International Journal of Plant & Soil Science

Volume 35, Issue 7, Page 120-128, 2023; Article no.IJPSS.97942
ISSN: 2320-7035

Soil Fertility Status in Relation to Fallow Cycle in Shifting Cultivated Areas of DIMA HASAO

Baosring Nunisa [a*], Danish Tamuly [b], Pallabi Hojai [b], Khirud Panging [c] and Kamir Taropi [d]

[a] Department of Soil Science, Assam Agricultural University, Jorhat, India.
[b] Department Zoology, Guwahati University, Guwahati, India.
[c] Department of Plant Breeding and Genetics, AAU, Jorhat, India.
[d] Department of Horticulture, AAU, Jorhat, India.

Authors' contributions

This work was carried out in collaboration among all authors. Author BN designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors' Sir guided author BN all throughout the research programme and author DT had major contribution in the soil analyses processes and interpretation of data. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2023/v35i72871

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here:
https://www.sdiarticle5.com/review-history/97942

Original Research Article

Received: 19/01/2023
Accepted: 24/03/2023
Published: 28/03/2023

ABSTRACT

Aim: To understand the effect of fallow cycle on soil fertility status under shifting cultivation.
Study Design: Latin square design (LSD).
Place and Duration of Study: Dima Hasao District, Assam. Between September 2019- August 2021.
Methodology: The present investigation was carried to study the effect of jhum fallow cycle on soil properties in the DIMA HASAO district of Assam. Total of 120 geo-referenced soil samples were collected from short jhum (1-3yrs.) fallow cycle, medium jhum (4-6yrs.) fallow cycle, long jhum

---

*Corresponding author: E-mail: baosringnunisa020@gmail.com;

(7-9 yrs.) fallow cycle and undisturbed soil. The collected soil samples were analyzed for parameters like pH, OC, N, P, K, S, Ca, Mg, CEC and soil texture.

Results: The studied soil samples showed wide variations in texture varying from sandy loam to clay loam. Coarse texture sand was found to be dominant in short jhum and medium jhum while finer particles (silt and clay) were dominant in the long jhum and the undisturbed soil. The Soil pH was found lowest (mean value 4.55) in short jhum and highest (mean value 5.00) in the undisturbed soil. The OC content was minimum at initial short jhum fallow cycle and maximum was observed in the Undisturbed soil. The CEC of the study area was found highest in undisturbed soil (mean value 8.64 cmol (p+) kg-1) followed by long jhum, medium jhum and short jhum. The Avl. N content of the study area was found low to medium. Among the jhum fallow cycle Avl. N of short jhum was lowest (mean value 269.30kgha-1) followed by medium jhum, long jhum and highest in undisturbed soil (mean value 350.11 kgha-1). The Avl. P content of the study area was found low to medium, highest mean value 12.61 kg ha-1 was observed in long jhum fallow cycle and lowest in short jhum (mean value 9.33 kgha-1). The highest content of Avl. S was observed in long jhum fallow cycle and lowest in the short jhum. The highest of Ex. Ca, Mg was found in the undisturbed followed by long jhum, short jhum and lowest in the medium jhum. All the soil fertility parameters i.e., N, P, K, S, Ca and Mg exhibited significant positive correlation with pH, OC, CEC, and percent Clay.

Conclusion: From the study it was observed that minimum of 7 to 10 years jhum fallow cycle is required in Dima Hasao are for the soil to restore its fertility and sustainable jhum cultivation.

Keywords: Shifting cultivation; fallow cycle; soil fertility; fertility restoration.

1. INTRODUCTION

“Agriculture, in India is regarded as the main occupation with more than 70% of workforce, has been in low even after Independent India” [1]. “With the advent of green revolution in the later 60’s, there has been a sea change in agricultural production. Shifting cultivation has been an age-old practice in the hilly areas of North Eastern region. Shifting cultivation is considered a strategy of resource management in which fields are shifted to exploit the nutrient capacity of vegetation” [2]. “Shifting of fields is cyclical and rotational. Fields are prepared by removal of vegetation with the use of fire. Field preparation is done during February/March followed by dibbling, sowing during April/May. Weeding is done during June/July, harvesting during September/October and threshing during September/October. The cultivated land after harvest is left abandoned for 8 to 15 years, during this fallow period the soil regain its fertility through various factors” [3,4]. Restoration of soil fertility during the fallow period is very diverse, the beneficial micro-organism acts of the fallen leaves, twigs and other fallen parts of a plant and gets decomposed which later adds fertility to the soil. The earthworms, plays a major role regaining natural soil fertility regarded as “friends of the farmers” by enriching the soil with their castings. Other biotic activities of flora and fauna and their litters of birds, animals and decomposed plant debris helps to soil health building [5]. “Hence, the fertility of soil during fallowed is restored with fair amounts of major nutrients like nitrogen, phosphorus and potassium besides, improving a good soil structure makes the soil virgin in a cycle of 10 - 15 years of fallow period” [6].

