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Full Research Article

Effect of Different Fertilizer Packages on the Performance of *Jhum* Crops

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Abstract

An experiment was conducted at Hill Agricultural Research Station, Khagrachari, Bangladesh during May, 2014 to January, 2015 to study the effects of different fertilizer on the performance of *jhum* crops. Rice, marpha, maize, sweet gourd, sesame and arhar were used as the *jhum* test crops. The experiment was laid out in Latin Square Design (LSD). The treatments consisted of four levels of NPK fertilizers i.e. no fertilizer (Control), 40 kg N+25 kg P_2O_5+30 kg K_2O ha^{-1}, 80 kg N+50 kg P_2O_5+60 kg K_2O ha^{-1} and 120 kg N+75 kg P_2O_5+90 kg K_2O ha^{-1}. The yield parameters and yields of *jhum* crops were significantly affected by fertilizer. NPK fertilizer plays a significant role on the yield of rice, marpha, maize, sesame, sweet gourd and arhar. The highest yield of rice (3.34 t ha^{-1}), marpha (984.8 kg ha^{-1}), maize (951.3 kg ha^{-1}), sweet gourd (1418.0 kg ha^{-1}), sesame (331.3 kg ha^{-1}) and arhar (349.9 kg ha^{-1}) were found in T_4 treatment that received 120 kg N+75 kg P_2O_5+90 kg K_2O ha^{-1}. On the other hand, lowest yield of rice (1.67 t ha^{-1}), marpha (453.8 t ha^{-1}), maize (517.5 t ha^{-1}), sweet gourd (781.3 t ha^{-1}), sesame (107.1 t ha^{-1}) and arhar (103.6 t ha^{-1}) were found in the treatment with no fertilizer.

1. Introduction

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

This traditional cultivation practice has been the only way of subsistence agriculture practice for many of the CHT people specially who are living in remote places. It is estimated that about 40,000 households are engaged with *jhum* cultivation in CHT (Ullah et al., 2012). In the past, land was left fallow for between 15 to 20 years, which allowed the soil to regenerate its fertility. These days however population pressure, coupled with acute land scarcity has forced that time frame to be reduced to a rotation cycle of between 2 to 3 years (CARE, 2000).

Seeds of different crops are mixed together and sown in the field after the first rain shower (monsoon) has fallen, usually during the months of April to May. Typically, upland rice and vegetables are harvested within a few months after sowing, whereas cotton and arhar are harvested after 8 or 9 months, during December. Once the land becomes inadequate for crop production it is then left to be reclaimed by natural jungle vegetation once again, while the same activity continues elsewhere, with this cycle continually repeating itself rice is the most common crop in *jhum* farming and cultivated in rain fed condition.

Indigenous hill people are generally very poor, not enough educated and their livelihood depends mostly on wage earnings and *jhum* cultivation. CHT is completely different in physical features, agricultural practices and soil conditions from rest of the country. Food insecurity is a great concern in CHT where it is sometimes becomes very difficult to arrange three meals particularly for medium or big families. As the World food prices have hit the record highs recently and the uptrend is still continuing, the household of Chittagong Hill Tracts (CHTs) are highly vulnerable to food security due to their limited access to food. Now a day's, the shrinkage of *jhum* fields and reducing yields has created a challenge for the Jumia families. Compared to this low return from the *jhum*, still many of the people either partly or fully depend on *jhum* for their livelihoods (Borggaard et al., 2003). Degradation of upland soils is widespread in CHT and continues to accelerate due to gradual intensification of crop production without applying balanced fertilizers or manures (Miah et al., 2008).

Productivity of hill soil is constrained by erosion, no or little use of fertilizers, fertility depletion, strong soil acidity, inappropriate cropping and faulty management practices (Rasul and Thapa, 2002). These days it is gradually evolving and becoming more market oriented, which is also adding pressure for shorter land rotation. Ironically it seems possible fertilizer will become more and more necessary, and come to play an important role in this process, in stark contrast to the purely organic practice of the past. The depleted soil fertility is a major constraint to higher crop production in Chittagong Hill Tracts, Bangladesh (Farid et al., 2009). The increasing land use intensity has resulted in a great exhaustion of nutrients in soils. Continuous cultivation of this highly exhaustive cropping sequence in most of the lands has resulted in the decline of soil physico-chemical condition. For that reason scientists are trying to improve the production systems with the help of applications of fertilizer. The improvement of soil physico-chemical properties by using fertilizers are supply for essential plant nutrient for higher yield. The applications of different fertilizer packages affect the yield, nutrient accumulation and quality of *jhum* crops.

