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Effect of Fertilizer on The Growth and Yield of Jhum Crop under the Slush-mulch Condition for Sustainable Crop Production in the Chittagong Hill Tracts (Chts) of Bangladesh

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Abstract

The purpose of this study was to evaluate the effect of fertilizer on the growth and yield of jhum crop under the Slush-mulch condition for sustainable crop production in Chittagong hill tracts (CHT) of Bangladesh. The experiments were conducted during March 2015 to February 2016 at Bandarban in Chittagong under the AEZ 29 (Northern and Eastern Hills Tract). The experiment was designed on Randomized Completely Block Design (RCBD) with three replications. Experiment had three treatments as T_1 Control T_2 Application of 100% chemical fertilizers on STB (N_{37} P_{15} K_{14} S_8 kg ha^{-1}) and T_3 Application of 125% chemical fertilizers on STB along with mulch (about 50 kg natural weed per 20 m^2 plot) and no mulch conditions. Fertilization under slush-mulch condition had a positive role on the yield of Jhum rice and that of other Jhum crops. Under sole application of fertilizer, the highest grain yield of rice (4.27 t ha^{-1}) was obtained from the application of 125%of RDF on STB, the lowest value (2.65 t ha^{-1}) being noted in control. On the other hand, mulching favored the yield of rice grain, the highest grain yield (4.44 t ha^{-1}) being obtained from the combination of mulching along with the application of fertilizers @ 125%RDF on STB, the lowest grain yield (1.89 t ha^{-1}) was recorded from the absolute control. The yield of jhum other crops also significantly influenced in mulch condition. The negative balance of soil nutrient was increased with the rates of fertilizer application under both mulch and no-mulch conditions.

Keywords: Mulch condition, Jhum crops yield, nutrient balance

1. Introduction

Jhum cultivation, popularly known as shifting cultivation, is the most prevalent form of cultivation in the hills of tropical Asian countries including Bangladesh. Jhuming involves cutting of forests in March, left on the hill slopes for one month for drying and burning of the dried plants (Borggaarrd et al., 2003). Seeds of different crops are sown by dibbling the land in May. Crops are harvested in succession as they ripe between July and December. In Bangladesh, Jhum cultivation is practiced in the hilly areas of Chittagong Hill Tracts (CHTs). The CHTs are located in the southern part of Bangladesh bordering with India and Myanmar and are the home to 11 different ethnic communities. Chakma and Tongchonga tribal community belief that they have to put Jhum soils (as sacred soil) on the feet of the goddess in every religious occasion (Arya, 2015). The

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Chittagong Hill Tracts (CHTs) 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 (Anonymous, 2016). In the hilly areas 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. A mulch is a layer of material applied to the surface of soil. Reasons for applying mulch include conservation of soil moisture, improving fertility and health of the soil, reducing weed growth and enhancing the visual appeal of the area. A mulch is usually, but not exclusively, organic in nature. It may be permanent (e.g. plastic sheeting) or temporary (e.g. bark chips). It may be applied to bare soil or around existing plants. Mulches of manure or compost will be incorporated naturally into the soil by the activity of worms and other organisms. The process is used both in commercial crop production and in gardening, and when applied correctly, can dramatically improve soil productivity (Jeff, 2008).

According to Chiezey and Yayock (2016) the use of improved varieties and inorganic fertilizers to maintain high yields of jhum crops has become increasingly important due to poor yield associated with increasing pressure on arable land and diminishing soil fertility in relation to crop production. (Okpara, 2014) concluded that extravagant use of fertilizers through large applications may result in increased rate of removal of trace elements in the produce. Hence, fertilizers must be efficiently and judiciously used in order to avoid wastes. There is paucity of literature on the rate of fertilizer required by the component crops in a jhum cropping system (Bhuiyan et al., 2017). Therefore, more research information is necessary for advising the farmers on appropriate use of fertilizer in jhum cropping systems (Tahura, 2017). Partial nutrient balances at plot level were estimated by separating inputs and outputs to the system. The main inputs added to the soil were N, P, K and S from inorganic fertilizer and crop residues. Nutrient losses from the plots occurred through crop harvest, crop residues, and soil erosion (Singh et al., 2014). A partial nutrient balance (N, P, K, and S) was calculated by subtracting nutrient outflow (losses) from the total nutrient added to the treatment plots. Nutrient balance exercises may serve as instruments to provide indicators for the sustainability of agricultural systems and importance for nutrient management (Roy et al., 2003). However, neither the addition of nutrients from rainfall nor dry deposition, biological nitrogen fixation, gaseous losses of N, or weed uptake of nutrients from the soil were taken into account for computing nutrient balance.

Nowadays, the shrinkage of Jhum fields and reducing yields has created a challenge for the Jhumia families. Compared to this low return from the Jhum, still many of the people either partly or fully depend on Jhum for their livelihoods. 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. To meet up the food demand of indigenous people in Chittagong Hill Tracts, it is necessary to practice suitable use of fertilizers under slush-mulch condition for increasing the sustainable productivity of Jhum. Fertilizer application increases the yield of jhum crops under slush-mulch condition. Some of the farmers of CHT use any kind of fertilizer nor adopt improve management practices on growth and yield of jhum crops. Considering the above facts, the present investigation has been undertaken to determine the effect of fertilizer on the growth and yield of jhum crop under the Slush-mulch condition for sustainable crop production in Chittagong hill tracts (CHT) of Bangladesh.

