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Development of Land Management Technology for Continuous Jhum Cultivation in Hilly Area of Bangladesh

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Authors' contributions

This work was carried out in collaboration between both authors. Author MZ designed the study, performed the statistical analysis, wrote the protocol, wrote the first draft of the manuscript and managed the analyses of the study. Author AKP managed the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

The experiments were conducted in three hill district of Bangladesh i.e. Bandarban, Khagrachari and Rangamati under the Agro Ecological Zone (AEZ) 29 (Northern and Eastern Hills Tract) during March 2018 to November 2019 to study the fertilizers packages, NPK briquette and residual effect of fertilizers for continuous jhum cultivation. In this experiments, jhum crops were used as the test crop. The experiment was designed on Randomized Completely Block Design. The treatments consider as normal fertilizers packages ($N_{60}P_{20}K_{30}$ S_{12} kg/ha), NPK briquette ($N_{50}P_{20}K_{30}$ S_{12} kg/ha) and residual effect of fertilizers instead of farmers practice. By different fertilizers packages the results showed that the highest yield of Jhum rice was 3.81 tha^{-1} at Khagrachari, Maize (0.436 tha^{-1}) at Rangamati, Sweet gourd (1.679 tha^{-1}) at Bandarban, Chili (0.348 tha^{-1}) at Khagrachari, Sesame (0.361 tha^{-1}) at Bandarban and Marpha (*Cucumis sativus*) (0.742 tha^{-1}) at Bandarban over farmers' practice. Instead of normal fertilizer application, fertilizer NPK briquette was used with the highest yield of rice was 4.18 t ha^{-1} at Khagrachari, Maize (0.674 tha^{-1}) at Bandarban, Sweet gourd (1.06 tha^{-1}) at Bandarban, Chili (0.514 tha^{-1}) at Khagrachari, Sesame (0.753 tha^{-1}) at Khagrachari

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and Marpha (0.316 tha^{-1}) at Khagrachari. After cultivation of jhum crops another short duration leguminous crops could be cultivated without fertilizers management. The highest yield of cowpea (1.043 tha^{-1}) was obtained at Bandarban site. Yard long bean and Bean yield was also obtained 1.02 and 1.5 tha^{-1} respectively.

Keywords: Fertilizers packages; NPK briquette; residual effect of fertilizers; Jhum.

1. INTRODUCTION

Bangladesh has a total land area of 147,570 km² including 17,342 km² hilly areas (around 12% of the total) [1]. The hills range height vary from several meters to 1,000 meter above the mean sea level. In the undulating terrain in hilly districts of Bandarban, Khagrachari and Rangamati, agriculture occupies only 6% of land area. Nearly 70% of the total households in the hill districts depend primarily on agriculture among them 71% are small and marginal farmers [2]. Jhum cultivation is popularly known as shifting cultivation. Shifting cultivation, once a subsistence farming system of mountainous people, has become unsustainable both environmentally and economically. Many Asian countries are replacing the system with permanent agriculture [3]. However, it is still being widely practiced in hilly areas of Bangladesh [4] and considered as the major source of livelihood for tribal people. It has been estimated that about 26,000 households practice shifting cultivation (jhum) every year, and nearly 143,000 people depend on jhum for livelihood [5]. Despite declining productivity, farmers follow jhuming because they believe it is the basis of hill people's cultural identity [6].

Imbalanced fertilizer application or no use of it along with low organic matter content of hill soils led to extreme depletion of plant nutrient and deterioration of soil productivity. Reports revealed that about 2.4 million tons of silts are carried annually from the upper riparian and hilly lands and deposited in the major riverbed and their tributaries because hilly areas people used fertilizers irregular way of distribution [7]. Now, flash flood and landslide have become a regular phenomenon in Bangladesh. The threats of soil degradation and soil erosion due to jhuming can affect the vitality of native vegetation due to loss of necessary nutrients and soil properties needed for their natural survival. In the hilly areas, seeds of different crops are mixed together and sown in the field after the first rain shower, usually during the months of April to May. Generally, upland rice and vegetables are harvested within a few months after sowing, whereas cotton is harvested after 8 or 9 months, during December [8]. Once the land becomes inadequate for crop production it is then left to be reclaimed by natural vegetation once again, while the same activity continues at new location, with this cycle continually repeating itself. They also cultivate many kinds of fruits and vegetables, which may cause huge amount of soil erosion and depletion of soil nutrient.