Average rice yield was recorded 1.15 t ha^{-1} under *Jhum* cultivation (Uddin et al., 2010) which is much lower than national average of rice (3.73 t ha^{-1}) (BBS, 2009). Rasul and Thapa (2002) reported that poverty is widespread in the CHT particularly in rural areas. Many rural families suffer from chronic food shortages. On average, per household per annum food (rice) shortage was found higher (0.87 t) for non-ethnic and lower for ethnic households (0.49 t) which constitutes 84.5% and 45.9% respectively (Uddin et al., 2010).

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

2. Materials and Methods

An experiment was conducted at Hill Agricultural Research Station, Khagrachari Hill District in Chittagong Hill Tracts (CHT), Bangladesh under the Agro Ecological Zone of Northern and Eastern Hills. The morphological, physical and chemical characteristics of initial soils are presented in Tables 1 and 2.

2.1. Land preparation

The selected land was slashed and burned and partially burnt plant parts were cleaned during land preparation and no tillage was given. All kinds of weeds and residues were removed from the field.

Table 1: Morphological characteristics of the experimental field

Morphology	Characteristics
Location	Hill agricultural research station, Khagrachari, Bangladesh
Agro-ecological zone	Northern and Eastern hills (AEZ-29)
General soil type	Brown Hill Soil
Topography	Sloppy
Slope %	12-15
Drainage	Well drained
Flood level	Above flood level

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

Characteristics	Value
Textural class	Silt loam
pH	5.3
Bulk density (g cc^{-1})	1.45
Particle density (g cc^{-1})	2.52
Organic carbon (%)	1.83
Total N (%)	0.06
Available P (ppm)	14.1
Exchangeable K (meq 100 g^{-1} soil)	0.76
Available S (ppm)	19.69

2.2. Experimental design

The experiment was designed in Latin Square Design (LSD)

2.3. Test crops

Rice, marpha (cucumber), maize, sweet gourd, sesame and arhar were used as the *jhum* test crop. Locally available varieties were used for all the crops.

2.4. Seed sowing

Seeds are sown by dibbling method with the help of *Da.* Seeds are sown directly on the soil. Before sowing, seeds of different *jhum* crops except sesame were mixed together. The seed mixture of rice to other crops was 100:1 i.e. rice cover major portion of the land. Sesame seed was broadcasted over the soil surface after sowing of rice and other crops seed mixture.
Treatments
There were 4 treatment combinations. The treatment combinations were as follows:

T_1: No fertilizer (Control)
T_2:40 kg N+25 kg P_2O_5+30 kg K_2O ha^{-1}
T_3: 80 kg N+50 kg P_2O_5+60 kg K_2O ha^{-1}
T_4:120 kg N+75 kg P_2O_5+90 kg K_2O ha^{-1}

Figure 1: Seed sowing in *jhum* cultivation

2.5. Application of fertilizers

Urea, TSP and MoP were used as a source of N, P and K respectively. The amounts of nitrogen, phosphorus and potassium fertilizers required plot^{-1} were calculated. 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.

2.6. Intercultural operations

The following intercultural operations were done for ensuring the normal growth of the crop. Top dressing of urea was done as per schedule and the normal cultural practices including weeding and insecticides spray were done as and when necessary. The crop was infested with some common weeds and controlled by uprooting. There were some incidence of insect attack specially rice hispa and rice stem borer, which were controlled by spraying Diazinon and Malathion. Disease i.e. brown spot of rice was controlled by spraying Filia @ 2 ml l^{-1}.

2.7. Plant sampling at harvest

Plants from 1 m^2 were randomly selected from each plot to record the yield of rice, marpha, maize, sesame, sweet gourd and arhar. The selected hills were collected before harvesting. Yields of all crops were recorded plot-wise and expressed at t ha^{-1} on sundry basis.

2.8. Harvesting

The crop was harvested at maturity. Harvesting of Marpha was done on 4th August, 2014, Maize on 9th August, 2014, Sweet Gourd on 18th August, 2014. Harvesting of rice was done on 19th September, 2014. In case of Arhar harvesting was done on 15th January, 2015. The harvested crop was threshed plot-wise. Grain yields of all crops and straw yields of rice were recorded separately plot-wise and after sun drying weight carefully.

