Environment and Ecology 38 (4) : 911—918, October—December 2020
ISSN 0970-0420

Changes in Soil Biochemical Properties along Different Land Uses of Mizoram, Northeast India

Ngangbam Somen Singh, Etsoshan Y. Ovung, S. K.Tripathi

Received 11 August 2020, Accepted 5 September 2020, Published on 7 October 2020

ABSTRACT

This study examined soil physico-chemical and microbial properties of four different land use types (i.e. Jhumland, JL; Secondary forest, SF ; Natural Bamboo forest, BF and Natural Woody Forest, WF) of Mizoram, Northeast India. In each land use types about 1 hectare area was selected and soil samples were collected from three randomly located plots (i.e. 15-20 m apart from each other) andthree soil depths (i.e. 0 – 10 cm, 10 – 20 cm and 20 – 30 cm). Soil bulk density (BD, g cm-3) was maximum in JL (1.18–1.31) and minimum in WF (0.55–1.15). BD increased with depths in all land uses (0.55 - 1.18 in 0–10 cm), 0.83 – 1.27 in 10-20 cm and 1.15 – 1.31 in 20-30 cm depths). Soil moisture content (%) was maximum in WF (32.7 - 41.5%) and minimum in BF and JL (27.1 – 33.0%). Soil maximum water holding capacity was significantly higher in SF compared to other land uses. Soil pH ranged from 4.7 - 5.4 in different land uses. The soil of WF was more acidic than other land uses. Soil organic carbon was maximum in WF (3.3 – 3.6 %) and minimum in JL (2.5 – 2.9%). Total soil nitrogen and available nitrogen (NH4-N+NO3-N) followed pattern similar to total organic carbon. Available P ranged between 3.4 and 5.4 mg kg^{-1} with maximum in WF. In different land use types, the values of MBC and MBP (mg kg^{-1}) ranged from 153.5 – 298.7 and 24.9 – 54.7, respectively with maximum values in WF. This study suggests significantly high soil fertility level in WF compared to other land uses.

Keywords: Land use types, Soil physico-chemical properties, Carbon, Phosphorus.

Ngangbam Somen Singh, Etsoshan Y. Ovung, S. K.Tripathi*
Department of Forestry, School of Earth Science and Natural Resource Management, Mizoram University 796004, India

Email: sk-tripathi@rediffmail.com
*Corresponding author

INTRODUCTION

The soil comprises of air, water, organic matters and macro-micro fauna which together provides physical and chemical properties that support life processes of various flora and fauna in terrestrial ecosystem (Kimmins 1987, Manpoong and Tripathi 2019, Singh and Tripathi 2020). In addition to provide food and shelter for flora and fauna, the soil also maintains ecological balance on earth (Doran and Parkin 1994). In natural forest ecosystems, the soil acts as a sink and source of nutrients for the growth and development of number of flora and fauna as result of tight coupling of carbon and nutrients between different component of ecosystems (Tripathi et al. 2008, Singh et al. 2015). However, the capacity of soil to act as source of nutrients decreases in modified ecosystems like in agro-ecosystems due to various losses of nutrients (Tripathi et al. 2012, Hauchhum and Tripathi 2019). The quality of soil is strongly influenced

Fig. 1. Location of study sites in Mizoram.

by the changes in various macro- and micro fauna that depends on the management practices operated inagriculture systems over time (Wapongnungsang and Tripathi 2018).

