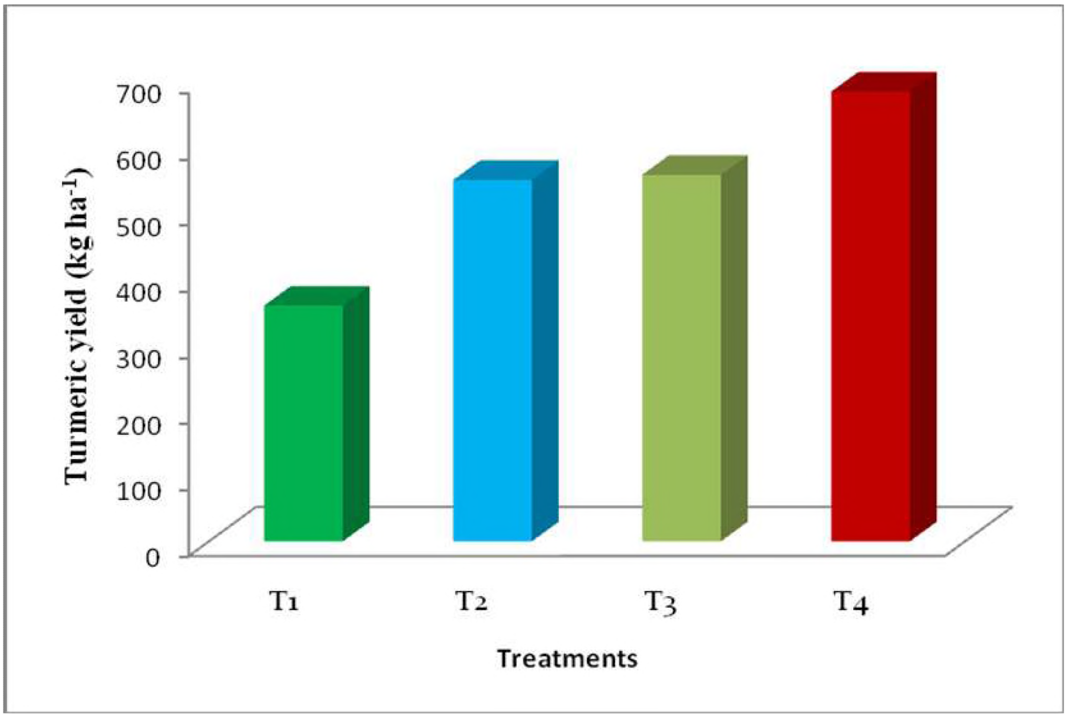


Fig. 19. Effect of NPK fertilizer on yield of turmeric (kg ha^{-1})

4.3.6 Yield of arhar (pigeon pea)

Different levels of NPK fertilizer showed statistically significant variation on the yield of arhar (Table 6). The yield of arhar ranged from 103.6 to 349.9 kg ha^{-1}. The highest yield 349.9 kg ha^{-1} was recorded from T_4 treatment receiving 120 kg N + 75 kg P_2O_5 + 90 kg K_2O ha^{-1} which was highly significant than other treatments. Second highest yield 275.9 kg ha^{-1} was recorded from T_3 treatment receiving 80 kg N + 50 kg P_2O_5 + 60 kg K_2O ha^{-1} which was statistically identical with T_2 treatment receiving 40 kg N + 25 kg P_2O_5 + 30 kg K_2O ha^{-1} (Fig. 20). The lowest yield 103.6 kg ha^{-1} was observed in T_1 treatment receiving no fertilizer. The treatment may be ranked in the order of $T_4>T_3>T_2>T_1$ in terms of arhar yield. Pachauri *el al.* (2008) reported that NPK fertilizer increase the yield of pigeon pea significantly. Naik (1989) found that N and P at highest rate give highest yield in pigeon pea. Kushwaha (2001) cited that application of 90 kg K_2O ha^{-1} increase the use efficiency of K and increase the yield of pigeon pea.