2.9. Statistical analysis

The statistical analyses for different characters of *jhum* crops were done following the MSTAT-C statistical package and the mean results in case of significant F-values were adjusted by the Least Significant Difference (LSD) (Gomez et al., 1984).

3. Results and Discussion

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

3.1. Yield of jhum rice

3.1.1. Grain yield

The grain yield of *jhum* rice varied significantly due to application of different rates of NPK fertilizer treatments (Table 3). The grain yield ranged from 1.67 to 3.34 t ha^{-1}. The highest grain yield (3.34 t ha^{-1}) was found in T_4 treatment receiving 120 kg N+75 kg P_2O_5+90 kg K_2O ha^{-1}. The lowest yield (1.67 t ha^{-1}) was recorded in T_1 (control) treatment. Second highest yield (2.93 t ha^{-1}) was found in T_3 treatment receiving 80 kg N+50 kg P_2O_5 +60 kg K_2O ha^{-1}. The treatments may be ranked in the order of T_4>T_3>T_2> T_1 with respect of grain yield. Satyanarayana et al. (2010) reported that grain yield increase significantly due to application of NPK fertilizers. Nyalemegbe et al. (2009); Islam et al. (2010) also cited that increase rate of NPK fertilizer will increase the yield of rice significantly.

3.1.2. Straw yield

Straw yield of *jhum* rice also varied significantly at different levels of fertilizer treatments under study (Table 3). The yields of straw ranged from 2.45 to 4.18 t ha^{-1}. The highest straw yield (4.18 t ha^{-1}) was obtained in T_4 treatment received 120 kg N+75 kg P_2O_5+90 kg K_2O ha^{-1} which was statistically differed with all other treatments. The lowest straw yield (2.45 t ha^{-1}) was noted in T_1 (control) treatment. The treatment may be ranked in the order of T_4>T_3>T_2>T_1 in terms of

Table 3: Effect of NPK fertilizers on the grain and straw yields (t ha^{-1}) of *jhum* rice

Treatment*	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1	1.67^d	2.45^d
T_2	2.48^c	2.78^c
T_3	2.93^b	3.69^b
T_4	3.34^a	4.18^a
LSD (p=0.01)	0.22	0.29

Means in a column followed by same letter (s) are not significantly different at 1% level of significance by LSD; *T_1: No fertilizer (Control); T_2: 40 kg N+25 kg P_2O_5+30 kg K_2O ha^{-1}; T_3: 80 kg N+50 kg P_2O_5+60 kg K_2O ha^{-1}; T_4: 120 kg N+75 kg P_2O_5+90 kg K_2O ha^{-1}

straw yield. Ravi et al. (2007) reported that the straw yield increasesignificantly due to application of NPK fertilizers. Nyalemegbe et al. (2009) also found the same results in case of straw yield of rice.

3.2. Yield of jhum crops other than rice

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

3.2.1. Yield of marpha

Different levels of NPK fertilizer showed statistically significant variation on fruit yield of marpha (Table 4). The maximum yield (984.8 kg ha^{-1}) was recorded from T_4 treatment that received 120 kg N+75 kg P_2O_5+90 kg K_2O ha^{-1} which was highly significant than other treatments. Second highest yield 683.5 kg ha^{-1} was recorded from T_3 treatment receiving 80 kg N+50 kg P_2O_5+60 kg K_2O ha^{-1}. The lowest yield (453.8 kg ha^{-1}) was observed in T_1 treatment received no fertilizer. The treatment may be ranked in the order of T_4>T_3>T_2>T_1 in terms of marpha yield. Ravikumar (2009) found highest fruit yield of cucumber with the application of 120:70:90 kg NPK ha^{-1}. Ubeiz (2009); Abdel-Mawgoud et al. (2005) reported that NPK fertilizer have a positive response in the vegetative growth and increasedyield of cucumber.

