

Effect of Different Processes of *Jhuming* on Soil Properties in Mid Hills of Arunachal Pradesh

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Abstract A study was conducted in year 2012-14 to determine the changes in the physico-chemical properties of soil occurred due to different process of *Jhuming* i.e (1) standing forest (before cutting of forest), (2) cutting and clearing of forest, (3) burning of forest and (4) harvesting of crop. The study area is situated between 28°01'87'' N and 94°41'07'' E. Different soil parameters important for crop growth were observed at two depths (0–20 and 20–40 cm) at different stages of *Jhuming* mentioned above. Three farmers were selected who were going to start new *Jhum* cultivation of different elevation in Bam village, soil samples were collected after each process of *Jhuming* of the selected farmer's field. The collected samples were analyzed for p₄, organic carbon, available nitro-

gen, available phosphorus and available potash. Data were analyzed in statistical analysis software 9.3 assuming the design was randomized block design. It was found that all the stage had significant effect on almost all above mentioned soil parameters except available potash of both the layers and SOC in sub-surface layer. The pH was found increasing in due course of advancement of the stage where in highest magnitude of pH rise was found after harvesting of the crops in both soil layers. Similar trend was observed in case of available phosphorus. The OC was increased in both soil layers from first (standing forest) to second (cutting and clearing of forest) event but suddenly decreased after burning.

Keywords *Jhum* land, Soil physico-chemical properties, Standing forest, Burning, Cutting and clearing.

Introduction

Shifting cultivation (SC) is one of the main forms of crop husbandry in north eastern region (NER) of India and it is locally known as *Jhuming* where as the cultivators are known as *jhumias*. It is more traditional and integrated form is ecologically and economically viable system of agriculture as long as the population densities are low and *jhum*/fallow cycles are long enough to maintain soil health including fertility.

The clearing and burning of forest (slash and burn) followed by subsequent sowing and harvest-

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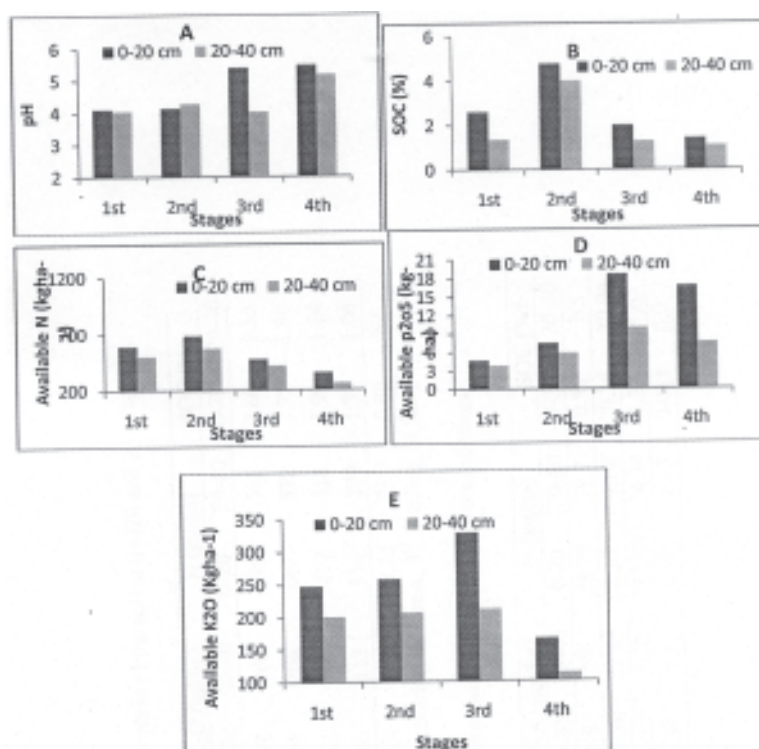


Fig. 1. Effect of different *Jhuming* stage on soil physico-chemical properties at both soil layers (0–20 and 20–40 cm).

ing of crop has great effect on soil properties. Determination of this effect is a basic step for understanding mineral cycling in the whole ecosystem. Understanding these changes can indicate the factors responsible for the changes in the fertility and other growing conditions for the crops during the different stages of the *Jhuming* (namely cutting and clearing of forest, burning of forest, sowing and harvesting of crops).