The state of Mizoram is one of the eight sister states of Northeast India. The state is characterized by tropical moist climate consisting of variety of forests. Champion and Seth (1968) classified Mizoram forest into six types: 1. Cachar Tropical Semi-Evergreen Forest, 2. Secondary Moist Bamboo Brakes, 3. Pioneer Euphorbiaceous Scrub, 4. East Himalayan Moist Mixed Deciduous Forest, 5. East Himalayan Subtropical Wet Hill Forest and 6. Assam Subtropical Pine Forest. Later on state forest was broadly classifies into six categories (i.e. 1. Tropical Wet Evergreen Forest, 2. Montane Sub-Tropical Forest, 3.Temperate Forests, 4. Bamboo Forests, 5. Quercus Forests and 6. Jhumland) based on elevation, precipitation and species composition as per Singh et al. (2002). In general, the state has high forest wealth representing of ~ 85.27% of the total geographical area (ISFR 2019). Out of which very dense forest constitutes (0.62%), moderate forest (27.8%), open forest (57.84%) and remaining area are under other non-forest (13.74%) (Tripathi et al. 2016).

The state occurs under Indo-Burma biodiversity hotspot and is famous for its ecological significance due to the presence of variety of endemic flora and fauna which are considerably affected by the anthrogenic activities as a result of *Jhum* cultivation carried out by more than 75% of the population (Tripathi et al. 2016,Tripathi et al. 2017). This practice of cultivation is also known as slash and burn agriculture (Yadav 2015, Wapongnung sang and Tripathi 2019). Number of anthropogenic activities including shifting cultivation has profoundly affected area under the dense forest. As a result majority of the forest of the region is in the form of open forest or *Jhum* fallows. The conversion of dense forest into open forest/fallow lands or in the form of some plantations along with lack of proper management practices in this region has led to the degradation of top soil especially in the *Jhum* land. Therefore, there is a need to assess the status of soil quality in different land uses that can be used for policy formulation. This study was designed to understand the changes in physico-chemical and biochemical characteristics of soils of different land uses and to suggest management strategies to maintain the soil health in the region.

MATERIALS AND METHODS

Study sites

Study sites were selected at four different landuse types of Mizoram (Fig.1): 1. *Jhum* land, JL (i.e. current *Jhum* fallow at Reiek, 23º41.705' N latitude and 92º39.244' E longitude with an elevation of 1169m amsl); 2. Secondary forest, SF (i.e. ~ 15 years old *Jhum* fellow at Ailong, 23º41.829' N latitude and 92º37.603' E longitude at 942m amsl); 3. Natural bamboo forest, BF located at Sairang, 23̊ 49.324' N latitude 92̊ 39.568' E longitude with elevation of 99 mamsl and 4.Woody forest, WF located at Hmuifang reserve forest, 23̊27.245 N latitude and 92̊45.217′ E longitude with elevation of 1455 mamsl).

Collection of soil samples

Soil samples were collected randomly from four sites using a soil corer (4.3 cm in diameter) at 3 different depths (i.e. 0-10 cm, 10-20 cm and 20-30 cm) from 3 randomly located permanent plots about 15–20 meters away from each other. The samples were brought to the laboratory for physico-chemical and microbiological analysis. Samples were hand picked up for debris, small stones and roots and sieved through a 2 mm mesh screen. One part of the soil samples were air dried for physico-chemical analysis and the other part was stored at -20ºC for biochemical analysis.

Soil analysis in laboratory

Soil moisture content (SMC%) was estimated gravimetrically. The soil pH was recorded using digital pH meter (Mettler Toledo, Switzerland) with soil- water ratio 1:2.5 w/v based on Bandyopadhyay et al. (2012). Bulk density was determined using metallic tube of known inner volume. Maximum soil water holding capacity is determined by Keen- Raczkowski box method using a fresh soil sample after removal of gravel (Coutts 1930). Soil texture was determined using hydrometer method (Bouyoucos 1962). After calculating the percentage of sand, silt and clay in the soil, textureclass was defined using the USDA textural classification system.

