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Study on Productivity of Jhum Crops and Post-harvest Soil Nutrient Status by Using NPK Briquette

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Abstract

The experiments were conducted at Bandarban hill district in Chittagong, Bangladesh during March, 2017 to November, 2017 to study the effect of NPK briquette on the growth and development of Jhum crops and examine of Jhum field soil by using NPK briquette. In this experiment, Jhum crops i.e. cucumber, maize, sweet gourd and chili were used as the test crop. The experiment was conducted in two fields designed on Randomized Completely Block Design (RCBD). The treatments consisted of 7(seven) levels of NPK briquette i.e. Control, 100% RFD (267.5 kg ha^{-1}), 120% RFD (320.8 kg ha^{-1}), 80% RFD (214.1 kg ha^{-1}), 100% NPK briquette (267.5 kg ha^{-1}), 120% NPK briquette (320.8 kg ha^{-1}), 80% NPK briquette (214.1 kg ha^{-1}). The highest yield of cucumber (912.6 kg ha^{-1}), maize (846.2 kg ha^{-1}), sweet gourd (1517.0 kg ha^{-1}) and chili (187.7 kg ha^{-1}) were found in 100% NPK briquette and for all cases lowest results were found in control treatment. Most of the time post-harvest soil of field-I and II contain higher organic matter (2.86%), organic carbon (1.70%), total nitrogen (0.087%), exchangeable K (0.14 meq 100 g^{-1}), available Zn (0.66 µg g^{-1}) in 100% NPK briquette (267.5 kg ha^{-1}) and for all treatment lower organic matter (2.65%), organic carbon (1.61%), total nitrogen (0.080%), exchangeable K (0.10 meq 100 g^{-1}), available Zn (0.41 µg g^{-1}) were found in control.

Keywords: Jhum crops, NPK briquette, post-harvest soil analysis

1. Introduction

Jhum cultivation (also called slash and burn agriculture, shifting cultivation or Sweden cultivation) is a centuries old agricultural practice of indigenous people of Chittagong Hill Tracts (CHT). It is closely related with the socio-cultural settings of some hill communities (Anonymous, 1997). Shifting cultivation, once a subsistence farming system of mountainous people, has become unsustainable both environmentally and economically, and many Asian countries are replacing the system with permanent agriculture (Rasul and Thapa, 2003). However, it is still being widely practised in hilly areas of Bangladesh (Haque et al., 2016), and considered as the major source of livelihood for tribal people. It has been estimated that about 26,000 households practise shifting cultivation (Jhum) every year, and nearly 143,000 people depend on Jhum for subsistence (Shoaib, 2000). Despite declining productivity, farmers practise Jhum because they feel it is the basis of hill people's cultural identity (Ahmed et al., 2005. Research on Jhum in the Chittagong Hill Tracts is as old as interest in the study of tribal culture, and dates back to British rule of the Indian subcontinent.

Article History

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Much of the mountainous land in Southeast Asian countries is populated by diverse cultural minority communities who practise different forms of shifting cultivation that in the past enabled them to coexist in relative harmony with the environment (Cairns and Garrity, 1999). But the most critical factor that governs the sustainability of shifting cultivation is the length of the fallow period (Abizaid and Coomes, 2004). Evidence indicates that socio-economic constraints and increasing demographic pressure have led farmers to switch from traditional low-input cropping systems towards a shorter fallow period (Clermont-Dauphin et al., 2005), which reduces crop yield. This low-level production system has created many problems in upland communities, the most visible ones being acute poverty and malnutrition.

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. Chittagong Hill Tracts is completely different in physical features, agricultural practices and soil conditions from rest of the country (Dasgupta and Ahmed, 1998). Degradation of upland soils is widespread and continues to accelerate due to gradual intensification of crop production without applying balanced fertilizers or manures and soil erosion (Das, 2014). Soil erosion varies with hill slope and rainfall intensity. Most erosion occurs during the peak rainy season. Soil loss and nutrient depletion due to erosion are very high, particularly in the rainfed marginal lands in the hills (Alam, 2014). Indigenous soil-fertility management approaches in managing soil productivity, farmers' perceptions and assessments on soil-fertility depletion are the important aspects for creating favorable soil conditions for plant growth, nutrient application, soil conservation and soil fertility management. Besides, effective soil erosion control become an essential part of sustainable upland agriculture systems and can be used to alleviate and solve the problems of agro-ecological and environmental degradation (Gafur et al., 2003).