The main Jhum crops are rice, maize, sesame, Jhummarfa, Jhum barbate, Jhum okra, cowpea, cotton, ginger and turmeric. In Bangladesh for the last two decades never exceeds more than two years and restoration cycle shorten to 3-4 years [9]. Slashing of vegetation and subsequent burning in the dry season followed by dibbling of seeds after the onset of rains (generally in April) are common in Jhum cultivation system in the CHT. Normally the land is cleared of shrubs, herbs and undergrowth vegetation, leaving the trees intact and all crops are planted at the same time under zero-tillage condition. After the onset of rains, crop germination and establishment pick up fast and along with other weeds, the crop plants also grow vigorously. Jhum crops are harvested one by one as these ripe successively between July and December. Now, Jhum can no longer support the families with their food and other daily requirements. But as no other alternatives are available, the indigenous people still depend on Jhum for their survival. On the other hand, shifting cultivation is considered as the major factor for deforestation, soil degradation, and nutrient depletion in the mountain regions of the world.

Research on jhum in the Chittagong Hill Tracts (CHT) is as old as interest in the study of tribal culture, and dates back to British rule of the Indian subcontinent. Much of the early work on jhum goes back to the 19th century [10,11] and was in the form of notes, memoranda, memoirs, and reports. These were mainly based on their observations, tours and the knowledge gained from experienced and conversant persons of the region. A few anthropologists [12,13] wrote about cultures, norms, practices and modes of livelihood, and the social structures of shifting

cultivators (jhumias). The goal of sustainable highland management is either to protect or improve soil productivity and enhance the soil water availability as a natural resource base. Soil productivity is an important determinant of its sustainability for a specific land use which can change soil quality and determines the sustainability of a specific management strategy. Soil productivity is governed by soil fertility and must be maintained or improved if a land management is to be sustainable. To document the extent and redress the problems, research experiments on estimation of soil erosion and fertility depletion, improvement of soil fertility for continuous jhuming, have been initiated at Khagrachari, Rangamati and Bandarban districts. Considering the above fact soil fertility management is necessary in hilly area of Bangladesh for continuous jhum cultivation. To sustain the livelihood of trible people, the present study was undertaken by development of land management technology (fertilizers packages, NPK briquette and residual effect of fertilizers) for continuous jhum cultivation in hilly area of Bangladesh.

2. MATERIALS AND METHODS

2.1 Experimental Site

All experiments were conducted under farmer's fields located at hill area of CHTi. e. Bandarban, Khagrachari and Rangamati site under the AEZ 29 (Northern and Eastern Hills Tract) 2017-2019 to study the fertilizers packages, NPK briquette and residual effect of fertilizers) for continuous jhum cultivation.

2.2 Research Collaborating Organization

Laboratory experiments and farmers participatory trials have been done to develop sustainable land management technologies for on-station, on-farm and hilly terrains of CHT in order to improve the productive capacity of the soil and crop yield. As an Institutional support, researchers and field/laboratory staffs of Hathazari Agricultural Research Station (HARS), Hartazari, Bangladesh Agricultural Research Institute (BARI), Khagrachari and On-Farm Research Division (OFRD), BARI Bhandarban, Cotton Development Board (CDB), Bandarban and Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur and Sher-e-Bangla Agricultural University (SAU), Dhaka along with recruited project officers, and other scientific staffs are engaged for setting the trials, data collection and processing.