Soil organic carbon (TOC) was analyzed by Walkey and Black (1947) rapid titration method. Available Phosphorus (P_{Avail}) was determined by Bray and Kurtz (1945) method. Total nitrogen (TN) content in the soil samples was estimated using micro Kjeldahl distillation apparatus (Baethgen and Alley 1989). Ammonium nitrogen (AN) in soil sample was determined by indophenol blue color method. In brief,10g of fresh soil sample was mixed with 100 ml of distilled waterand extracted after hand shaking. Then 5 ml of aliquot was added with 8 ml of rochelles reagent, 1 ml of sodium nitroprusside solution, 2 ml of sodium phenate reagent and 0.5ml of hypochlorite solution (pure). The volumes of this content were maintained to 50 ml then kept in hot water bath at 40ºC for 20 minutes. Afterwards the samples were cooled and the absorbance was recorded at 625 nm in spectro photometer. Microbial biomass carbon (MBC) in soil was determined using chloroform fumigation extraction method as suggested by Jenkinson and Powlson (1976). Microbial biomasses phosphorus (MBP) in soil was determined by chloroform fumigation extraction method (Vance et al.1987).

Statistical analysis

Soil physico-chemical properties were statistically analyzed for Analysis of Variance (ANOVA) using

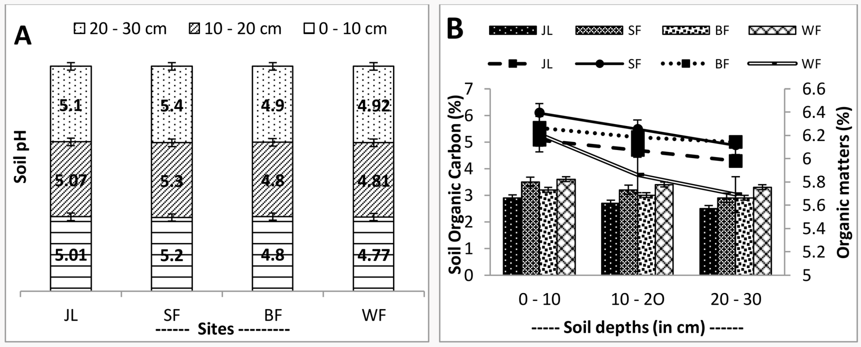

Fig. 2. Various chemical concentrations in different soil depths (i.e. 0-10cm, 10-20cm and 20-30 cm) of four different land use types in Mizoram. (A)soil pH and (B) soil organic carbon (TOC%) and Organic matter (OM%).(Mean ± 1SE, n = 3; LSD0.05 pH = 0.13, TOC = 0.39 and OM = 0.77).

MS-Excel-7 followed by LSD. To determine significant relation of various soil physico-chemical properties within site, pearson correlation was performed using MS-Excel-7. Further, 2-tailed correlation was performed using SPSS ver-18 to understand significant relation of various soil physico-chemical properties along with soil depth in different land use types.

RESULTS AND DISCUSSION

Soil physical and bio-chemical analysis

Variations in soil moisture content (SMC) from 27 to 41.5% in different land use types were broadly similar (28 – 38%) to the reports of Singhaand Tripathi (2017) or higher (17 - 24%) compared to Manpoongand Tripathi (2019) in different land use systems of Mizoram. SMC in upper soil depth was significantly high (40-42%) in WF and SF compared to BF and JL (32-33%) (Table 1). WHC ranged from 62 – 73% in all sites. Among the sites, BD was maximum in JL followed by SF and minimum in WF site (Table 1).

Soil texture in all sites was sandy loam - loamy sand (Table 1). Percent sand, silt and clay content in the present study ranged from 60 – 72, 13 - 20 and 12 – 20 respectively (Table 1). Percent sand, silt and clay contents were: 62 – 72, 17 – 21 and 11 – 17 reported for different land use systems of Mizoram

Table 1. Depth wise soil physical (i. e. SMC% = Per cent soil moisture content, WHC% = Water Holding Capacity, BD=Bulk Density and Percent Sand, Silt and Clay) properties of different land use types in Mizoram (Mean ± 1SE, n= 3 and LSD, p ≤ 0.05).