Once the land becomes inadequate for crop production it is then left to be reclaimed by natural jungle vegetation once again, while the same activity continues elsewhere, with this cycle continually repeating itself. They also cultivate many kinds of fruits and vegetables in the same month of the year, which may cause huge amount of soil erosion and depletion of soil nutrient (Roy, 2002). In Jhum cultivation, the fallow period was long enough to permit the growth of natural vegetation because of the availability of enough land for such cultivation. But in recent times, it has been dangerously reduced from its traditional ten year fallow period to two to three years (Alim, 2012). This is because of population pressure and the reduction of agricultural land due to the Kaptai reservoir and large-scale non-tribal settlements. Harmful results of Jhum cultivation include reduction of soil fertility, erosion of land, deforestation, and siltation of rivers and lakes. As a result of all these, crop yields have decreased significantly. Thus it is very important to find out suitable alternatives to Jhuming.

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. The Jhum yields are almost equal to the input values and the farmers are experienced food shortage of 2 to 6 months every year (Das, 2011). The Jhum cultivation lead to decline of productivity by 50%, the yields are almost equal to the input values and the farmers are experienced food shortage of 2 to 6 months every year. The Jhum farmers adopt new occupations to support their livings. An amount of 100 to 250 metric tons of topsoil per hectare are depleted per year due to Jhum cultivation. The rotation cycle of fallowing has been reduced from 7-8 to 3-4 years especially in Bangladesh (Anonymous, 2015).

To sustain the livelihood of the Jhum cultivators, the farmers adopted alternate occupations and frequent shifting from one land to other the ecology of the area has been affected badly. So that there earning means are declining day by day which affect there all livelihood system. Although Jhum cultivation is a non-viable resource utilization practice in Bangladesh, the tribal are clinging to this practice to sustain their livelihood due to their religious faith on it. In most cases, the Jhum farmers does not use any fertilizer or use in little amount. As a result, the productivity of Jhum crops 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. Considering these facts as stated, the present study will be undertaken to cultivate of Jhum Crops (cucumber, maize, sweetgourd and chilli) and Examine of Jhum field soil by using NPK briquette. For that reason, this detailed study was under taken to study yield of the Jhum crops and post-harvest soil nutrient status.

2. Materials and Methods

Two experiments were conducted at Ramery para, Bandarbansadar, Bandarban hill district in Chittagong, Bangladesh under the AEZ 29 (Northern and Eastern Hills Tract) during March 2017 to November 2017. General soil type, Brown Hill soil (loamy and acidic), Topography: Sloppy and Steep %, Slope: 30-35%, Drainage: Well drained, Flood level: Above flood level. The selected land was slashed and burned and partially burnt plant parts were cleaned before final land preparation. The experiments were laid out in Randomized Completely Block Design (RCBD).

NPK briquette was applied just after emergence of seedling of different Jhum crops by dibbling method. This chapter presents a brief description of the soil, crop, and experimental design, treatments, pre and post-harvest collection of soil, plant samples and analytic methods followed in the experiment. To fulfill my objectives, two experiments were conducted in two hills of same areas simultaneously.

2.1. Details of the experimental site

2.1.1. Climatic condition

The climate is tropical in Bandarban. Bandarban has significant rainfall most months, with a short dry season. The average temperature in Bandarban is 25.9 °C. Bangladesh Meteorological Department, Agargoan, Dhaka-1207(2017). The muggiest day of the year is August 1, with muggy conditions 100% of the time. The average hourly wind speed in Bandarban experiences significant seasonal variation over the course of the year. The windier part of the year lasts for 3.2 months, from May 22 to August 29, with average wind speeds of more than 5.3 miles per hour. The windiest day of the year is June 28, with an average hourly wind speed of 7.0 miles per hour. Details of weather data in respect of temperature (°C), rainfall (mm) and relative humidity (%) for the study period was collected from Bangladesh Meteorological Department, Agargoan, Dhaka-1207 (2017).