These changes can also cause various indirect impacts including increased hydrophobicity, which results in decreased infiltration and increased runoff that often results in increased erosion. The objective of this paper is to study overall possible effect of clearing and burning of forest (slash and burn) its subsequent sowing and harvesting of crop on pH, organic carbon (OC), available nitrogen (AN), available phosphorus (AP) and available potash (AK).

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Materials and Methods

Our study area was in West Siang district of Arunachal Pradesh background information (Table 1). Where local ethnic people practice shifting cultivation or *Jhum* for their livelihood. To select representative study sites, a preliminary survey was done in the shifting cultivated area and bam village of Arunachal Pradesh was selected for study area. The criterion for selecting farmers was the starting of new *Jhum* by slash and burning of native forest in the different elevation mentioned above. The process of

Table 1. Back ground information of study area.

Spot	Latitude	Longitude	Altitude (ft)	Degree of slope (%)
1	N 28°01.867	E 94°41.067	2493	45
2	N 28°01.842	E 94°41.027	2414	45
3	N 28°01.874	E 94°41.077	2509	50

Jhuming and step undertaken during the month of November 2012, first they select the forest after then cut it down the forest in the month of December to January 2013 and left it for some time to woods and bushes to become dry. After drying some timber woods and fire wood keep for household use and remain burn during the month of February to March 2013 and start sowing in the month of April 2013. Some timber woods they intentionally left in field and it kept across the slope to reduce the water erosion along with the runoff.

In the study, a multistage sampling technique was adopted. At every stage of *Jhuming* process soil samples were collected at all the three *Jhum* spot and two soil depth i.e 0–20 and 20–40 cm. Although season is important for collection of soil sample but our objective was to study the effect of *Jhuming* process on soil properties. Therefore we collected soil sample at completion every stage of *Jhuming* process to see the is effect on different processes on soil parameters. Different soil parameters important for crop growth were observed at two depths (0–20 and 20–40 cm) at four stages i.e (1) standing forest (before cutting of forest), (2) cutting and clearing of forest, (3) burning of forest and (4) harvesting of crop. In the *Jhum* farmers are not sowing only one crop rather they are cultivating mixed crop as per their requirement in which main crop is the upland rice and other crop is vegetables like chilli, ladies finger, brinjal, maize.

From each field the soils were collected from two depths (0–20 cm and 20–40 cm) at every step of *Jhumming* process. The soils were taken from 3 spots of each reach and depth and finally collected soils were composited at all the above four stages. The

soil samples were brought to the laboratory, air dried, grinded and sieved (0.20 mm) prior to the detail physico-chemical analysis. SOC was determined by rapid titration method. The soil pH was measured using a glass combination pH meter in the supernatant solution of 1:2.5 soils to water solution ratio. Common procedures were followed for estimation of available N, P and K.

The individual variables such as pH, OC, N, P, K were analyzed using a one way analysis of variance (ANOVA). Three replications ($r=3$) were used to records observations on each variable (Table 2).

Results and Discussion

No general trend was found for moisture content at different stages in both the soil layers. Highest water content was observed between 1st and 2nd stages (Table 3). Might be due to addition of leaf and forages, soil water holding capacity was increased. Similar trend was found in subsurface layer (20–40 cm).

A slight increase in pH was found between 1st and 2nd stage (Table 3) however from 2nd to 3rd and 4th stage a sudden increase of pH was found. This is might be due to burning of forest add some bases into the soil. The soil pH is generally increased after forest fire [1–3]. The presence of ash may increase soil pH due to high pH of ash [4, 5]. Similar trend was observed in subsurface layer (Fig. 1). At 3rd to 4th stage again variation in pH was non-significant.

Slashing and burning of vegetation caused an increase in pH in the present study. Two apparent reasons for this are incorporation of cations freed after burning of standing vegetation and destruction of organic matter which releases humic acid. Recorded a rise in pH from 5.2 to 8.1 and from 6.6 to 9.0 in top 5 cm soil soon after burning.