Sites	Deaths (cm)	SMC%	WHC %	BD (g/cm³)	% Sand	% Silt	% Clay
JL	0 –10	33 ± 0.04	61.3 ± 2.3	1.18 ± 0.4	70.5 ± 0.5	13.3 ± 0.5	16.2 ± 1
	10–20	29.5 ± 0.04	68.4 ± 3.6	1.27 ± 0.3	68.5 ± 0.5	14.4 ± 1	17.1 ± 0.5
	20–30	27.9 ± 0.02	72.7 ± 1.7	1.31 ± 0.1	66.5 ± 0.5	15.1 ± 0.3	18.4 ± 0.2
SF	0 –10	40.9 ± 0.04	66 ± 1.9	0.98 ± 0.12	65 ± 1	16.3 ± 0.5	18.7 ± 0.5
	10–20	38.1 ± 0.02	71.6 ± 1.9	1.04 ± 0.06	63 ± 1	17.6 ± 1.2	19.4 ± 0.2
	20–30	36.2 ± 0.02	84 ± 3.7	1.13 ± 0.12	61.5 ± 0.5	18.5 ± 0.3	20 ± 0.8
BF	0 –10	32.2 ± 0.02	62.3 ± 2.1	0.74 ± 0.01	69.3 ± 1.3	16.7 ± 0.7	14 ± 2
	10–20	28.8 ± 0.03	70.6 ± 1.8	0.93 ± 0.02	67.1 ± 0.7	17.9 ± 0.8	15 ± 0.5
	20–30	27.1 ± 0.02	60.7 ± 3.6	1.17 ± 0.03	71.8 ± 0.1	15.5 ± 0.5	12.7 ± 0.6
WF	0 –10	41.5 ± 0.02	70 ± 2.6	0.55 ± 0.03	67.6 ± 2.4	18.4 ± 1	14 ± 2
	10–20	36.9 ± 0.04	63.4 ± 2.5	0.83 ± 0.02	69.3 ± 2	17 ± 0.4	13.7 ± 1.7
	20–30	32.7 ± 0.03	68.4 ± 2.1	1.15 ± 0.03	64.1 ± 2	19.5 ± 1.1	16.3 ± 1.2
$LSD_{0.05}$		5.84	11.83	0.36	4.17	2.11	2.1

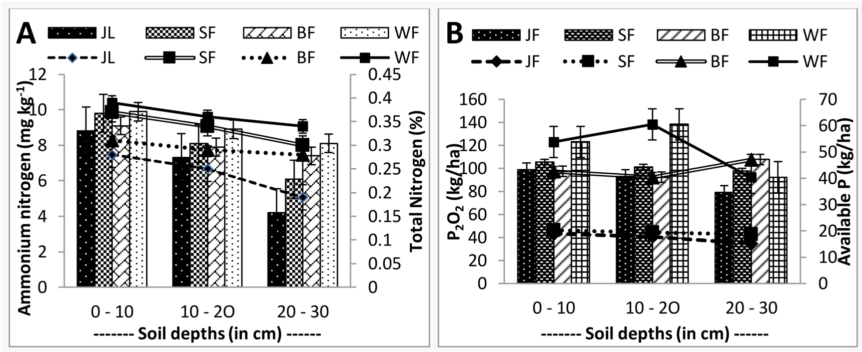

Fig. 3. Various chemical concentrations in different soil depths (i.e. 0-10cm, 10-20 cm and 20-30 cm) of four different land use types. A) Ammonium nitrogen (AN mg kg-1) and Total nitrogen (TN mg kg-1);B) Available P (P_{Avail} kg ha^{-1}) and P2O2 kg ha^{-1}. (Mean ± 1SE, n = 3; LSD0.05 AN = 3.05, TN = 0.06, P avail= 11.1 and P2O2= 25.4).

(Manpoong and Tripathi 2019).