2.1.2. Soil

The Northern and Eastern Hills are underlain by sandstone, siltstone and shale of Tertiary and Quaternary ages. The soils developed on these parent materials are brown in colour, usually loamy in texture and very strongly acidic in reaction. Landscape is steep and soils were mainly developed on steep slopes and some occur on more gentle slopes. The steepness of the landscape determines the depth of the soil. Soils are in general shallow in depth. In field-I, physical and chemical properties of the soil sample before planting, Sand 20%, Silt 44% Clay 36%, Textural class: Clay loam, pH: 4.4, Bulk Density (g cc^{-1}): 1.43, Particle Density (g cc^{-1}): 2.54, Organic carbon (%): 1.74, Organic matter (%): 2.93, Total N (%): 0.090, Available P (μg g^{-1}): 1.5, Exchangeable K : (meq/100 g soil) 0.10, Available S (μg g^{-1})): 6.8 and in field-II, sand 12%, Silt 21% Clay 67%, Textural class: Clay, pH: 4.6, Bulk Density (g/cc): 1.37, Particle Density (g cc^{-1}): 2.51, Organic carbon (%): 1.77, Organic matter (%): 2.87, Total N (%): 0.080, Available P (μg g^{-1}): 1.8, Exchangeable K : (meq/100 g soil) 0.09, Available S (μg g^{-1})): 7.1.

2.1.3. Planting material

Jhum crops also cultivate by their local collection of previous year Jhum cultivation. In my experiment we were used seed of local variety for cucumber, maize, sweet gourd, and chili cultivation.

2.1.4. Land selection

Land selection is done during the month of February-March. Soil fertility, degree of hill slope, accessibility and distance from the villages are the main consideration for the selection of land for Jhum. Cultivator determines soil fertility from the soil color and growth of the bushes. Black colored soil and lands with vigorous growth of vegetation are considered as fertile land suitable for Jhum cultivation. The lands were selected at Ramery para (name of the villages) of two hills of same areas simultaneously.

2.1.5. Experimental design and treatments

The experiments were laid out in a Randomized Completely Block Design (RCBD) with three replications. The total number of plots was 21(3×7). The unit plot size was 12 m^2. Block to block distance was 0.5 m and plot to plot distance was 0.5m.There were 7 treatment combinations. The treatment combinations were as follows: T_1 = Control, T_2 = 100% RFD*, T_3 = 120% RFD, T_4 = 80% RFD, T_5 = 100% NPK briquette, T_6 = 120% NPK briquette, T_7 = 80% NPK briquette. RFD: N 60 kgha^{-1}, P 20 kg ha^{-1} and K 30 kg ha^{-1}.

2.1.6. Collection and preparation of initial soil sample

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

2.1.7. Seed sowing

Sowing commences as soon as the monsoons starts and the ground is saturated, generally in the months of May and June. In Jhum cultivation, dibbling method is used for sowing the seed with the help of locally made iron fork. Sometimes Khurpi (a tool for ploughing), tagol (knife) is also used in this method seeds are sown directly in the soil without disturbing the soil. The seeds of maize, cucumber, sweet gourd and chili were mixed together and sown in the field.

2.1.8. Application of fertilizers (RFD) and NPK briquette

Generally In the experiment Urea, TSP, MoP and Gypsum were used as a source of N, P and K. Half urea and full amount of TSP and MoP and some amount of gypsum were applied at the time of final land preparation by dibbling method. After that seed were sown in the field. When seedling emergence after 8-10 days of seed sowing, NPK briquette were used in every plot by dibbling method without control. The amounts of nitrogen, phosphorus and potassium fertilizers required per plot were calculated from NPK briquette ratio rate per hectare. T_5:100%NPK briquette (267.5 kg ha^{-1}), T_6: 120% NPK briquette (320.8 kg ha^{-1}), T_7: 80% NPK briquette (214.1 kg ha^{-1}).