3.2.2. Yield of maize

The grain yield of maize was significantly influenced by different levels of NPK fertilizer (Table 4). The yields of maize ranged from 517.5 to 951.3 kg ha^{-1}. The highest maize yield (951.3 kg ha^{-1}) was obtained from T_4 treatment that received 120 kg N+75 kg P_2O_5+90 kg K_2O ha^{-1} which was statistically differed with other treatments. The lowest maize yield (517.5 kg ha^{-1}) was recorded in T_1 (control) treatment with no fertilizer application. Second highest maize yield (751.0 kg ha^{-1}) was found in T_3 treatment (80 kg N+50 kg P_2O_5+60 kg K_2O ha^{-1}) which was statistically identical with T_2 treatment (40 kg N+25 kg P_2O_5+30 kg K_2O ha^{-1}). The treatment may be ranked in the order of T_4>T_3>T_2>T_1 in terms of maize yield. Halim et al. (2004) found that maize yield increased with combined application of NPK fertilizer. Talukder et al. (2011) reported that increase rates of P and/or K will increased seed protein and grain yield of maize with 120 N kg ha^{-1} as a basal dose.

Table 4: Effect of NPK fertilizers on the yields (kg ha^{-1}) of marpha, maize, sweet gourd, sesame and arhar

Treat-ments	Marpha (kg ha^{-1})	Maize (kg ha^{-1})	Sweet gourd (kg ha^{-1})	Sesame (kg ha^{-1})	Arhar (kg ha^{-1})
T_1	453.8[d]	517.5[c]	781.3[d]	107.1[c]	103.6[c]
T_2	502.5[c]	749.3[b]	1033.0[c]	241.4[b]	275.9[b]
T_3	683.5[b]	751.0[b]	1113.0[b]	245.4[b]	277.7[b]
T_4	984.8[a]	951.3[a]	1418.0[a]	331.3[a]	349.9[a]
LSD (*p*=0.05)	52.40	22.66	30.79	7.15	12.62

Means in a column followed by same letter (s) are not significantly different at 5% level of significance by LSD; *T_1: No fertilizer (Control); T_2:40 kg N+25 kg P_2O_5+30 kg K_2O ha^{-1}; T_3:80 kg N+50 kg P_2O_5 +60 kg K_2O ha^{-1}; T_4:120 kg N+75 kg P_2O_5+90 kg K_2O ha^{-1}

3.2.3. Yield of sweet gourd

NPK fertilizer increases the yield of sweet gourd significantly. Different levels of NPK fertilizer management showed significant variation on yield of sweet gourd (Table 4). The maximum yield of sweet gourd (1418.0 kg ha^{-1}) was recorded in T_4 treatment that received 120 kg N+75 kg P_2O_5 +90 kg K_2O ha^{-1}. The lowest yield (781.30 kg ha^{-1}) was recorded in T_1 treatment where no fertilizer was used. The treatment may be ranked in the order of T_4>T_3>T_2>T_1 in terms of sweet gourd yield. Makal et al. (2007) and Nmanop (1997) reported that the combined applicationof NPK fertilizers increase the fruit yield of sweet gourd significantly. Alom (2005) found that application of NPK at the rate of 120-70-90 kg ha^{-1} produced the highest yield of sweet gourd.

3.2.4. Yield of sesame

The NPK fertilizer plays a significant role on the seed yield of sesame (*Sesamum indicum*). The seed yield of sesame was significantly influenced by different levels of NPK fertilizer (Table 4). The yield ranged from 107.1 to 331.3 kg ha^{-1}. The highest yield (331.3 kg ha^{-1}) was found in T_4 treatment received 120 kg N+75 kg P_2O_5+90 kg K_2O ha^{-1}. The lowest yield (107.1 kg ha^{-1}) was recorded in T_1 (control) treatment. Second highest yield (245.4 kg ha^{-1}) was found in T_3 treatment with 80 kg N+50 kg P_2O_5+60 kg K_2O ha^{-1} which was statistically similar with T_2 treatment received 40 kg N+25 kg P_2O_5+30 kg K_2O ha^{-1}. Sandabe el al. (2011) found that optimum number of capsule and seed yield was obtained with the combined application of NPK fertilizer @ 120:75:90 kg ha^{-1}.

3.2.5. Yield of arhar (pigeon pea)

Different levels of NPK fertilizer showed statistically significant variation on the yield of arhar (Table 4). The yield of arhar ranged from 103.6 to 349.9 kg ha^{-1}. The highest yield (349.9 kg ha^{-1}) was recorded from T_4 treatment that received 120 kg N+75 kg P_2O_5+90 kg K_2O ha^{-1}. Second highest yield (277.7 kg ha^{-1}) was recorded from T_3 treatment with 80 kg N+50 kg P_2O_5+60 kg K_2O ha^{-1} which was statistically identical with T_2 treatment received 40 kg N+25 kg P_2O_5+30 kg K_2O ha^{-1}. The lowest yield (103.6 kg ha^{-1}) was observed in T_1 treatment receiving no fertilizer. The treatment may be ranked in the order of T_4>T_3>T_2>T_1in terms of arhar yield. Pachauri et al. (2008) reported that NPK fertilizer increase the yield of pigeon pea significantly. Kushwaha (2001) cited that application of 90 kg K_2O ha^{-1} increase the use efficiency of K and increase the yield of pigeon pea.