Soil pH was ranged from 4.7 – 5.4 in the present study (Fig. 2A).More acidic soil in WF compared to others land uses suggests high microbial activity due to considerably high litter input which resulted in the release more acids. Number of researchers reported pH value of soil in the range of (3.9 – 5) in different land use types of Mizoram (Manpoong and Tripathi 2019, Singha and Tripathi 2017, Wapongnung sang and Tripathi 2019). Range of per cent TOC and organic matter in the present study varied from 2.5–3.6 and 4.2–6.2 with maximum observed in WF followed by SF and minimum in JL (Fig. 2B). In recent report, percent TOC ranged between 1.8 and 3 in different parts of the state(Wapongnungsang and Tripathi 2019,Wapongnungsang and Tripathi 2018). Percent total nitrogen (TN%) content ranged 0.19 to 0.39% (Fig. 3A) with maximum in WF site followed by SF and minimum in JL. The values were within the ranged reported for different land use types of the state (Manpoong and Tripathi 2019). Ammonium nitrogen (AN) ranged from 4.2 - 9.9 (Fig. 3A) with maximum in WF followed by SF and minimum value in JL sites (Fig. 3A). Available phosphorus ranged between 34 and 61 kg per ha and diphosphorus dioxide ranged between 79 and 140 kg per hectare (Fig. 3B). In all sites, majority of the chemical properties (i.e. TOC,

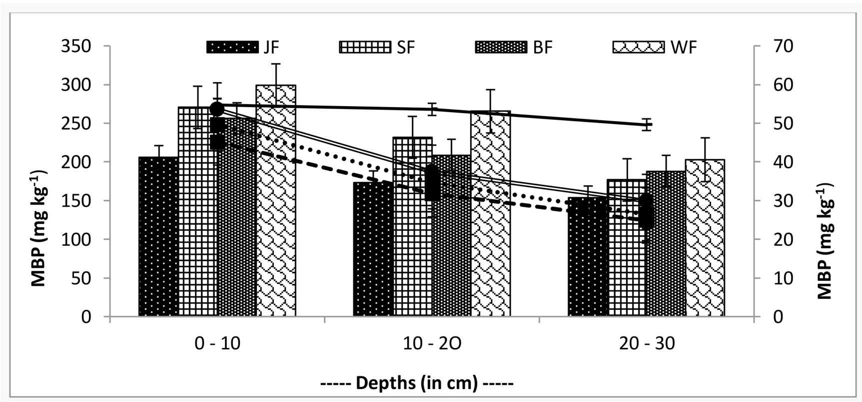

Fig. 4. Concentrations of soil biomass carbon (MBC mg kg^{-1}) and phosphorus (MBP mg kg^{-1}) in different soil depths (i.e. 0-10cm, 10-20cm and 20-30 cm) of four land use types.(Mean ± 1SE, n = 3; LSD0.05 MBC=75.9, MBP = 18.76).

Table 2. Correlation matrix of various soil physico-chemical properties of different land use types (n=36).

	SMC %	WHC %	BD (g cm^{-3})	Sand %	Silt %	Clay %	TOC %	TN (mg kg^{-1})	AN (mg kg^{-1})	P_{Avail} (kg ha^{-1})	MBC (mg kg^{-1})	MBP (mg kg^{-1})
SMC %	1											
WHC %	.175	1										
BD (g cm^{-3})	588*	.158	1									
Sand %	.424	.822**	.108	1								
Silt %	.401	.477	.462	.621*	1							
Clay %	.239	.689*	.483	.805**	.034	1						
TOC %	798**	.209	.792**	.125	.558	.262	1					
TN (mg kg^{-1})	.836**	.112	.737**	.202	.584*	.183	.977**	1				
AN (mg kg^{-1})	.609*	.522	.713**	.229	.163	.415	.851**	.831**	1			
P_{Avail} (kg ha^{-1})	.578*	.311	.646*	.277	.187	.491	.689*	.715**	.618*	1		
MBC (mg kg^{-1})	.766**	.327	.900**	.086	.327	.354	.924**	.872**	.873**	.725**	1	
MBP (mg kg^{-1})	.695*	.387	.702*	.054	.286	.287	.878**	.813**	.858**	.590*	.869**	1

OM, TN, AN, P avail and P2O2) were higher in WF ± by SF and BF with minimum in JL site (Fig. 3B).