2.1.9. Inter cultural operations

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

2.1.10. Data collection

The data on the following growth and yield contributing characters of the Jhum crops were recorded: For cucumber, maize, sweet gourd and chili: i) Yields (kg ha^{-1}). In this experiment harvesting field-1, of Maize was done on 12 August, 2017, Cucumber on 15 August, 2017, Chili on 21 August, 2017 Sweet gourd on 30 August, 2017. In case of

Field-2 harvesting of Maize was done on 18 August, 2017, Cucumber on 24 August, 2017, Chili on 19 August, 2017 Sweet gourd on 1 September, 2017.

2.1.11. Physical and chemical analysis of soil samples

Both physical and chemical properties of soil samples were analyzed in the soil science laboratory of Sher-e-Bangla Agricultural University, Dhaka and Soil Research Development Institute (SRDI) Farmgate, Dhaka. The properties studied included soil texture, pH, organic matter, organic carbon, total N, available P and exchangeable K.

2.1.12. Particle size analysis

Hydrometer Method was used in particle size analysis of soil (Bouyoucos, 1926) and the textural class was determined by plotting the values for % sand, % silt and % clay to the "Marshall's Textural Triangular Coordinate" according to the USDA system.

2.1.13. Statistical analysis

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

3. Results and Discussion

Two experiments were conducted to examine the influence of NPK briquette levels on the yield of Jhum crops in hilly areas. The experiments results were conducted under field conditions. Treatments effect of NPK briquette on all the studied parameters have been presented and discussed under the observation of field-I and field-II.

3.1. Effect of NPK briquette on the yield of Jhum crops

The yield of Jhum crops namely cucumber, maize, sweet gourd, chilli were mentioned in Table 1 and Table 2.

3.1.1. Yield of cucumber

Cucumber cultivation was greatly significant by different levels of NPK briquette in hilly areas. In field-I, maximum fruit yield of cucumber ranged over control was observed from 124.8 kg ha^{-1} to 912.6 kg ha^{-1}. The highest fruit yield of cucumber (912.6 kg ha^{-1}) was found in treatment T_5, which was statistically different from all other treatments. The lowest fruit yield of cucumber (124.8 kg ha^{-1}) was found in T_1 treatment where no fertilizer was applied i.e. control treatment. The fruit yield of cucumber per treatment was ranked in $T_5>T_6>T_7>T_4>T_2>T_3>T_1$. (Azam et al., 2012) showed the similar results that application of different levels of NPK fertilizers significant affected the growth and yield components of cucumber. The effect of burning was to increase soil nutrient content relative to the Caatinga area samples, followed by decreases of N and organic P by 20%, available P by 70%, and exchangeable bases by 55%, on average, after abandonment. The unfertilized control of the missing-element trial gave the lowest dry matter (DM) yields (Salcedo et al., 1997).

In field-II, fruit yield of cucumber ranged over control was observed from 129.1 kg ha^{-1} to 763.3 kg ha^{-1}. The highest fruit yield of cucumber (763.3 kg ha^{-1}) was found in treatment T_5, which was statistically different from all other treatments. The lowest fruit yield (129.1 kg ha^{-1}) was found in T_1 treatment where no fertilizer was applied i.e. control treatment. The second highest yield was also obtained from NPK briquette treatment (T_7) by receiving 120% NPK briquette. The minimum fruit yield of 124.8 kg ha^{-1} was found in T_1 (control) treatment having no fertilizer. The fruit yield per treatment was ranked in $T_5>T_7>T_6>T_3>T_2>T_4>T_1$. Ubeiz (2009) found the effect of NPK on the yield of cucumber. It had been found that the NPK at the rate of 120: 80: 90 kg ha^{-1} gave higher fruit yield than the control (Shukla and Gupta, 1980). According to Van Reuler and Janssen, 1993) mass fractions of N, Ca and Mg in wood < 5 cm ~ and of N in leaves were higher in the 20-Y vegetation than in the 4-Y vegetation. The mass fractions of the other nutrients in the 20-Y vegetation are equal to or lower, especially of K, than those in the 4-Y vegetation. The smaller materials (leaves and litter) have the highest and the coarser materials (wood 5-15cm~ and >15cm 0) the lowest nutrient mass fraction. The 20-Y vegetation contains more N, Ca, and less P and K than the 4-Y vegetation.