2. Materials and Methods

2.1. Climate

Bangladesh has a sub-tropical humid climate. Heavy rainfall occurs in the monsoon and scanty in the other seasons. The mean annual rainfall recorded at the Soil Conservation and Watershed Management Center (SCWM), SRDI, Bandarban, nearest to the experimental sites was 3010.9 mm and the annual average temperature was 31.63°C as maximum and 21.46°C as a minimum. Meteorological data like rainfall, temperature, and relative humidity during the study period.

2.2. Soil characteristics

The general soil type of the experimental plot was Brown Hill soil collected from Tiger Para, Bandarban (AEZ 29). Morphological and general characteristics of the experimental soils are described ,Geographic position: 22010.673’ N Latitude 920 12 .208’ E Longitude, 216 m height above sea level, Slope 25% Moderate slope, Agro-ecological zone (FAO and UNDP, 1988): Northern and Eastern Hills (AEZ -29), General Soil Type: Brown Hill Soil Soil Group: Suvolong Parent material Sedimentary rocks, Drainage: Highly drained Flood level, Land type: High land. Depth of soil: 0-15 cm and 15-30 cm, Texture Loam: Clay Loam, pH: 4.6-4.4, OM (%): 2.24-2.02, Exchangeable Ca (cmol kg^{-1}): 3.01-2.83, Exchangeable Mg (cmol kg^{-1}): 0.99-0.93, Exchangeable K (cmol kg^{-1}): 0.27-0.28, Total N: (%): 0.212-0.101, Available P (mg kg^{-1}): 3.91-3.82, Available S (mg kg^{-1}): 1.74-1.61, Available Zn (mg kg^{-1}): 2.98-3.18, Available Mn (mg kg^{-1}): 5.86-5.78, Available Fe (mg/kg): 68.15-79.45, Available Cu(mg kg^{-1}): 0.56-0.44, Available B (mg kg^{-1}): 0.11-0.05.

2.3. Treatment details and crop management

The experiment was set up with two factors viz: mulch & fertilizer in Randomized Complete Block Design (RCBD) with three replications. The treatment details are given as a factor A and factor B. Factor A: M0= No mulch, M1=Mulch (About 50 kg natural weed per 20 m2 plot), Mulch with natural weed 25 t ha^{-1}, Where, 0.4 % N, 0.1 % P, 0.4% K and 0.2% S (Ref. Fertilizer Recommendation Guide-2012). Factor B: F_1= Control (Farmers’ practice), F_2=Management with 100% chemical fertilizer by STB, (N_{37} P_{15} K_{14} S_8 kg ha^{-1}), F_3= Management with 125% chemical fertilizer by STB (F_2+125% more fertilizer).

Jhum crops were used in the experiment namely Jhum rice, marpha, sesame, maize, yard-long bean and sweet gourd.

Before the initiation of this experiment we met the farmer, 'Joy Fal Tongconga' in Tiger Para, Bandarban Sadar and agreed to set experiment in the farmer's field. After preparation of all experimental plots Jhum seeds were sown on 03 June 2015 by the dibbling method. Weeds were used as mulching material. Chemical fertilizers were applied by soil test basis (STB). Before sowing ofJhum seed, all dose of TSP, MoP and gypsumfertilizer**s** were applied by dibbling as per treatment. The experimental field was monitored frequently and necessary management actions such as weeding and application of pesticides were done as per requirement.

2.4. Data collection, soil and plant analysis

After threshing and cleaning, crop yield and yield contributing data like plant height, number of panicles m^{-2}, length of panicle, number of grains $panicle^{-1}$, number of filled grains $panicle^{-1}$, number of unfilled grains $panicle^{-1}$, grain yield m^{-2}, grain yield ha^{-1}, straw yield ha^{-1} and dry matter of other crops were collected in time.

Jhum crops were harvested from the experimental field on 03 October 2015 and brought for processing at the Farmyard of HCRC, Balaghata, Bandarban. The eroded soil was collected from catch pit and calculated by the electric balance on dry basis. Two initial soil samples were collected from both the surface (0-15 cm) and sub-surface region (15-30 cm) of the soil profile of each spot with the help of an auger and core sampler. Collected soil samples were analyzed for determining soil pH, and the contents of organic matter, total N, P, K, Zn, B, Ca, Mg and S and other basic soil physical properties.

Hill slope was measured by Abney Level. Elevation, longitude and latitude were determined by the GPS meter.

After selection of experimental sites, hill bushes and weeds were cleaned by cutting and burning. The individual plots were prepared by putting a one feet high tin fence surrounding each plot.This was done to restrict the transfer of water and eroded soil from outside to inside the plot and vice-versa. The dimension of each plot was 22×5 m^2. A pit having the size of 5×1×1 m^3 was made at the foot of each plot and wrapped by black polyethylene sheet for collecting eroded soil from the plot. Urea fertilizer was appliedtreatmentwise at15 days after sowing (DAS) and at 40 DAS by the dibbling method. The experimental field was frequently monitored and necessary management practices such as weeding, pesticide application, and earthening were done as required.