Maximum value of microbial biomass carbon (MBC mg kg-1) and microbial biomass phosphorus (MBP mg kg-1)in all depths were recorded in WF followed by SF and minimum in JL site (Fig. 4). MBC value in the present study ranged from 150 to 300 which is slightly lower compared to value reported by Wapongnungsang and Tripathi(2019). MBP value in the present study ranged from 24 to 55 (Fig. 4).

Correlation analysis

Soil physico-chemical properties from different sites along with depths were correlated with each other (Table 2). TOC, TN, AN and P_{Avail} were significant positively ($p<0.01$) correlated with SMC but significant negatively correlated BD. Increase in the organic matter content has been widely reported to increase the SMC and nutrient contents in the soil and decrease in BD as the soil becomes more lighter, porous and fertile. WHC hadstrong negative correlation with sand but positive correlation with clay content. This is consistent with the earlier published work (Wapongnungsang and Tripathi 2019 andManpoong and Tripathi 2019) which indicates that the increasing clay content tend to increase the capacity of the soil to hold considerably high water content and the reverse was true in case of sand content. BD had significant strong negative correlation with TOC, TN, AN and P_{Avail}. This is quite obvious that the increase in BD decreases soil nutrient contents. Sand content had significant negative correlation with silt and clay.

TOC was strongly positively correlated with TN, AN and PAvail. TN was significantly positively correlated with AN andPAvail. AN andPAvailwere significantly positively correlated with each other (Table 2). Organic matter and TOC has been widely reported to control the TN and many available nutrients in the soil (Wapongnungsanget al. 2017) as they provide the scope for the microorganisms to feed on them and releases nutrients in the soil. Significant positive correlation of SMC and WHC with clay content indicate significant role of clay content.

CONCLUSION

This study concludes that natural WFconserve soil nutrients more efficiency compared to other land use types because this system allows significantly higher soil micro-floral activities on the plenty of litter material available on the soil.SF and BFwere next in the order to recycle the organic matter and nutrients with the system. However, the nutrient availability in the current JL was poor compared to other land uses because of considerably low organic inputs which requires proper management strategies to accelerate the process of organic matter buildup and recycling within such ecosystem.

ACKNOWLEDGEMENT

The authors acknowledge to University Grant Commission, New Delhifor financial (RGNF Fellowship) support and also Department of Forestry, MizoramUniversity for providing laboratory facility and assistance during this research.

REFERENCES

Baethgen W.E., Alley M.M. (1989)A manual colorimetric procedure for measuring ammonium nitrogen in soil and plant Kjeldahl digests. Commun. Soil Sci. and Pl.Anal. 20(9-10): 961-969.

Bandyopadhyay K., Aggarwal P., Chakraborty D., Pradhan S., Garg R.N., Singh R. (2012) Practical Manual on Measurement of Soil Physical Properties.

Bouyoucos G.J. (1962) Hydrometer method improved for making particle size analyses. Agron.J. 54(5): 464-465.

Bray R.H. and Kurtz L.T. (1945) Determination of total, organic, and available forms of phosphorus in soils. Soil Sci. 59(1): 39-46.

Champion S.H., Seth S.K. (1968) A revised survey of the forest types of India. A revised survey of the forest types of India.

Coutts J.R.H. (1930) "Single Value" Soil Properties. A Study of the Significance of Certain Soil Constants. III. Note on the Technique of the Keen-Raczkowski Box Experiment (With Three Text-figures.). J. Agric. Sci. 20(3): 407–413.