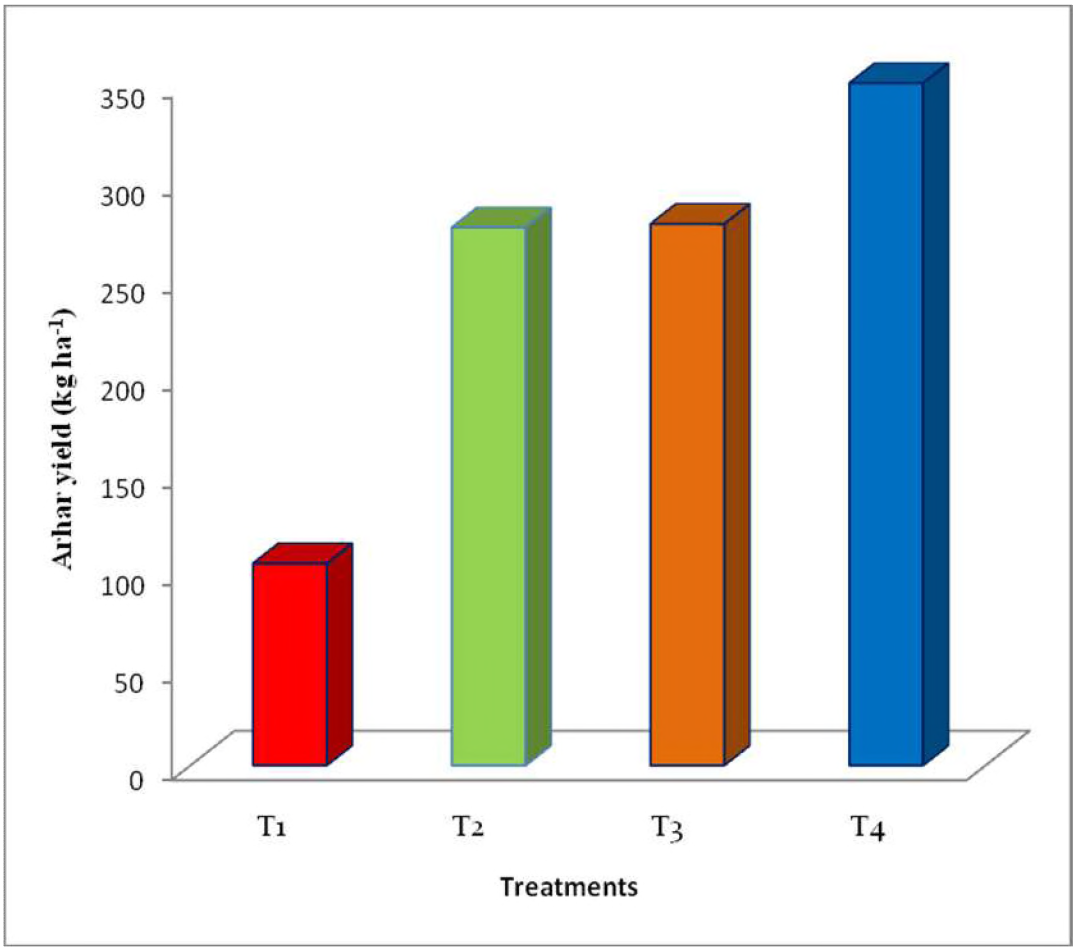


Fig. 20. Effect of NPK fertilizer on yield of arhar (kg ha^{-1})

Table 6. Effect of NPK fertilizers on the yields (kg ha^{-1}) of marpha, maize, sweet gourd, sesame, turmeric and arhar

Treatments	Marpha (kg ha^{-1})	Maize (kg ha^{-1})	Sweet Gourd (kg ha^{-1})	Sesame (kg ha^{-1})	Turmeric (kg ha^{-1})	Arhar (kg ha^{-1})
T_1	453.8 ^{d}	517.5 ^{c}	781.3^{d}	107.1^{c}	356.5^{c}	103.6^{c}
T_2	502.5 ^{c}	749.3 ^{b}	1033.0^{c}	241.4 ^{b}	546.4^{b}	275.9^{b}
T_3	683.5 ^{b}	751.0^{b}	1113.0^{b}	245.4 ^{b}	554.4^{b}	277.7^{b}
T_4	984.8^{a}	951.3^{a}	1418.0^{a}	331.3 ^{a}	680.2^{a}	349.9^{a}
LSD $_{(0.05\%)}$	52.40	22.66	30.79	7.15	35.05	12.62
CV %	2.21	1.33	1.00	1.99	2.85	3.11

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

T_1: No fertilizer (Control)