Four initial, 40 post-harvest and 06 eroded soil samples were collected, cleaned, and dried and stored for analysis. Soil analysis includes pH, organic matter, total N, exchangeable K, Ca, Mg, Na, and available P, S, B, Mn, Zn, and Cu contents. After harvest, 90 plant samples (rice, maize, marpha, sesame, sweet gourd and yard-long bean) were collected and were divided straw and grain. The samples were cleaned, dried and kept for chemical analysis. After harvest, plant samples from each pot were collected and divided into, straw and grain. The collected plant samples were then oven dried at 65°C for 24 hours. To obtain a homogeneous powder, the samples were finely ground by using a Grinding-Mill to pass through a 60-mesh sieve. Plant samples were digested with di-acid mixer (HNO_3:$HClO_4$ = 5:1) for determination of N, P, K and S concentrations following standard methods, as described below.

Methods for N: Micro-Kjeldahl method (Bremner and Mulvaney, 1982): Plant sample was digested with conc. H_2SO_4 in presence of K_2SO_4 catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Se=10:1:0.1). Nitrogen in the digest was estimated by distilling the digest with 10N NaOH followed by titration of the distillate trapped in H3BO3 indicator solution with 0.01N H_2SO_4. Method for P: Digesting the samples in the di-acid mixture (HNO_3-$HClO_4$) and determined colorimetrically using molybdovanadate solution yellow color method (Yoshida et al., 1976). Method for K: Digesting the samples in the di-acid mixture (HNO_3-$HClO_4$) and determined directly by a flame photometer (Yoshida et al. 1976). Method for S: Digesting the samples in the di-acid mixture (HNO_3-$HClO_4$) and determined turbidity method using $BaCl_2$ (Chapman and Pratt, 1961).

The apparent nutrient balance was estimated considering the total amount of nutrients added to the soil through different sources of nutrient management and the total amount of nutrient uptake by the crops (main product and by-product) in the pattern. The apparent nutrient balance was expressed in kg ha^{-1} yr^{-1}. Nitrogen losses through de-nitrification, leaching and ammonia volatilization were ignored. Biological fixation and the addition of S from rainwater were not taken into consideration. Nutrient uptake by weed was considered zero. Statistical analysis was done by 'Statistics 10'program. The mean effects were adjudged by LSD.

3. Results and Discussion

The study was accomplished in Bandarban hills under Northern and Eastern Hills (AEZ 29). The objective was to assess the growth and yield of jhum crop under the Slush-mulch condition for sustainable crop production in Chittagong hill tracts (CHT). The field experiments were carried out at farmers' fields in Bandarban SadarUpazila. Results of these experiments are presented in different tables and figures. Description of experimental results is made under various sub-sections, as follows.

3.1. Rice

3.1.1. Plant height

Mulch had taller plant height (146.5 cm) than that of no mulch practice (142.7 cm). The tallest plant (154.4 cm) was obtained at 125% STB fertilization and the lowest plant (128.9 cm) was obtained at control plot. The second highest tall plant was observed at 100% STB fertilization which is statistically similar with 125% STB fertilizer recommendation. The tallest plant

(155.4 cm) was obtained in the interaction between mulch at 125% STB fertilizer recommendation and the lowest plant height (125.9 cm) was found in the interaction between no mulch at control ferti1izer recommendation.

Plant height was significantly favored by mulching. This result might be due to the conservation of soil moisture that has facilitated the crop for the availability of water for a longer period. (Elliott et al., 2008) reported that the rice straw mulch and nitrogen fertilization increased soil moisture and decreased soil temperature. Application of rice straw mulch and nitrogen fertilizer significantly increased the response of rice plants to improve rice yield in upland rice fields. Plant height was significantly influenced by the fertilizer application but the influence of mulching was not significant. The interaction effect between mulching and fertilizer applications was also insignificant. The treatments were ranked in the order of $T_3 > T_2 > T_1$ treatments. (Awan, 2011) found that increased fertilizer dose of NPK increased plant height. Rajarathinam et al. (2013) observed that the yield contributing characters like plant height was the highest in 120 kg ha^{-1} of N.

3.1.2. Number of tillers $hill^{-1}$

The total number of tillers/hill (I3.7) was higher in mulch than that of no mulch (11.76). A total number of tillers $hill^{-1}$ was significantly influenced by the fertilizer application at 5% level of significance. Figure showed that the highest number of total tillers $hill^{-1}$ (14.28) was found at the 100% STB fertilizer recommendation which was statistically identical tillers $hill^{-1}$ (13.27) in 125% STB fertilizer management and the lowest number of total tillers/hill (10.7) was found at control treatment. The highest total number of tillers $hill^{-1}$ (14.77) was found from the interaction between mulch at 100% STB fertilizer recommendation and the lowest total number of tillers $hill^{-1}$ (9.67) was found from no mulch at no fertilizer recommendation (control).