3.1.2. Yield of maize

Grain yield of maize was significantly influenced by different level of NPK briquette. In field-I, grain yield of maize ranged over control was observed from 116.7 kg ha^{-1} to 846.2 kg ha^{-1}. The highest grain yield of Jhum maize (846.2 kg ha^{-1}) was found in treatment T_5, which was statistically different from all other treatments (Yaqub et al., 2010). The lowest grain yield of Jhum maize (116.7 kg ha^{-1}) was found in T_1 treatment where no fertilizer was applied i.e. control treatment. (Sharma and Mahajan, 1997) showed by an experiment 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. The grain yield of maize per treatment was ranked as$T_5>T_6>T_3>T_2>T_4>T_7>T_1$.

In field-II, grain yield of maize ranged over control was observed from 164.2 kg ha^{-1} to 625.7 kg ha^{-1}. The highest grain yield of Jhum maize (625.7 kg ha^{-1}) was found in treatment T_5, which was statistically different from all other treatments. The lowest grain yield of Jhum maize (164.2 kg ha^{-1}) was found in T_1 treatment where no fertilizer was applied i.e. control treatment. The grain yield of maize per treatment was ranked in $T_5>T_6>T_3>T_2>T_4>T_7>T_1$. (Sani et al., 2011) showed an experiment to identify the combined effects of NPK on growth and yield of maize. They found that the higher yield obtained by applying NPK @ 130:70:90 kg ha^{-1}. (Leharia and Zaad, 2004). Burning of a 12-year fallow plot resulted in only moderate nutrient recycling via ashes and unburned plant materials (12.5, 2.8 and 29.8 kg ha^{-1} of N, P, and K, respectively) but losses (off-take and atmospheric) from the field of 91, 82 and 70% of N, P, and K, respectively of nutrients contained in plant biomass. Economic yields of rice and cassava declined rapidly with successive cropping cycles. Average yearly atmospheric depositions amounted to 29, 7, and 37kg ha^{-1} of total N, P, and K, respectively. (Dung et al., 2008).

3.1.3. Yield of sweet gourd

Sweet gourd yield also significantly influenced by different levels of NPK briquette in hilly areas of Bandarban. NPK briquette was increased sweet gourd yield because of its slow releasing capability in the field, Table**.** In field-I, fruit yield of sweet gourd ranged over control was observed from 354.5 kg ha^{-1} to 1554.6 kg ha^{-1}. The highest fruit yield of sweet gourd (1554.6 kg ha^{-1}) was found in treatment T_5, which was statistically different from all other treatments. The lowest fruit yield of sweet gourd (354.5 kg ha^{-1}) was found in T_1 treatment where no fertilizer was applied i.e. control treatment. The fruit yield of sweet gourd per treatment was ranked in $T_5>T_6>T_2>T_3>T_4>T_7>T_1$. (Johannes et al., 2003) studies that as the NPK fertilizer application increased above 100 kg NPK ha^{-1}, there was no significant influence of additional application on the fruit growth and fruit size. The mass ratios of N, P and K in leaves may be used as an indication of the relative availabilty of these nutrients in the soil. At both sites the N:P ratio is well over 15 and the K:P ratio over 10. Compared to the values for perennial crops at optimum nutrition, the ratios point to shortage of P (Van Reuler and Janssen, 1989).

In field-II, fruit yield of sweet gourd ranged over control was observed from 205.9 kg ha^{-1} to 1517.0 kg ha^{-1}. The highest fruit yield of sweet gourd (1517.0 kg ha^{-1}) was found in treatment T_5, which was statistically different from all other treatments. The lowest fruit yield of sweet gourd (205.9 kg ha^{-1}) was found in T_1 treatment where no fertilizer was applied i.e. control treatment. (Bala et al., 2016) conducted by an experiment that NPK fertilizer increases the yield of sweet gourd significantly. The second highest yield of sweet gourd also obtained from NPK briquette treatment (T_6) by receiving 120% NPK briquette the third highest yield also obtained 80% NPK briquette treatment (T_7). The fruit yield of sweet gourd per treatment was ranked in $T_5>T_6>T_7>T_2>T_4>T_3>T_1$. Shukla and Gupta (1980) observed that the average yield was 385.37 q ha^{-1} with the full dose of NPK and 300.74 q ha^{-1} with the reduced dose.