T_2: 40 kg N + 25 kg P_2O_5 + 30 kg K_2O ha^{-1}

T_3: 80 kg N + 50 kg P_2O_5 + 60 kg K_2O ha^{-1}

T_4: 120 kg N + 75 kg P_2O_5 + 90 kg K_2O ha^{-1}

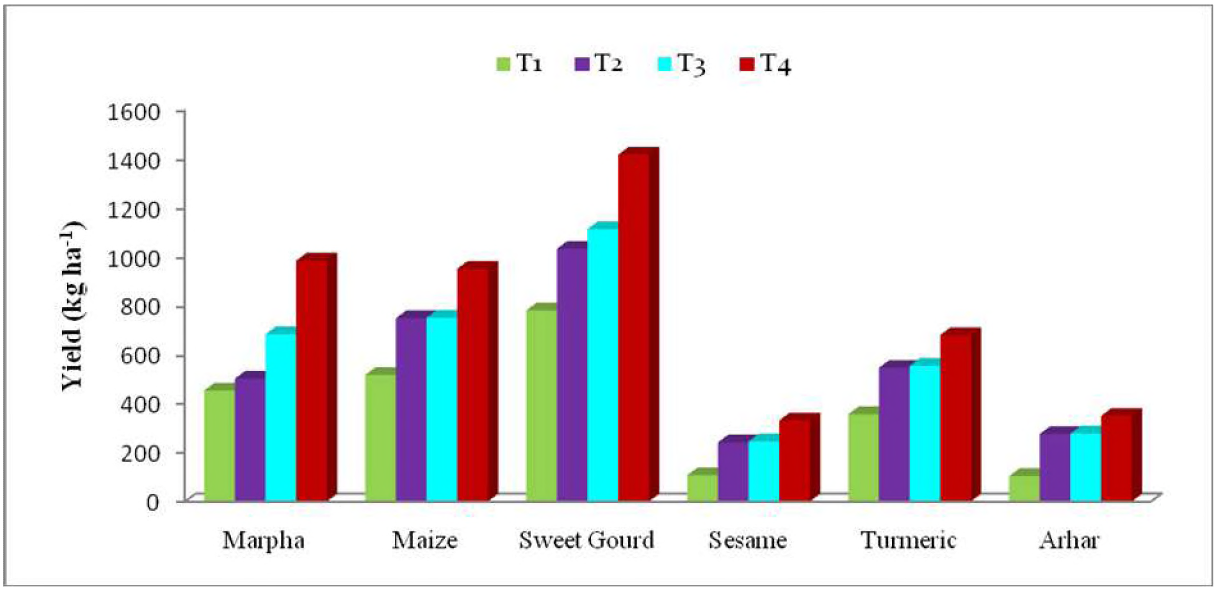


Fig. 21. Effect of NPK fertilizer on the yields of marpha, maize, sweet gourd, sesame, turmeric and arhar (kg ha^{-1})

4.4 Nutrient content in post harvest soil

4.4.1 pH

Variation was recorded in post harvest soil pH due to the application of different levels of NPK fertilizer for jhum crops cultivation (Table 7). The highest pH of post harvest soil (5.25) was found from T_4 treatment receiving 120 kg N + 75 kg P_2O_5 + 90 kg K_2O ha^{-1}. The lowest pH in post harvest soil (5.15) was recorded from T_1 treatment receiving no fertilizers.

4.4.2 Organic matter

Organic matter in post harvest soil was varied with different levels of NPK fertilizer for jhum cultivation (Table 7). The highest organic matter in post harvest soil (3.05%) was recorded from T_4 treatment receiving 120 kg N + 75 kg P_2O_5 + 90 kg K_2O ha^{-1} which is statistically superior to the rest of the treatment under study. The lowest organic matter in post harvest soil (2.95%) was observed from T_1 treatment with no fertilizers.

4.4.3 Total nitrogen

Total nitrogen in post harvest soil showed statistically non-significant at different levels of NPK fertilizer for jhum cultivation (Table 7). The highest total nitrogen in post harvest soil (0.055%) was recorded from T_4 treatment receiving 120 kg N, 75 kg P_2O_5 and 90 kg K_2O ha^{-1}. On the other hand, the lowest total nitrogen in post harvest soil (0.050%) was obtained from T_1 treatment with no fertilizer.

4.4.4 Available phosphorous

A significant difference in available phosphorous content of post harvest soil was observed at different levels of NPK fertilizers for jhum cultivation (Table 7). The highest available P (14.25 ppm) in the post harvest soil was recorded in T_4 treatment and the lowest available P (12.87 ppm) was noted in T_1 (control) treatment.