Mulching had created significant influence on the number of tillers $hill^{-1}$ at 5% level of probability. It has favored in conserving soil moisture for crop use and increasing the number of tillers $hill^{-1}$. A total number of tillers $hill^{-1}$ was also significantly influenced by the fertilizer application. Figure showed that the highest number of total tillers $hill^{-1}$ (14.28) was found at the 100% STB fertilizer recommendation which was statistically similar to that of 125% STB fertilizer management (13.27). The lowest number of total tillers/hill (10.7) was found at control treatment. (Zhou et al., 2012) found that N, P and K nutrition increased the number of tillers/hill of rice plants. Fertilizer applications and mulching did not interact significantly with each other in respect of production of a total number of tillers $hill^{-1}$.

3.1.3. Number of effective tillers $hill^{-1}$

The number of effective tillers $hill^{-1}$ (13.2) was greater in mulch than that of no mulch (11.3). Figure revealed that the highest number of effective tillers $hill^{-1}$ (12.8) was obtained from 125% STB fertilizer recommendation and the lowest number of effective tillers $till^{-1}$ (10.15) was found in control plot. Mulch had significant (5% level of significance) effect on a number of effective tillers/hill. Number of effective tillers/hill was also significantly influenced fertilizer applications. The number of effective tillers $hill^{-1}$ was significantly affected due to the interaction between mulching and fertilizer recommendations. The treatments may be ranked in the order of $T_3>T_2>T_1$ in terms of effective tillers $hill^{-1}$. (Karim, and Ahmed, 1997) cited that application of NPK fertilizers increases the effective tillers $hill^{-1}$.

3.1.4. Panicle length (cm)

Mulch gave higher panicle length (31.2 cm) than that of no mulch (29.1 cm) (Table 1). 125% STB fertilizer produced the highest panicle length (32.6 cm) followed by 100% STB fertilizer (30.7 cm) and the lowest length of panicle (27.2 cm) produced from the treatment where no fertilizer was applied. The highest panicle length (33.2 cm) was obtained from the interaction between mulch with 125% STB fertilizer. The lowest panicle length (25.5 cm) was obtained from the interaction between no mulch with no fertilizer.

Though there was a no significant effect of mulching on panicle length of rice, the impact of fertilizer application on it was significant. The results were supported by the findings of (Mondal et al., 2010) who prepared that panicle length of rice increased with the increasing rates of N, P and K. The effect of interaction between the fertilizer applications and mulch on panicle length was not significant. The treatments may be ranked in the order of $T_3 > T_2 > T_1$.

3.1.5. Number of grains $panicle^{-1}$

Mulch gave a higher number of grains $panicle^{-1}$ (209.8) than that of no mulch (171.2) (Table 1). 125% STB fertilizer recommendation produced the highest number of grains $panicle^{-1}$ (213.3) and the lowest number of grains $panicle^{-1}$ (159.3) was produced from the control plot. The highest number of grains $panicle^{-1}$ (213.03) was obtained from the interaction between mulch with 125% STB fertilizer recommendation. The lowest number of grains $panicle^{-1}$ (126.2) was obtained from the interaction between no mulch with no fertilizer (Table 2). The effect of mulching and fertilizer application on a total number of filled grain $panicle^{-1}$ was significant. The results were supported by the findings of (Mondal et al., 2010) who reported that the number of grains $panicle^{-1}$ of rice increased with the increasing rates of N, P and K. The interaction effects of mulching and fertilizer application on a total number of filled grain $panicle^{-1}$ was also significant.

3.1.6. Thousand grain weight

Mulch had a higher weight of 1000-grains (24.4 g) than that of no mulch (24.2 g) (Table 1). 125% STB fertilizer produced the highest weight of 1000-grain (24.7 g) and without fertilizer, recommendation produced the lowest weight of 1000-grains (23.9 g). However, the highest weight of 1000-grain (24.9 g) was observed in the interaction between 125% STB fertilizer recommendation and no mulch, and the lowest weight of

Table 1: Effects of mulch on the growth and yield of Jhum crop under the slush-mulch condition

Mulch	Plant height (cm)	No of tillers hill^{-1}	No of effective tillers hill^{-1}	Panicle length (cm)	Filled grains panicle^{-1}	1000-grain wt (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
No Mulch	143^{b}	11.7^{b}	11.3^{b}	29.1^{a}	171.2^{b}	24.4^{a}	3.34^{b}	5.73^{b}
Mulch	147^{a}	13.7^{a}	13.2^{a}	31.2^{a}	210^{a}	24.2^{a}	4.04^{a}	6.69^{a}
$\sigma_{\bar{x}}$	0.1213	0.121	0.121	0.121	0.121	0.121	0.121	0.121

Note: Different letters in a column indicate statistically significant difference at 5% level, $\sigma_{\bar{x}}$ means: Standard Error

Table 2: Interaction effects of fertilizer and mulches on the growth and yield of Jhum crop under the slush-mulch condition