3.1.4. Yield of chili

Yield of chili was greatly increased due to use of different level of NPK briquette in hilly areas. Yield of chili also increased by recommended dose of fertilizer dose, Table 1 and 2. In field-I, fruit yield of chili ranged over control was observed from 12.8 kg ha^{-1} to 116.7 kg ha^{-1}. The maximum fruit yield of chili (116.7 kg ha^{-1}) was found in treatment T_5, which was statistically different from all other treatments. The minimum fruit yield of chili (12.8 kg ha^{-1}) was found in T_1 treatment where no fertilizer was applied i.e. control treatment. Tumbare and Niikam (2004) reported that NPK fertilizer increased fruit weight, yield and fruit number of chili peppers. The second highest yield of chili also obtained from NPK briquette treatment T_6 and T_7 by receiving 120% and 80% NPK briquette. The fruit yield of chili per treatment was ranked in $T_5>T_6>T_7>T_2>T_3>T_4>T_1$.

In field-II, chili yield was ranged from 19.8 kg ha^{-1} to 187.7 kg ha^{-1}. The highest fruit yield was 187.7 kg ha^{-1} over control. In field-II, the maximum fruit yield was found T_5 treatment by receiving 100% NPK briquette. The second highest yield of chili also obtained from NPK briquette treatment T_6 and T_7 by receiving 120% and 80% NPK briquette. The lowest fruit yield of 19.8 kg ha^{-1} was found in T_1 (control) treatment having no fertilizer. The fruit yield of chili per treatment was ranked in $T_5>T_7>T_6>T_2>T_4>T_3>T_1$. (Riaz et al., 2004) observed that the mineral nutrients, N, P and K are known to affect growth and yield of the capsicums. So in case of field-I and field-II yield

Table 1: In field-I, effect of NPK briquette on the yield (kg ha^{-1}) cucumber, maize, sweet gourd and chili

Treatments	Cucumber (kg ha^{-1})	Maize (kg ha^{-1})	Sweet Gourd (kg ha^{-1})	Chili (kg ha^{-1})
T_1	124.83^f	116.74^e	354.5^d	12.86^g
T_2	448.16^d	334.32^d	654.9^b	76.05^d
T_3	353.51^e	415.75^c	656.3^b	65.56^e
T_4	516.95^c	334.51^d	516.8^c	57.35^f
T_5	912.63^a	846.22^a	1454.6^a	116.78^a
T_6	608.26^b	467.79^b	648.7^b	102.93^b
T_7	439.72^d	315.11^d	347.8^d	84.90^c
LSD (p=0.05)	15.39	12.96	25.08	1.92

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

Table 2: In field-II, effect of NPK briquette on the yield (kg ha^{-1}) cucumber, maize, sweet gourd and chili

Treatments	Cucumber (kg ha^{-1})	Maize (kg ha^{-1})	Sweet Gourd (kg ha^{-1})	Chili (kg ha^{-1})
T_1	129.18^g	164.23^f	205.9^f	19.89^f
T_2	248.07^e	284.12^e	520.0^d	93.43^d
T_3	319.97^d	359.83^d	451.0^e	77.70^e
T_4	184.13^f	291.71^e	481.7^{de}	90.03^d
T_5	763.30^a	625.76^a	1517.0^a	187.76^a
T_6	396.33^c	409.86^c	758.0^b	114.45^c
T_7	431.11^b	511.14^b	622.2^c	134.52^b
LSD (p=0.05)	8.49	5.49	22.81	3.43

Means in a column followed by same letter(s) are not significantly different at 5% level of significance by RCBD of chili was increased due to using of fertilizer compared with control but highest yield obtained from NPK briquette treatment (Surendra et al., 1995).