Doran J.W., Parkin T.B. (1994) Defining and assessing soil quality. Defining soil quality for a sustainable environment, (definingsoilqua), 1-21.

Hauchhum R., Tripathi S.K. (2019) Impact of rhizosphere microbes of three early colonizing annual plants on improving soil fertility during vegetation establishment under different fallow periods following shifting vation. Agric Res 1–9.

India state of forest report, ISFR(2019) Forest Survey of India 2019.

Jenkinson D.S., Powlson D.S. (1976) The effects of biocidal treatments on metabolism in soil—V: A method for measuring soil biomass. Soil Biol. and Biochem. 8(3): 209-213.

Kimmins J.P. (1987) Forest ecology. New York.

Manpoong C., Tripathi S.K. (2019) Soil properties under different land use systems of Mizoram, North East India. J. Appl. and Natural Sci. 11(1): 121-125.

Singh N.P., Singh K.P., Singh D.K. (2002) Flora of Mizoram Vol. I Botanical Survey of India.

Singh N. S.,Tripathi S. K. (2020) Temporal changes in soil microbial diversity of tropical and sub-tropical forests of Mizoram, Northeast India. Environ. Ecol. 38(1): 31–37.

Singh S.B., Mishra B.P., Tripathi S.K. (2015) Recovery of plant diversity and soil nutrients during stand development in subtropical forests of Mizoram, Northeast India. Biodiver. J.Biol. Diver. 16(2): In press.

Singha D., Tripathi S.K. (2017) Variations in fine root growth during age chronosequence of moist tropical forest following shifting cultivation in Mizoram, Northeast India. Trop. Ecol. 58: 769-779.

Tripathi R.S., Roy A., Kushwaha D., Lalnunmawia F., Lalnundanga L.H., Lalnunzira C., Roy P.S. (2016) Perspectives of forest biodiversity conservation in Northeast India. J.Biodiver.Bioprospect.and Develop. 3: 1-9.

Tripathi S.K., Kushwaha C.P., Basu S.K. (2012) Application of fractal theory in assessing soil aggregates in Indian tropical ecosystems. J. For. Res. 23(3): 355-364.

Tripathi S.K., Kushwaha C.P., Singh K.P. (2008) Tropical forest and savanna ecosystems show differential impact of N and P additions on soil organic matter and aggregate structure. Global Change Biol. 14(11): 2572-2581.

Tripathi S.K., Vanlalfakawma D.C., Lalnunmawia F. (2017) Shifting cultivation on steep slopes of Mizoram, India: Impact of policy reforms. In: Cairns M. (ed). Shifting Cultivation Policies: Balancing Environmental and Social Sustainability: CABI Publishing, London, pp. 395–413.

Vance E.D., Brookes P.C., Jenkinson D.S. (1987) An extraction method for measuring soil microbial biomass C. Soil Biol.Biochem. 19(6): 703-707.

Walkey A., Black I.A. (1934) An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Sci. 37 (1) : 29–38.

Wapongnungsang, Hauchhum R., Tripathi S.K.(2017) Litter Decomposition Vis-a-Vis Carbon and Nitrogen Dynamics of Tephrosia candida Components in Different Fallow Periods Following Shifting Cultivation in Mizoram. Ind. J. Ecol.44 (4) : 791–796.

Wapongnung sang, Tripathi S.K. (2019) Fine root growth and soil nutrient dynamics during shifting cultivation in tropical semi-evergreen forests of Northeast India. J.Environm.Biol. 40(1): 45–52.

Wapongnungsang C. M., Tripathi S. K. (2018) Changes in soil fertility and rice productivity in three consecutive years cropping under different fallow phases following shifting cultivation. Int. J. Pl. and Soil Sci. 25(6): 1–10.

Yadav P.K. (2015) Slash-and-Burn Agriculture: Environmental Intimidation in Garo Hills.