Interaction	Plant height (cm)	No of tillers hill^{-1}	No of effective tillers hill^{-1}	Panicle length (cm)	Filled grains panicle^{-1}	1000-grain wt (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
M_1T_1	126^{c}	10^{b}	9.1^{c}	25.5^{b}	126.23^{c}	24.1^{bc}	1.89^{b}	3.66^{c}
M_1T_2	149^{b}	14^{a}	13.5^{ab}	30^{a}	173.7^{bc}	24.1^{bc}	4^{a}	6.83^{b}
M_1T_3	153^{ab}	12^{ab}	11.4^{abc}	31.8^{a}	213.6^{ab}	24.8^{a}	4.1^{a}	6.72^{b}
M_2T_1	132^{c}	11^{ab}	11.2^{bc}	28.9^{ab}	192.4^{ab}	23.7^{c}	3.42^{a}	4.47^{c}
M_2T_2	152^{ab}	15^{a}	14.1^{ab}	31.3^{a}	223.9^{a}	24.3^{abc}	4.3^{a}	7.31^{ab}
M_2T_3	155^{a}	15^{a}	14.3^{a}	33.2^{a}	213^{ab}	24.6^{ab}	4.4^{a}	8.32^{a}
$\sigma_{\bar{x}}$	2.850	0.563	0.553	0.750	9.466	0.114	0.241	0.425

Note: Different letters in a column indicate statistically significant difference at 5% level, $\sigma_{\bar{x}}$ means: Standard Error.
The highest number of effective tillers hills^{-1} (14.3) was found in the treatment combination of mulch and 125% STB fertilizer recommendation and the lowest number of effective tillers hill^{-1} (9.1) was found in the treatment combination of no mulch and without fertilizer recommendation.

1000-grain (23.7 g) was observed in the interaction between without fertilizer and mulch (Table 2).

Mulching had no significant effect on the weight of 1000 grain of rice, but fertilizer application created a significant impact on it. The interaction effect of mulching and fertilizer applications on the weight of 1000 grain was significant. The treatments were ranked in the order of $T_3>T_2>T_1$ with respect to 1000-grain weight. (Sarkar and Singh, 2008) found that application of NPK fertilizers increased 1000-grain weight.

3.1.7. Grain yield

The grain yield (4.03 t ha^{-1}) was higher in mulch than that (3.34 t ha^{-1}) of no mulch (Table 1). The highest grain yield (4.3 t ha^{-1}) was achieved at the use of 125% STB fertilizer and the lowest grain yield (2.7 t ha^{-1}) was found in without the use of chemical fertilizer. The highest grain yield (4.4 t ha^{-1}) was obtained from the interaction between mulch with the 125% STB fertilizer recommendation which was identically followed by the interaction M_2T_2 (4.26 t ha^{-1}), M_1T_3 (4.09 t ha^{-1}), M_1T_2 (4.03 t ha^{-1}), and M_2T_1 (3.42 t ha^{-1}). The lowest grain yield (1.89 t ha^{-1}) was obtained from the interaction between no mulch with no fertilizer (Table 2).

The impact of mulching on grain yield of rice was not significant, but it was significantly favored by fertilizer application. Sharma and Bali (2001) found that yield and total N, P and K uptake of rice increased significantly with the increased levels of N, P and S application. (Singh and Singh, 2002) found that rice yield was significantly increased with increasing level of NPK to 100% of the recommendation rate. The interaction effects between mulching and fertilizer applications on grain yield of rice were not significant. (Satyanarayana et al., 2010) reported that grain yield was significantly increased due to the application of NPKS fertilizers. (Nyalemegbe et al., 2009) also cited that increasing the rate of NPK fertilizer application increase the yield of rice significantly.

3.1.8. Straw yield

The higher straw yield (6.69 t ha^{-1}) was obtained in mulch than that (5.73 t ha^{-1}) of no mulch (Table 1). The highest straw yield (7.5 t ha^{-1}) was obtained from 125% STB fertilizer recommendation which was followed by 100% STB fertilizer recommendation (7.1 t ha^{-1}) and the lowest straw yield (4.1 t ha^{-1}) was obtained from without use of fertilizer . The highest straw yield (8.32 t ha^{-1}) was obtained from the interaction between mulch with 125% STB fertilizer recommendation which was followed by M_2T_2 (7.31 t ha^{-1}).The lowest straw yield (3.66 t ha^{-1}) was obtained from the interaction between no mulch with no fertilizer treatment which was statistically similar in M_2T_1 (4.47 t ha^{-1}) (Table 2).

The straw yield of rice was significantly favored by the adoption of the mulching practice. The effect of fertilizer applications on the straw yield was significant and positive. Straw yield was significantly favored by the combined adoption of mulching and fertilizer application. The treatment performance in terms of straw yield ranked in the order of $T_3 > T_2 > T_1$. (Islam et al., 2010) reported that the straw yield was significantly increased due to the application of NPK fertilizers. (Nyalemegbe et al., 2009) also found the same results in case of the straw yield of rice.