2.3 Experimental Methods and Materials

The experiments were laid out in Randomized Completely Block Design (RCBD) because experimental plot was heterogeneous condition. The method was found by previous research and also inspired [14]. The trials were carried out at the farmers' field of three hill districts of CHTi.e. Bandarban, Rangamati and Khagracharion the performance of jhum crops without fallowing. The trials were experimented as a treatment wise forthree years and finally developed fertilizers dose was N_{60} P_{20} K_{30} kg/ha. In last three years this fertilizers dose was tried forupscaling. Rice(*Oryza sativa*), sesame (*Sesamum indicum*), white gourd (*Benincasa hispida*), marpha (*Cucumis sativus*), okra (*Abelmoschus esculentus*), yard-long bean (*Vigna unguiculata ssp. Sesquipedalis*), pumpkin (*Cucurbita pepo*), and jhum chilli (*Capsicum frutescens*) were used as the experimental crops. The selected land was slashed and burnt, and partially burnt plant parts were cleaned before final land preparation. Grain yields of all crops and straw yields of rice were recorded plot-wise and expressed at t ha^{-1}. In case of NPK briquette, the experiments were also conducted at Bandarban, Rangamati and Khagrachari hill district in Chittagong under the AEZ 29 (Northern and Eastern Hills Tract). The selected land was slashed and burned and partially burnt plant parts were cleaned before final land preparation. NPK briquette (Ratio: 100 kg NPK briquette contain 50 kg Urea: 30 kg TSP: 20 kg MoP) was applied by dibbling method. In case of residual effect of fertilizers, cow pea/yard long bean were introduced as new crop after harvest of rice crop in jhum with residual moisture and fertilizer. All Jhum crops were harvested in the month of September-October, and most of the Jhum farmers kept their field fallow for next jhum season. In the meantime a relay crops like cowpea, yard long bean, bean after jhum cultivation can be used. After harvest of jhum crops i.e rice, marpha, pumpkin white gourd and chili etc seeds of cowpea, yard long bean and bean were sown in September and harvested in November without any irrigation and fertilizer management.

2.4 Application of Fertilizers

Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MoP) were used as a source of N, P and K, respectively. The amounts of N, P and K 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 and other crops during May to June. Fertilizers were applied as per treatment after emergence of seedlings by dibbling method.

2.5 Data Collection

The data was collected 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 yields were recorded.

2.6 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) [15].

3. RESULTS

3.1 Fertilizers Packages Increase the Yield of Jhum Rice

All parameter of Jhum rice was significantly influenced by fertilizers package over farmers' practice. Grain yield of Jhum rice was significantly influenced by the application of fertilizers package. In Bandarban, Khagrachari and Rangamati, jhum rice yield was ranged from 2.60 to 3.81 ton/ha with highest yield was found in Khagrachari site (3.81 tha^{-1}) over farmers' practice (1.43 tha^{-1}).

3.2 Fertilizers Package Increased the Yield of Other Jhum Crops

Data on the yield of jhum crops as affected by fertilizers (maize, sweet gourd, chili, sesame and marpha grown in Bandarban and Khagrachari and Rangamati depicted in Table 1. Yield of Jhum crops i.e maize, sweet gourd, chili, sesame and marpha were significantly influenced by fertilizers package. The highest yield of maize (0.436 tha^{-1}) at Rangamati, Sweet gourd (1.679 tha^{-1}) at Bandarban, Chili (0.348 tha^{-1}) at Khagrachari, Sesame (0.361 tha^{-1}) at Bandarban and Marpha (0.742 tha^{-1}) at Bandarban were obtained with fertilizers package over farmers' practice.

3.3 NPK Briquette Application Increase the Yield of Jhum Rice and Other Jhum Crops

In Bandarban, Khagrachari and Rangamati, jhum rice yield was ranged from 3.58 to 4.18 ton/ha with the application of NPK briquette instead of normal fertilizers practices, and highest yield was found in Khagrachari site with 4.18 tha^{-1}instead of normal fertilizers practices 3.73 ton/ha. Fertilizer NPK briquette produced the highest yield of rice was 4.18 tha^{-1} at Khagrachari, Maize (0.674 tha^{-1}) at Bandarban, Sweet gourd (1.06 tha^{-1}) at Bandarban, Chili (0.514 tha^{-1}) at Khagrachari, Sesame (0.753 tha^{-1}) at Khagrachari and Marpha (0.316 tha^{-1}) at Khagrachari.

3.4 Cultivation of Leguminous Crops (Cowpea, Yard long Bean, Bean Etc) as a Relay Crop without Application of Fertilizer After Jhum crops

Cow pea/yard long bean/bean was introduced as new crop after harvest of jhum crops of jhum with residual moisture and fertilizer. The highest yield of cowpea, yard long bean and bean were obtained at Bandarban site with 1.043,1.02 and 1.5 t ha^{-1}, respectively.