3.2. Physio-chemical properties in post-harvest soil

Available nitrogen and phosphorus significantly increased, and there was an increasing trend in soil organic matter following cultivation. The Additional differentiated nine types of soil and preferred specific soil types for shifting and settled cultivation. We documented soil management and methods of soil fertility retention practised by the Additional use of fertilizers (Teegalapalli and Lawrence, 2018). Due to nutrient exports with crops and increasing nutrient leaching, soil fertility is expected to reduce with SC intensity. Therefore, the data indicate that intensification of SC reduces recovery of species richness, composition and basal area of SGs. Environmental sustainability of SC may be achieved by extending fallow periods, limiting the maximum yield. (Villa et al., 2018). The chrono-sequence study revealed that during the five years of fallow there was an increase in soil organic matter and total N attributed to the addition of litterfall from the fallow species, but a decline in pH, available P, and extractable K, Ca, and Mg (Wangpakapattanawong, 2001).

3.2.1. Soil texture

In field-I, after harvesting of crops, percentage of sand, silt and clay were found 20, 45 and 35, respectively. Textural classes were found clay. In field-II, after harvesting of crops, percentage of sand, silt and clay were found 11, 23 and 66, respectively. Textural classes were also found clay. So textural classes and particle size of soil was least significant changed by NPK briquette treatment of Jhum crops.

3.2.2. pH

Most of the soil pH was ranged in these areas from 4.0 to 4.5. After Jhum crops cultivation, variation was observed in post-harvest soil pH due to the application of different levels of NPK briquette (Table 3, 4). In field-I, the pH of post-harvest soil was found highest (4.6) in T_5 treatment and the lowest pH in post-harvest soil 4.1 in T_2 treatment. In field-II, the pH of post-harvest soil was highest (4.4) in T_5 treatment receiving 100% NPK briquette. The lowest pH in post-harvest soil 4.1 was observed from T_1 treatment (control) receiving no fertilizer. The changes in the pH and major soil nutrients after burning

Table 3: In field-I, effect of NPK briquette on pH, organic matter, organic carbon N, P, K and S content in post-harvest soil of Jhum cultivation

Treatments	pH	Organic Matter (%)	Organic Carbon (%)	Total N (%)	Available P ($\mu g\ g^{-1}$)	Exchangeable K (meq 100 g^{-1})	Available S ($\mu g\ g^{-1}$)
T_1	4.4	2.65	1.63	0.080	9.76^d	0.10	5.66^c
T_2	4.1^c	2.84	1.65	0.084	10.13^c	0.12	6.13
T_3	4.3	2.91	1.64	0.080	10.26	0.11	5.86
T_4	4.6^b	2.76	1.64	0.082	10.36^b	0.11	5.76
T_5	4.4^a	2.86	1.66	0.085	11.13^a	0.14	6.46^a
T_6	4.1	2.75	1.64	0.084	11.13^a	0.10	6.46
T_7	4.4	2.78	1.62	0.082	10.03	0.11	6.36^b
LSD (p=0.05)	0.07	NS	NS	NS	0.059	NS	0.035

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

Table 4: In field-II, effect of NPK briquette on pH, organic matter, organic carbon N, P, K, and S content in post-harvest soil of Jhum cultivation

Treatments	pH	Organic Matter (%)	Organic Carbon (%)	Total N (%)	Available P (µg/g)	Exchangeable K (meq/100g)	Available S (µg/g)
T_1	4.1c	2.70	1.61	0.081	9.16^c	0.10	5.86
T_2	4.3b	2.71	1.62	0.083	9.53^c	0.10	6.43^b
T_3	4.1c	2.76	1.64	0.083	10.10^b	0.11	5.86^c
T_4	4.1	2.78	1.67	0.082	10.33^b	0.11	5.86
T_5	4.4a	2.79	1.70	0.087	11.23^a	0.13	6.83^a
T_6	4.4	2.71	1.62	0.082	11.13^a	0.12	6.83
T_7	4.4	2.73	1.65	0.086	11.13^a	0.11	6.53
LSD (p=0.05)	0.10	NS	NS	NS	0.080	NS	0.069

Means in a column followed by same letter(s) are not significantly different at 5% level of significance by RCBD are shown respectively, which indicate the mean and it's 95% confidence interval. Except for NO_3^--N, the concentrations of all the major nutrients and the pH showed steep increases. (Tulaphitak et al., 1985)

3.2.3. Organic matter

Organic matter is the most important element for growing better of all kinds of crops. Jhum cultivation in hilly areas contain higher value of organic matter due burning weeds and straw residues of crops. In post-harvest soil organic matter was varied with different levels of NPK fertilizer for Jhum cultivation. In field-I, the organic matter of post-harvest soil maximum 2.86 was found from T_5 treatment receiving 100% NPK briquette. The minimum organic matter in post-harvest soil 2.65 was observed from T_1 treatment receiving no fertilizer (control). In field-II, the organic matter of post-harvest soil maximum 2.79 was found from T_5 treatment receiving 100% NPK briquette. The minimum organic matter in post-harvest soil 2.70 was observed from T_1 treatment receiving no fertilizer (control).