3.2. *Maize*

The highest grain yield (927.7 kg ha^{-1}) was achieved at the use of 125% STB fertilizer and the lowest grain yield (494.5 kg ha^{-1}) was found in without the use of chemical fertilizer. The grain yield of maize (781 kg ha^{-1}) was higher in mulching than that (707.1 kg ha^{-1}) of no mulch. The highest grain yield (975 kg ha^{-1}) was obtained from the interaction between mulch with the 125% STB fertilizer recommendation which was significantly higher than the interaction effect of M_2T_2 (856 kg ha^{-1}), M_1T_3 (880.3 kg ha^{-1}), M_1T_2 (764 kg ha^{-1}) and M_2T_1 (512 kg ha^{-1}). The lowest grain yield (477 kg ha^{-1}) was obtained from the interaction between no mulch with no fertilizer (Figure 1 and Table 3).

Jhumia farmers use rice as a major crop and other crops as the minor. Seeds of different crops are mixed together and sown. The ratio of seed mixture (rice: another crop) is 100:1. That rice cover 95% of the total land area and other crops cover 5% of rest of the land. The yield of Jhum crops other than rice got from that 5% are represented here. Grain yield of maize was significantly influenced by the use of chemical fertilizer and the adoption of mulch practice. (Sarkar and Singh, 2008) assessed the integrated effect of chemical fertilizer (NPK) on grain yield and nutrient availability and they found that rice yields were significantly increased level of NPK up to 100% of the recommendation rate. The interaction effect of mulching practice and addition of different levels of fertilizer on grain

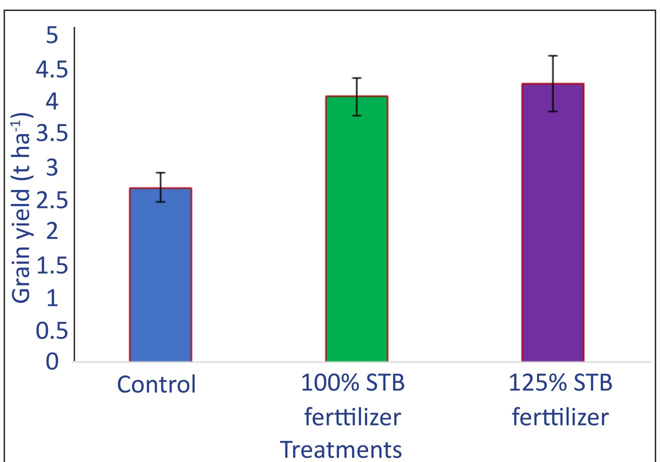

Figure 1: Effects of fertilizer on the yield of Jhum rice under the slush-mulch condition

Table 3: Effects of fertilizers and mulches on the yield of crops other than rice under the slush-mulch condition

nter-action	Maize (kg ha^{-1})	Sweet gourd (kg ha^{-1})	Marpha (kg ha^{-1})	Sesame (kg ha^{-1})	Yard long bean (kg ha^{-1})
M_1T_1	477^d	680^d	436^d	133^d	2552^d
M_1T_2	764^c	933^c	515^c	257^b	2740^{bc}
M_1T_3	880^b	1039^b	663^b	289^{ab}	2852^b
M_2T_1	512^d	665^d	442^{cd}	190^c	2670^{cd}
M_2T_2	856^b	1078^{ab}	613^b	328^a	2813^b
M_2T_3	975^a	1176^a	746^a	345^a	3930^a
$\sigma_{\bar{x}}$	29.02	45.68	33.7	25.3	57.7
CV%	4.78	6.03	7.27	12.04	2.41

Note: Different letters in a column indicates statistically significant difference at 5% level Here, $\sigma_{\bar{x}}$ means: Standard Error

yield of maize was also significant. The treatments were ranked in the order of $T_3 > T_2 > T_1$ in terms of maize yield. (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.

3.3. *Sweet gourd*

The fruit yield of sweet gourd ranged from 672.8 to 1108 kg ha^{-1}. The maximum yield of 1108 kg ha^{-1} was recorded in T_3 treatment receiving 125% STB fertilizer followed by the yield of T_2 treatment (1006 kg ha^{-1}). The minimum yield of 673 kg ha^{-1} was recorded in T_1 treatment where no fertilizer was used. The yield of sweet gourd (973 kg ha^{-1}) was higher in mulching than that (884 kg ha^{-1}) of no mulch. The highest yield of sweet gourd (1176 kg ha^{-1}) was obtained from the interaction effect of mulch with the 125% STB fertilizer recommendation which was identically followed by the interaction M_2T_2 (1078 kg ha^{-1}), M_1T_3 (1039 kg ha^{-1}), M_1T_2 (933 kg ha^{-1}), and M_1T_1 (680 kg ha^{-1}). The lowest grain yield (665 kg ha^{-1}) was obtained from the interaction between mulch with no fertilizer (Table 3). Both mulching and fertilizer treatments individually and combinedly created significant impact on yield of the sweet gourd. The yield response of the treatments were being ranked in the order of $T_3 > T_2 > T_1$. (Alam, 2014) reported that the combination of NPK fertilizers increased the fruit yield of sweet gourd significantly.