3.3. Nutrient content in post-harvest soil

3.3.1. pH

Variation was recorded in post-harvest soil pH due to the application of different levels of NPK fertilizer in *jhum* cultivation (Table 5). The highest pH of post-harvest soil (5.25) was found from T_4 treatment that received 120 kg N+75 kg P_2O_5+90 kg K_2O ha^{-1}. The lowest pH in post-harvest soil (5.15) was recorded from T_1 treatment receiving no fertilizers.

3.3.2. Organic matter

Organic matter in post-harvest soil was varied with different levels of NPK fertilizer for *jhum* cultivation (Table 5). The highest organic matter in post-harvest soil (3.05%) was recorded from T_4 treatment which received 120 kg N+75 kg P_2O_5+90 kg K_2O ha^{-1} which is statistically superior to the rest of the treatment under study. The lowest organic matter in post-harvest soil (2.95%) was observed from T_1 treatment with no fertilizers.

3.3.3. Total nitrogen

Total nitrogen in post-harvest soil showed statistically non-significant at different levels of NPK fertilizer for *jhum* cultivation (Table 5). The highest total nitrogen in post-harvest soil (0.055%) was recorded from T_4 treatment receiving 120 kg N, 75 kg P_2O_5 and 90 kg K_2O ha^{-1} and the lowest total nitrogen (0.050%) was obtained from T_1 treatment with no fertilizer.

3.3.4. Available phosphorous

A significant difference in available phosphorous content of post-harvest soil was observed at different levels of NPK fertilizers for *jhum* cultivation (Table 5). The highest available P (14.25 ppm) in the post-harvest soil was recorded in T_4 treatment and the lowest available P (12.87 ppm) was noted in T_1 (control) treatment.

3.3.5. Exchangeable potassium

Exchangeable potassium in post-harvest soil showed statistically non-significant at different levels of NPK fertilizer (Table 5). The maximum exchangeable potassium inpost-harvest soil (0.73 meq 100 g^{-1} soil) was found in T_4 treatment received NPK @ 120:75:90 kg ha^{-1} which was superior to the rest of the treatment under study. The lowest available K (0.68 meq 100 g^{-1} soil) was observed in T_1 (control) treatment.

3.3.6. Available sulphur

A significant difference in available sulphur content of post-harvest soil was observed at different levels of NPK fertilizers (Table 5). The highest available S (17.11 ppm) in the post-harvest soil was recorded in T_1 treatment received no fertilizer. The lowest available S (16.04 ppm) was found in T_4 treatment received NPK @ 120:75:90 kg ha^{-1} which was statistically similar with T_3 treatment.

Table 5: Effect of NPK fertilizers on pH, organic matter, N, P, K and S content in post-harvest soil of *jhum* cultivation

Treatment	pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (meq100 g^{-1} soil)	Available S (ppm)
T_1	5.15	2.95	0.050	12.87^b	0.68	17.11^a
T_2	5.20	3.01	0.053	14.12^a	0.70	16.56^b
T_3	5.25	3.01	0.055	14.10^a	0.70	16.05^c
T_4	5.25	3.05	0.055	14.25^a	0.73	16.04^c
LSD (p=0.05)	NS	NS	NS	0.48	NS	0.51

Means in a column followed by same letter (s) are not significantly different at 5% level of significance by LSD; T_1: No fertilizer (Control); T_2: 40 kg N+25 kg P_2O_5+30 kg K_2O ha^{-1}; T_3: 80 kg N+50 kg P_2O_5+60 kg K_2O ha^{-1}; T_4: 120 kg N+75 kg P_2O_5+90 kg K_2O ha^{-1}

4. Conclusion

Fertilizer had a significant effect on the yield characters of *jhum* crops. The application of 120 kg N+75 kg P_2O_5+90 kg K_2O ha^{-1} fertilizer was most favorable for improving yield and yield contributing characters of *jhum* crops.

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