3.2.4. Organic carbon

Organic carbon in post-harvest soil was found non-significance due to the treatments. In field-I, 100% NPK briquette produced highest the organic carbon content whereas the minimum was observed in control. In field-II, the similar trend was found.

3.2.5. Total nitrogen

Total nitrogen in post-harvest soil remained significant as influenced by the treatments. In field-I, the total nitrogen of post-harvest soil was highest (0.085%) in T_5 treatment (Xing and Zhu, 2000) and minimum was in control. In field-II, highest (0.087%) total nitrogen was found in the treatment receiving 100% NPK briquette and lowest in control. This corresponds with the findings of Savci, 2012. Volume and horizon specific soil samples were analysed for nutrient contents including plant-available N and P. Yields from the test plots were measured and related to land use factors and soil properties. (Bruun et al., 2006)

3.2.6. Available phosphorus

Available P in post-harvest soil was significantly influenced by the different levels of NPK briquette treatment (Table 3 and 4). In field-I, 100% NPK briquette recorded highest (11.13 μg g^{-1}) available P of post-harvest soil which significant over all the treatments except the treatment with 120% NPK briquette. In field-II, the available P of post-harvest soil highest 11.23 (μg g^{-1}) was found from T_5 treatment receiving 100% NPK briquette. The lowest available P in post-harvest soil 9.16 (μg g^{-1}) was observed from T_1 treatment receiving no fertilizer (control).

3.2.7. Exchangeable potassium

Fertilizer K is applied to rice by dibbling method immediately before or after transplanting and in multiple doses during the crop growth period. In general, a major portion, and sometimes all, of the K fertilizer should be applied at or near the time of seeding/transplanting of crops. Exchangeable K in post-harvest soil was greatly influenced by different level of NPK briquette treatment but it was non- significance because variation of K is comparatively near all the treatment. (Table). In field-I, the exchangeable K of post-harvest soil highest 0.14 (meq 100 g^{-1}) was found from T_5 treatment receiving 100% NPK briquette. The lowest exchangeable K in post-harvest soil 0.10 (meq/100g) was observed from T_1 treatment receiving no fertilizer (control). In field-II, the exchangeable K of post-harvest soil highest 0.13 (meq 100 g^{-1}) was found from T_5 treatment. The lowest exchangeable K in post-harvest soil 0.10 (meq 100 g^{-1}) was observed from T_1 treatment receiving no fertilizer (control).

3.2.8. Available sulphur

Available sulphur in post-harvest soil was significantly influenced by different levels of NPK briquette treatment compared with control. In field-I, the available S of post-harvest soil maximum 6.46 (μg g^{-1}) was found from T_5 treatment receiving 100% NPK briquette. The minimum available S in post-harvest soil 5.66 (μg g^{-1}) was observed from T_1 treatment receiving no fertilizer (control). In field-II, the available S of post-harvest soil maximum 6.83 (μg g^{-1}) was found from T_5 treatment receiving 100% NPK briquette. The minimum available S in post-harvest soil 5.86 (μg g^{-1}) was observed from T_1 treatment receiving no fertilizer (control) (Singh and Trivedi, 2017).

4. Conclusion

The growth and yield of Jhum crops were significantly influenced by different levels of NPK briquette and post-harvest soil characteristics like soil physical and chemical properties also influenced. In case of field-I and II, the highest yield of cucumber (912.6 kg ha^{-1}), maize (846.2 kg ha^{-1}), sweet gourd (1517.0 kg ha^{-1}), and chili (187.7 kg ha^{-1}) were found in T_5 by receiving 100% NPK briquette and for all treatment lowest results were found in T_1 (Control) treatment.

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