3.4. *Marpha (cucumber)*

The maximum yield 705 kg ha^{-1} was recorded from T_3 treatment receiving 125% STB fertilizer which was slightly higher than other treatments. Second highest yield 564 kg ha^{-1} was recorded from T_3 treatment receiving 100% STB fertilizer. The lowest yield 439 kg ha^{-1} was observed in T_1 treatment receiving no fertilizer which was statistically identical with T_2 treatment receiving only mulch. The yield of marpha (600 kg ha^{-1}) was higher in mulching than that (538 kg ha^{-1}) of no mulch. The highest yield of marpha (746 kg ha^{-1}) was obtained from the interaction between mulch with the 125% STB fertilizer recommendation which was identically followed by the interaction M_2T_2 (613 kg ha^{-1}), M_1T_3 (663 kg ha^{-1}), M_1T_2 (515 kg ha^{-1}), and M_2T_1 (442 kg ha^{-1}). The lowest yield of marpha (436 kg ha^{-1}) was obtained from the interaction between no mulch with no fertilizer (Table 6). The yield of marpha was significantly affected by both adoptions of mulch and fertilizer applications individually as well as combinedly. The treatments were ranked in the order of $T_3 > T_2 > T_1$ in terms of marpha yield. (Bolotskikh and Leivi, 2013) recorded highest fruit yield of cucumber with the application of 120:70:90 kg NPK ha^{-1}. (Ubeiz, 2009) reported that NPK fertilizer has a positive response to the vegetative growth and increased yield of cucumber.

3.5. Sesame

The sesame yield ranged from 161.5 to 317 kg ha^{-1}. The highest yield of 317 kg ha^{-1} was found in T_3 treatment receiving 125% STB fertilizer. The lowest yield of 161.5 kg ha^{-1} was recorded in T_1 (control) treatment. The treatment T_3 produced the highest grain yield than other treatments. The second highest yield of 292.5 kg ha^{-1} was found in T_2 treatment receiving 100% STB fertilizer which was statistically similar with T_3 treatment receiving 125 % STB fertilizer practice. The yield of sesame (287.67 kg ha^{-1}) was higher in mulching than that (226.33 kg ha^{-1}) of no mulch. The highest yield of sesame (345 kg ha^{-1}) was obtained from the interaction between mulch with the 125% STB fertilizer recommendation which was identically followed by the interaction M_2T_2 (328 kg ha^{-1}), M_1T_3 (289 kg ha^{-1}), M_1T_2 (257 kg ha^{-1}), and M_2T_1 (190 kg ha^{-1}).The lowest yield of sesame (133 kg ha^{-1}) was obtained from the interaction between no mulch with no fertilizer (Table 3). The second highest yield of sesame (328 kg ha^{-1}) was obtained from the interaction between mulch with the 100% STB fertilizer which was statistically similar with M_2T_3 treatment. Both mulching and fertilizer treatments individually and combinedly created significant impact on yield of sesame. The yield response of the treatments were ranked in the order of $T_3 > T_2 > T_1$. (Tumbare, and Bhoite, 2002) found that application of 75 kg P_20_5/ha increased the number of capsule plant^{-1}, seeds capsule^{-1} and seed yield of sesame.

3.6. Yard long bean

The yield of yard long bean ranged from 2610.8to 3391 kg ha^{-1}. The highest yield 3391 kg ha^{-1} was recorded from T_3 treatment receiving 125% STB fertilizer which was slightly higher than other treatments. Second highest yield 2777 kg ha^{-1} was recorded from T_2 treatment receiving 100 % STB fertilizer. The lowest yield 2611 kg ha^{-1} was observed in T_1 treatment receiving no fertilizer. The yield of yard long bean (3138 kg ha^{-1}) was higher in mulching than that (2715 kg ha^{-1}) of no mulch. The highest yield of yard long bean (3930 kg ha^{-1}) was obtained from the interaction between mulch with the 125% STB fertilization which was identically followed by the interaction M_1T_3 (2852 kg ha^{-1}), M_2T_2 (2813 kg ha^{-1}), M_1T_2 (2740 kg ha^{-1}) and M_2T_1 (2670 kg ha^{-1}). The lowest yield of yard long bean (2552 kg ha^{-1}) was obtained from the interaction between no mulch without any fertilizer (Table 3). Both mulching and fertilizer treatments individually and combinedly created significant impact on yield of the yard-long bean. The yield response of the treatments were ranked in the order of $T_3 > T_2 > T_1$. (Shukla and Gupta, 2014) reported an increase in a number of fruits and size due to increase in N application.

3.7. Apparent nutrient balance

3.7.1. Apparent nutrient balance in no mulch condition

Erosion removed from the topsoil, which is the part of the soil containing the highest concentration of nutrients. There were appreciable differences in nutrient status between applications of no mulch practice under Jhum cultivation. The Figure 2 showed that all the nutrients i.e N, P, K and S was negative balance in after harvesting of Jhum cultivation. In case of no mulch plot in Jhum without fertilizer (control) treatment, the soil nutrient balances were -240.47, -26.18, -107.11 and -53.78 kg ha^{-1} for N, P, K and S respectively. In