4.4.5 Exchangeable potassium

Exchangeable potassium in post harvest soil showed statistically non-significant at different levels of NPK fertilizer for jhum cultivation (Table 7). The maximum exchangeable potassium of post harvest soil (0.73 meq/100g soil) was found in T_4 treatment received NPK @ 120:75:90 kg ha^{-1} which is statistically superior to the rest of the treatment under study. The lowest available K (0.68 meq/100g soil) was observed in T_1 (control) treatment received no fertilizers.

4.4.6 Available sulphur

A significant difference in available sulphur content of post harvest soil was observed at different levels of NPK fertilizers for jhum cultivation (Table 7). The highest available S (17.11 ppm) in the post harvest soil was recorded in T_1 treatment received no fertilizer. The lowest available S (16.04 ppm) was found in T_4 treatment received NPK @ 120:75:90 kg ha^{-1} which is statistically similar with T_3 treatment.

Table 7. Effect of NPK fertilizers on pH, organic matter, N, P, K and S content in post harvest soil of jhum cultivation

Treatment	pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (meq/100g soil)	Available S (ppm)
T_1	5.15	2.95	0.050	12.87^b	0.68	17.11^a
T_2	5.20	3.01	0.053	14.12^a	0.70	16.56^b
T_3	5.25	3.01	0.055	14.10^a	0.70	16.05^c
T_4	5.25	3.05	0.055	14.25^a	0.73	16.04^c
$LSD_{0.05}$	NS	NS	NS	0.48	NS	0.51
CV (%)	1.21	1.62	7.33	2.18	2.28	3.02

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

T_1: No fertilizer (Control)

T_2: 40 kg N + 25 kg P_2O_5 + 30 kg K_2O ha^{-1}

T_3: 80 kg N + 50 kg P_2O_5 + 60 kg K_2O ha^{-1}

T_4: 120 kg N + 75 kg P_2O_5 + 90 kg K_2O ha^{-1}

Chapter 5

Summary and Conclusion

SUMMARY AND CONCLUSION

The experiment was conducted at Hill Agricultural Research Station, Bangladesh Agricultural Research Institute, Khagrachari, Bangladesh during the period from May 2014 to January 2015 to study the effect of different fertilizer packages on the performance of jhum crops. The experiment was laid out in Latin Square Design (LSD), where the experimental area was divided into four blocks representing the replications to reduce soil heterogenetic effects. The treatments consisted of 4(four) levels of NPK fertilizers i.e T_1: no fertilizer (Control), T_2: 40 kg N + 25 kg P_2O_5 + 30 kg K_2O ha^{-1}, T_3: 80 kg N + 50 kg P_2O_5 + 60 kg K_2O ha^{-1} and T_4: 120 kg N + 75 kg P_2O_5 + 90 kg K_2O ha^{-1}.

Yield contributing characters and yields of jhum rice were significantly affected by different levels of NPK fertilizer. The highest plant height of jhum rice (132.8 cm), effective tillers $hill^{-1}$ (14.38), panicle length (30.80 cm), highest number of filled grain per panicle (132.7), 1000 grain weight (25.17 gm), straw yield (4.18 ton/ha) and grain yield (3.34 ton/ha) were found from T_4 treatment receiving 120 kg N + 75 kg P_2O_5 + 90 kg K_2O ha^{-1} and all cases lowest in T_1 treatment receiving no fertilizer (control). The grain yield of different fertilizer treatments followed the order of $T_4 > T_3 > T_2 > T_1$.

NPK fertilizer plays a significant role on the yield of marpha, maize, sesame, sweet gourd, turmeric and arhar. The highest yield of marpha (984.8 kg ha^{-1}), maize (951.3 kg ha^{-1}), sweet gourd (1418.0 kg ha^{-1}), sesame (331.3 kg ha^{-1}), turmeric (680.2 kg ha^{-1}) and arhar (349.9 kg ha^{-1}) were found in T_4 treatment receiving 120 kg N + 75 kg P_2O_5 + 90 kg K_2O ha^{-1} and for all cases lowest results were found in T_1 treatment receiving no fertilizer (control).

The chemical properties of post harvest soil were affected by application of different levels of NPK fertilizer. The highest pH of post harvest soil (5.25) was found from T_4 treatment received 120 kg N + 75 kg P_2O_5 + 90 kg K_2O ha^{-1} and the lowest pH in post harvest soil (5.15) was recorded from T_1 treatment with no fertilizer (Control).