4. DISCUSSION

Farming systems prevailing in the CHT can be broadly classified into two types, (i) slash and burn type shifting cultivation or Jhum, and (ii) cultivation agriculture. Jhum cultivation, an indigenous farming system is the foundation of the ethnic community in CHT. The major concept of this system is to utilize a piece of land for few (1-4) years and leaving the land for 10-20 years (even longer) for fertility restoration through natural processes.

Experiments on assessment of the fertilizer management trials on jhum cropping system and vegetable crops were carried out at Khagrachari, Rangamati and Bandarban. Rice, sesame, marpha, maize, yardlong bean, bean, cowpea, pumpkin and jhum chilli were used as the experimental material. The hills being mostly made of soil has the potentiality of growing varieties of crops under proper soil management. Jadhav, A. S., (1992) reported 80-100 kg N/ha were used for maximum yields during the wet

season and 120-150 kg N/ha was used during dry season of Jhum crops. Phosphorus deficiency symptoms results decreased leaf number and size, reduced seeds per panicle and reduced filled seeds per panicle [16]. The optimum and economic rate of P for rice vary from 20 to 30 kg P/ha depending on season. Moreover, varietal response is noticeable such as hybrid entries EH1 and EH2 used P more efficiently than inbred varieties. A negative P balance could be observed up to 10 kg P/ha Islam, MA et al. [17]. Potassium is a virtually important macronutrient in plant growth and in sustainable rice production [18].

Most of the experiments were conducted with fertilizer to evaluate the performance of jhum crops in Bangladesh. But due to application of normal form of fertilizer in sloping land, there were a huge loss of nutrient through runoff. Runoff nutrient loss also lead to environmental pollution or degradation. The savings in applied N reached 70 and 35 kg ha^{-1} when N fertilizer applied as urea super granual (USG) during the Boro (February-June) and Aman (August-December) seasons, respectively [19]. Upendra Singh [20] reported that the deep-point placement of N, P and K briquettes significantly increased grain and straw yields. Mahendra [21] observed that placement of urea super briquette in the reduced zone of soil recorded more grain and straw yield compared to the commercial urea application by broadcasting. Placing fertilizer N at about 10 cm below the soil surface after puddling has long been known to improve plant uptake of NPK briquette. But loss of fertilizer nutrients can be minimized by using NPK briquette in slopping hill area for better jhum production. Table 2 show the effect of NPK briquette on the yield of jhum crops. One briquette is used per 4 hills or between 4 hills as a common dose. Nitrogen use efficiency (NUE) of different rice cultivars such as BRRI dhan1 [22], BRRI dhan28, BRRI dhan36 [23], BRRI dhan29 [24] had been reported. All parameters of jhum rice were significantly influenced by using different level of NPK briquette instead of normal fertilizers. Among all those the grain yield of jhum rice was most significantly influenced by the application of different levels of NPK briquette.

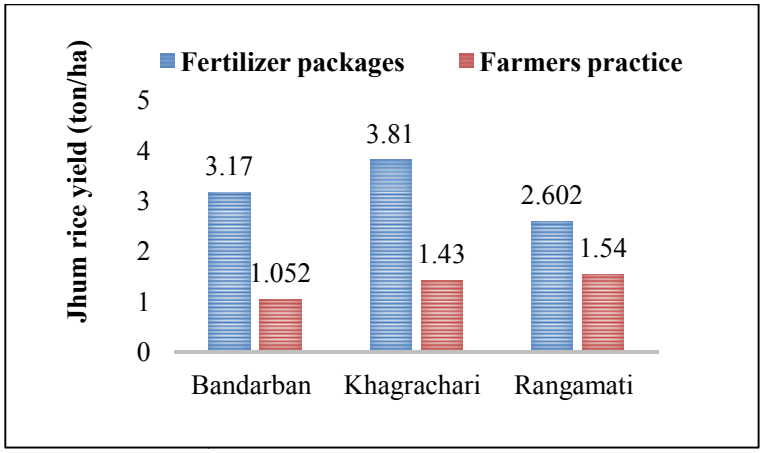

Fig. 1. Yield of jhum rice as affected by fertilizer package and farmers' practice

Table 1. The yield of jhum crops as affected by fertilizer package and farmers practice