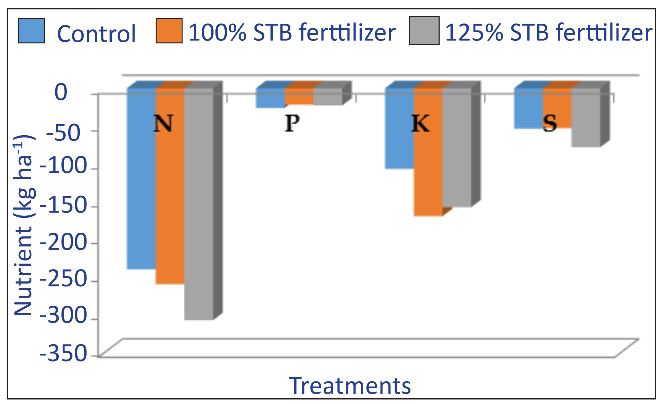

Figure 2: Apparent nutrient balance in Jhum system under no mulch condition

100 % STB fertilizer treatment, the soil nutrient balances were -260.2, -21.92, -169.89 and -53.19 kg ha^{-1} for N, P, K and S respectively. On the other hand, a negative nutrients balance was found in soil of no mulch condition of 125 % STB fertilizer treatment which was -308.06, -22.94, -157.91 and -79.39 kg ha^{-1} for N, P, K and S respectively. (Singh et al., 2008) reported that there was a general negative nutrient balance in *Khet* land in Nepal. This might be the higher crop yields on hilly land, which extracted significantly more nutrients. The maximum negative balance was found in T_3 treatment. The negative balance was intensified with an increased rate of fertilization. It may be due to an increase of nutrient in the soil, which influenced to produce more yield. In fact, due to the increased crop yield, the plants up took more nutrients from the soil which caused nutrient depletion. It might be due to more nutrient up taken for more yields in 125% recommended

doses of chemical fertilizer. The lowest negative balance was observed in control plot where yield was lowest.

3.7.2. Apparent nutrient balance in mulch condition

The experimental result shows that negative nutrients balance was observed in case of mulch condition in Jhum cultivation. Highest nutrient depletion occurs for N followed by K, S and thus P. The nutrient balance was found in T_1 treatment (without any fertilizer) as -143.83, -2.68, -30.35 and -8.36 kg ha^{-1} for N, P, K and S, respectively. In T_2 treatment, the nutrient balance was found as -220.17, -3.28, -79.9 and -44.15 kg ha^{-1} for N, P, K and S, respectively. In addition, the negative nutrients balance were also found in the soil of mulch condition of 125 % STB fertilizer treatment which was -259.96, -5.76, -114.32 and -46.1 kg ha^{-1} for N, P, K and S, respectively. Similarly, the negative nutrient balance of N, P, K and S was found in Jhum cultivation under mulch condition for all treatments. Nitrogen loss was found as -143.83, -220.17 and -259.96 kg per hectare of control, T_2 and T_3, respectively. Loss of K was found as -30.35, -79.9 and -114.32 kg per hectare of control, T_2 and T_3, respectively. In case of S, the loss was found as -8.36, -44.15 and -46.1 kg ha^{-1} of control, T_2 and T_3, respectively. Besides that, P was found negative balance in all treatments which was -2.68, -16.41, and -22.06 kg ha^{-1} in control, T_2 and T_3, respectively (Figure 3).

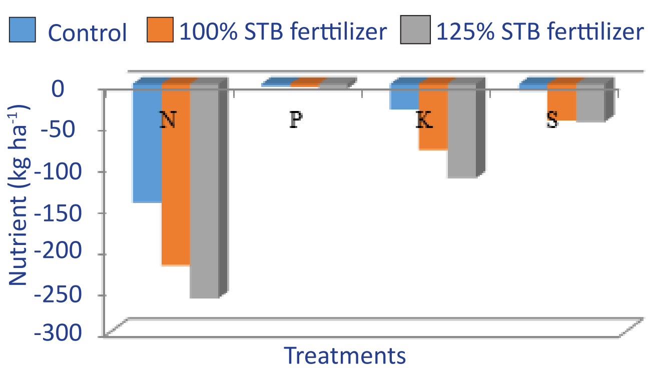

Figure 3: Apparent nutrient balance in Jhum system under mulch condition

The experimental result shows that the negative nutrient balance was observed for all nutrients except P in case of mulch condition in Jhum. The negative balance of N, K and S were found in Jhum cultivation under mulch condition for all treatments. Besides that, P was found positively balanced in all treatments. The only P showed a positive balance with inputs after post-harvest. Comparing with mulching and non-mulching condition, it is found that the negative balance of nutrient was lower than mulching plot. It may be, due to a decrease in soil erosion from the mulched plot.

This statement was supported by Manna et al. (2007). Thus, under current management practices, the Jhum cultivation system may not be sustainable in the long-term if current traditional practices remain unchanged. It is indicated that P has no depletion or loss since most of it remains in acidic soil in an unavailable form. So, most P remains in the soil.

4. Conclusion

Mulch treated plants showed significantly higher plant height (146.5 cm), number of tillers (13.7), panicle length (31.2 cm), number of grains panicle^{-1} (209.8) and yield plants^{-1} over the non-mulched plant. Mulched plants produced the higher yield of Jhum rice (4.44 t ha^{-1}) and other than Jhum crops as compared to the plants with no mulch. There were considerable differences in nutrient status between mulch and no-mulch practice under on Jhum cultivation.

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