Across all, *Jhuming* stage, SOC content was significantly higher (Table 3) in the top surface than in the lower layer. In the upper surface higher SOC content was observed than subsurface layer. The highest SOC, (2.71%) was found after 1st stage i.e. after cutting of the forest. This slight increase in SOC car-

Table 2. Moisture, pH, EC, SOC and available N, P₂O₅ & K₂O content of the soil at 0 to 20 and 20 to 40 cm depth under different *Jhuming* stage. *1st standing forest (before cutting of forest), 2nd cutting and clearing of forest, 3rd burning of forest and 4th harvesting of crop.

Stages*	Moisture (%)		pH		P ₂ O ₅ (kg/ha)		K ₂ O (kg/ha)		N (kg/ha)		SOC (%)	
	0–20	20–40	0–20	20–40	0–20	20–40	0–20	20–40	0–20	20–40	0–20	20–40
1 st	31.76	31.88	4.10	4.03	4.7	3.87	248	200	596	503	2.60	1.35
2 nd	35.57	34.39	4.13	4.27	7.5	5.87	258	206	687	572	2.71	1.90
3 rd	32.46	33.58	5.40	4.01	8.6	9.9	327	210	477	418	1.99	1.24
4 th	29.32	30.7	5.47	5.17	16.7	7.6	165	113	334	259	1.39	1.06
CD (0.05)	3.41	1.77	0.426	0.3426	4.352	2.69	NS	NS	28.75	79.7	0.88	NS

bon might be due to addition of carbon from deforested forage lying on the surface after cutting and clearing of forest. After 3rd stage i.e after burning of forest it was found reduced to 1.99% and it further decreased to 1.39% due to oxidation of organic matter as a result of cultivation. Similar trend was observed in subsurface layer (Fig. 1). Similar trend was also reported in East Sinag of Arunachal Pradesh [6]. Significant variation in SOC among the sites might be mainly due to the differences in the plant species composition as it was also reported. Surface soil layer had significantly greater concentration than the subsurface soil depth. Soil organic carbon ranged between 1.06% and 2.71% in the present study, which is higher than the values reported 1.42–1.74%.

The highest available nitrogen content (Table 3) was observed before burning of forest since *Alnus Parkia* and *Albizia* are fast growing nitrogen fixing trees with large crown diameter, dense foliage, extensive litter enrichment capability, profuse rooting systems (mostly active fine roots), secretion of substantial root exudates, polysaccharides, enzymes, which immensely help in internal catalytic nutrient churning/recycling ability from lower depths and thus surface enrichment of bases, organic matters, nutrients, microbes and it was found decreased later. Higher nutrients content could be associated with more accumulation of microbial biomass in the soil [7]. This might be due to loss through volatilization because of high temperature [8]. Burned soils have lower nitrogen than unburned soils, higher calcium and nearly

unchanged potassium, magnesium and phosphorus stocks [9]. Reduction in available nitrogen is attributed to the conversion of organic nitrogen to volatile forms during pyrolysis and it further decreased after first year *Jhum* crop which is obvious that plant uptake nutrient from soil and also during cropping it may lost through runoff and leaching and conversion from available to non-available forms from 1st to 2nd stage, the available N increase, this may be attributed to the addition of organic matter through deforested debris. Similar trend was observed in subsurface layer (Fig. 1). Lower N in *Jhum* is also reported [10].

The highest available phosphorus content (Table 3) was observed after burning of forest i.e after 3rd stage, this is attributed by the addition of ash. The available phosphorus at 1st to 2nd stage, attributed by addition of organic matter and it was further increased during 2nd to 3rd stage attributed by addition of ash after burning estimated phosphorus as much as 27 kg ha⁻¹, provided by the ash of a 10 years forest fallow. In our study, phosphorus addition ranges between 2.3 kg^{-ha} and 9.2 kg^{-ha}. A decline in soil available phosphorous level is naturally expected. Net uptake of nutrients by growing crop may be responsible partly for lowering the available phosphorus level. Shifting cultivation such as burning of slashed materials, sowing, weeding and harvesting of crops cause deterioration of soil fertility with increasing cropping periods year after year [11, 12]. In addition of this the field were situated on steep slope resulting in erosion and

Table 3. One way of ANOVA showing the effect of *Jhuming* process on soil parameters at both the soil layers.