Treatment	Location	Maize (tha^{-1})	Sweet gourd (tha^{-1})	Chili (tha^{-1})	Sesame (tha^{-1})	Marpha (tha^{-1})
Fertilizer package	Bandarban	0.118	1.679	0.123	0.361	0.742
	Khagrachari	0.195	0.719	0.348	0.205	0.340
	Rangamati	0.436	0.815	0.037	0.185	0.362
Farmers practice	Bandarban	0.047	0.231	0.056	0.078	0.137
	Khagrachari	0.098	0.094	0.014	0.095	0.112
	Rangamati	0.163	0.216	0.052	0.036	0.142
Grand Mean		0.17	0.62	0.10	0.16	0.30
CV (%)		44.10	54.5	12.89	40.10	50.87
LSD (0.05%)		0.27	1.19	0.45	0.22	0.54

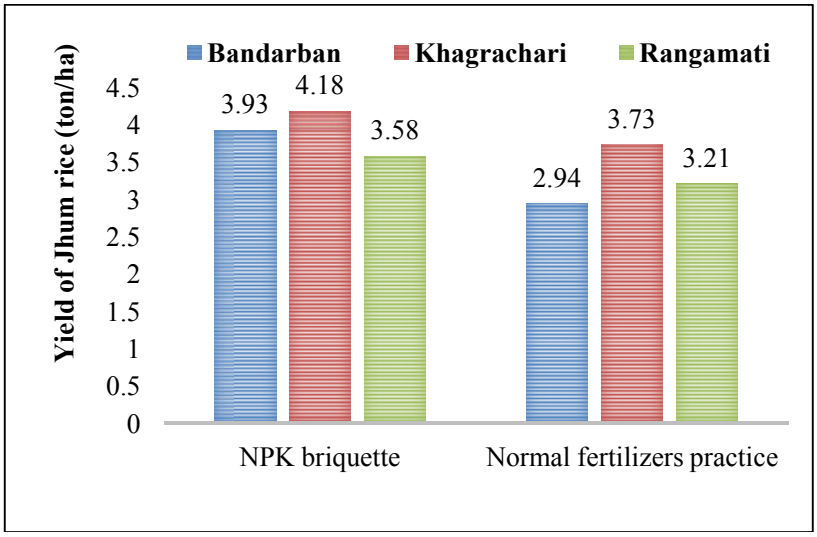

Fig. 2. Yield of jhum rice influenced by NPK briquette

Table 2. Yield of jhum crops influenced by NPK briquette

Treatment	Location	Rice (ton/ha)	Maize (ton/ha)	Sweet gourd (ton/ha)	Chili (ton/ha)	Sesame (ton/ha)	Marpha (ton/ha)
NPK briquette	Bandarban	3.93	0.674	1.06	0.432	0.584	0.231
	Khagrachari	4.18	0.532	0.875	0.514	0.753	0.316
	Rangamati	3.58	0.573	0.954	0.328	0.489	0.204
Normal Fertilizer packages	Bandarban	2.94	0.257	0.641	0.152	0.337	0.113
	Khagrachari	3.73	0.421	0.365	0.096	0.314	0.241
	Rangamati	3.21	0.389	0.567	0.0251	0.418	0.106
Grand Mean		3.59	0.47	0.74	0.25	0.48	0.20
CV (%)		6.63	23.8	6.07	20.28	26.97	7.54
LSD (0.05%)		0.83	0.39	0.15	0.18	0.45	0.05

Table 3. Cultivation of leguminous crops (cowpea, yardlong bean and bean) as a relay crop without application of irrigation and fertilizer after jhum crops

Sl	Location	Cowpea (tha^{-1})	Yardlong bean (tha^{-1})	Bean(tha^{-1})
1	Bandarban	1.043	1.02	1.5
2	Khagrachari	0.982	0.562	1.2
3	Rangamati	0.853	0.974	0.865
	CV (%)	22.43	19.65	17.83
	LSD (0.05%)	0.46	0.53	0.91

5. CONCLUSION

This report reflects the progress with many aspects including jhum cultivation, soil and fertilizers management which have great impact on the economy of CHTs people. Continuous jhum cultivation with fertilizers package and NPK briquette were successful in the hilly area of Bandarban, Khagrachari and Rangamati districts. One more short duration leguminous crops could be cultivated without fertilizers management in some locality of hilly area.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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