The highest organic matter (3.05%), total nitrogen (0.055%), available P (14.25 ppm) and exchangeable K (0.73 meq /100 g soil) in post harvest soil were recorded in T_4 treatment receiving 120 kg N + 75 kg P_2O_5 + 90 kg K_2O ha^{-1}. On the other hand, the lowest organic matter (2.95%), total nitrogen (0.050%), available P (12.87 ppm) and exchangeable K (0.68 meq/100 g soil) in post harvest soil were recorded in T_1 treatment with no fertilizer (control). In case of available sulphur, highest (17.11 ppm) and lowest (16.04 ppm) S in post harvest soil was found in T_1 and T_4 treatment respectively.

From the above discussion it can be concluded that fertilizer had a significant effect on yield and yield contributing characters of jhum crops. The application of 120 kg N + 75 kg P_2O_5 + 90 kg K_2O ha^{-1} fertilizer was most favorable for improving yield and yield contributing characters of jhum crops.

Before recommend findings of the present study, the following recommendations and suggestions may be made:

1. Such study is needed in different sites of Chittagong Hill Tracts, Bangladesh for regional adaptability and other performance.

2. Another combination of NPK fertilizer may be included for further study.

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Appendices

APPENDICES

Appendix I. Analysis of variance of the data on yield and yield contributing characters of jhum rice

Sources of variation	df	Plant height (cm)	Panicle length (cm)	Effective tillers hill^{-1} (no.)	Non-effective tillers hill^{-1} (no.)	Filled grain/ panicle (no.)	Un-filled grain/ panicle (no.)	1000 seed weight (g)	Grain weight (t/ha)	Straw weight (t/ha)
Replication	3	1.678	1.255	1.254	1.269	0.324	0.454	0.191	0.387	3.280
Factor A	3	14.980**	36.776*	19.637**	0.890*	37.753**	30.064*	4.121*	35.832**	32.261**
Error	9	16.220	0.306	0.738	0.365	0.968	2.212	0.504	0.090	0.017

Appendix II. Analysis of variance of the data on yield of marpha, maize, sweet gourd, sesame, turmeric and arhar

Sources of variation	df	Marpha yield (t/ha)	Maize yield (t/ha)	Sweet gourd yield (t/ha)	Sesame yield (t/ha)	Turmeric yield (t/ha)	Arhar yield (t/ha)
Replication	3	0.468	0.560	1.381	1.264	0.374	1.473
Factor A	3	94.094**	23.776**	38.134*	55.017*	36.289**	42.064*
Error	9	11.194	7.220	9.738	9.682	11.628	12.120

Appendix III. Analysis of variance of the data on n, p, k and s content in post harvest soil of jhum cultivation

Sources of variation	df	Soil					
		Organic matter (%)	pH	Total N (%)	Available P (ppm)	Exchangeable K (meq./100g soil)	Available S (ppm)
Replication	3	0.020	0.120	0.001	1.220	0.001	0.001
Factor A	3	0.001 NS	0.001 NS	0.001 NS	5.813 *	0.001 NS	19.055 *
Error	9	0.331	0.241	0.001	0.421	0.001	0.701

** = Significant at 1% level of probability, * = Significant at 5% level of probability, **NS** = Non Significant.

Appendix-IV: Some commonly used abbreviations and symbols

Abbreviations	**Full word**
%	Percent
@	At the rate
AEZ	Agro-Ecological Zone
Agric.	Agriculture
Agril.	Agricultural
Agron.	Agronomy
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BSMRAU	Bangladesh Sheikh Mujibur Rahman Agricultural University
cm	Centi-meter
CV%	Percentage of coefficient of variation
LSD	Least Significant Difference
et al.	and others
FAO	Food and Agricultural Organization
g	gram
j.	Journal
kg	kilogram
Kg ha^{-1}	kilograms per hectare

m	Meter
MSE	Mean square of the error
No.	Number
ppm	parts per million
LSD	Latina Square Design
Rep.	replication
Res.	research
SAU	Sher-e-Bangla Agricultural University
Sc.	science
Univ.	University
var.	variety
Wt.	Weight

Appendix-V: Pictorial view of research plot

Picture 1: Land preparation

Picture 2: Fertilizer application by dibbling method

Picture 3: Seed sowing

Picture 4: Seedling stage of jhum crops

Picture 5: Vegetative stage of jhum crops

Picture 6: Field visit

Picture 7: Different types of jhum crop

Picture 8: Field day on jhum cultivation

Picture 9: Jhum field after harvesting of rice