Stages*	Moisture (%)		pH		P ₂ O ₅ (kg/ha)		K ₂ O (kg/ha)		N (kg/ha)		SOC (%)	
	0–20	20–40	0–20	20–40	0–20	20–40	0–20	20–40	0–20	20–40	0–20	20–40
CD (0.05)	3.41	1.77	0.426	0.3426	4.352	2.69	NS	NS	28.75	79.7	0.88	NS
CV	5.29	2.71	4.47	3.924	18.32	15.94	41.30	57.55	2.74	9.19	20.24	20.94
F Cal	6.807	10.55	38.116	30.217	29.57	50.51	1.25	1.12	337.84	34.34	5.77	4.65
F Prob	0.023	0.008	0	0.001	0.001	0.00	0.37	0.41	0.00	0.00	0.033	0.052

runoff loss. Similar trend was observed in subsurface layer (Fig. 1).

There was non significant variation in available potash was found amongst different stage of *Jhuming* in both soil layers. However the trend was similar as observed in available phosphorus. The highest available potash (Table 3) was observed after burning of the forest i.e after 3rd stage in both soil layer and it further decreased after 4th stage which was expected as a result of uptake by crop as well as loss through runoff. Similar trend was found in subsurface layer (Fig. 1).

Though shifting cultivation has many negative effects, the recorded little change at the slashing stage on soil physical and chemical properties. Most of the studies have suggested that increase in the total plant available forms of nitrogen, reduction in the amount of available nitrogen. This reduction in the nitrogen is because of volatilization. Other nutrients are also affected during different *Jhuming* stages.

References

- Aref IM, Atta HA, Ghamade ARM (2011) Effect of forest fires on tree diversity and some soil properties. *Int J Agric and Biol* 13 : 659–664.
- Boerner REC, Hart S, Huang J (2009) Impacts of fire and fire surrogate treatments: A meta-analytical approach. *Ecol Appl* 19 : 338–358. doi: <http://dx.doi.org/10.1890/07-1767.1>
- Tufeccioglu A, Kucuk M, Saglam B, Bilgili E, Altun L (2010) Soil properties and root biomass responses to prescribed burning in young corsican pine (*Pinus nigra* Arn.) stands. *J Environ Biol* 31 : 369–373.
- Molina M, Fuentes R, Calderón R, Escudey M, Avendano K, Gutierrez M (2007) Impact of forest fire ash on surface charge characteristics of andisols. *Soil Sci* 172 :820–834. doi: 10.1097/ss.0b013e31814cee44.
- Schafer JL, Mack MC (2010) Short-term effects of fire on soil and plant nutrients in palmetto flatwoods. *Pl and Soil* 334 : 433–447. doi:10.1007/s11104-010-0394-2.
- Bhuyan SI, Tripathi OP, Khan ML (2013) Soil nutrients status in prominent agro-ecosystems of East Siang district, Arunachal Pradesh. *Int J Environ Sci* 3 No 6 1967–1968. doi: 10.6088/ijes.2013030600017.
- Barbhuiya AR, Arunachalam A, Pandey HN, Arunachalam K, Khan ML, Nath PC (2004) Dynamics of soil microbial biomass C, N and P in disturbed and undisturbed stand of a tropical wet-evergreen forest. *Europ J Soil Biol* 40 : 113–121.
- Certini G (2005) Effect of fire on properties of soil - A review. *Oecologia* 143:1-10. doi:10.1007/s00442-004-1788-8.
- Neff J, Harden J, Gleixner G (2005) Fire effects on soil organic matter content, composition and nutrients in inboreal interior Alaska. *Canad J For Res* 35 : 2178–2187.
- Biswas A, Alamgir M, Haque SMS, Osman KT (2012) Study on soils under shifting cultivation and other land use categories in Chittagong hill tracts, Bangladesh. *J For Res* 23 : 261–265.
- Biswas S, Swanson ME, Shoaib JUM, Haque SMS (2010) Soil chemical properties under modern and traditional farming systems at Khagrachari, Chittagong hill district, Bangladesh. *J For Res* 21 : 451–456.
- Miah S, Dey S, Haque SMS (2010) Shifting cultivation effects on soil fungi and bacterial population in Chittagong hill tracts, Bangladesh. *J For Res* 21 : 200–201.