“In India, shifting cultivation is widely practiced by tribal people of many states including Assam, Meghalaya, Arunachal Pradesh, Nagaland, Manipur, Tripura, Mizoram, Madhya Pradesh, Orissa, Andhra Pradesh, and Kerala. Every year, approximately 2 million hectares of forest vegetation are slashed and burnt in-situ followed by cropping for 1 or 2 years depending on the soil fertility after that abandonment jhum land to recover soil fertility through natural regeneration” [7]. “Shifting cultivation is an important traditional cultivation in North East India. Out of the total geographical area of the North-East i.e., 25.50 million hectares, Shifting cultivation accounts for 1.47 million hectares. About 0.44 million tribal families survive on jhum cultivation in North-East” [4]. “In Dima Hasao district, about 65 per cent of the people dependent on jhum cultivation as documented by DAO Dima Hasao. The people cultivate on the same plot of land after an interval of 7-10 years. So, the people have to move from one hillock to another in search of new plots of land. In NER, though total area under Shifting Cultivation has been decreasing, yet, the major concern is the shrinking of fallow periods from the earlier practice of 10-15 years to the present one of 2-3 years. Population pressure, limited land resources owing to difficult and inaccessible hilly terrain features, socio- economic impediments, land tenure systems, rapid decline in soil health and predominance of several other anthropogenic degradation over aggradation processes are responsible for this shrink in fallow periods in NER of India" [8]. The shifting cultivation became unsustainable today primarily due to the increase in population that led to increase in food demand. Jhuming cycle in the same land, which extended to 20-30 years in earlier days, has now been reduced to 3-6 years.

"Shifting Cultivation in its 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" [9]. "During the past decades, the fallow period of shifting cultivation was substantially long, and therefore, it was sustainable" [10]. "However, due to increased population pressure, high demand of cereals and growth of urban markets for forest products, fallow period for shifting cultivation has been significantly reduced (<3 years) from 20-25 years" [10,11]. "In this system of cultivation, fallow management is one of the primitive practices associated with crop rotation [12] which continues throughout the arid and semiarid regions of West Asia and North Africa" [13]. "Therefore, the fallow phases of varying ages of jhum cycles are important in enhancing our scientific understanding of the impact of fire on nutrient cycling processes that recovers through the interactions of shift in plant community and soil microbiota. The regenerated plant biomass of the secondary forest stand accumulated over time play a key role in restoration of ecological soil functions of jhum lands. Ecological restorations in these ecosystems are driven by varying degrees of relationships in the pattern of accumulation of forest floor litters, release of locked nutrients within plant biomass, and microbiologically induced biochemical reactions in jhum soils following burning, which vary depending on the length of the fallow period. Therefore, an understanding of the impact of fallow length on the nutrient cycling potentials of jhum soils would be of great significance in formulating sustainable nutrient management practices for enhancing jhum productivity" [14]. "The practice of slash-and- burn farming under reduced fallow cycle is a threat to biodiversity and soil conservation. It is no longer Sustainable" [15]. In view of the nature of the problem, the present study has been taken up in Dima Hasao District of Assam with the following objective.

- To understand the effect of fallow cycle on soil fertility status under shifting cultivation.

2. METHODOLOGY

The present study was carried out (2019-21) in Assam with special emphasis on Dima Hasao district. The specific objectives were pertaining to dynamics of shifting cultivation by evaluating soil fertility status in relation to fallow cycle. The Dima Hasao district is one of the two hills district of Assam between longitude (92.3°. and 93.2° E) and latitude (25°and 25.5° N). The district is located in Assam's hill region, shifting cultivation is dominant method of Agriculture. The soils samples were collected from Dima Hasao district of Assam (blocks: Diyung valley, Diyungbra and Jatinga valley) from various elevation ranging from 90 m to approximately 400 m above mean sea level. The total geographical area is 489000 ha. In the lower elevation areas mainly jhum cultivation were practiced but in higher elevation areas dense forest was seen.

2.1 Materials and Method

Representative soil samples from different jhum fallow cycle of surface layers (0-15 cm) were collected in the month of February and August from different locations of Dima Hasao district of Assam. A total of 120 representative samples were collected out of which 30 short Jhum a (1 to 3 years), 30 medium jhum (4 to 6 years), 30 long jhum (7 to 9 years) and 30 from the undisturbed soil (more than 10 years). The collected soil samples were air dried in shade at room temperature, ground and passed through a 2 mm sieve. The sieved samples were stored in polythene bags and used for various analysis. Collected soil samples were analyzed for various parameters like particle size (texture), OC, CEC, N, P, K, S, Ca and Mg following the standard procedure.

2.2 Statistical Analysis

Data were subjected to Latin square design (LSD). Multiple comparison among the treatment were done with Duncan's Multiple Range test (DMRT). Correlation studies were carried out in software package IBM SPSS Statistics 20.0 for Windows to reveled the magnitude and direction of relationship between selected soil physico-chemical properties.

3. RESULTS AND DISCUSSION

3.1 Effect of Fallow Cycle on Soil Physical Properties

“The slashing and burning of successional secondary forest, as well as the length of the fallow period, resulted in changes in the physicochemical properties of jhum soils” [16]. In the initial short jhum and medium jhum fallow cycle had higher coarse fraction sand compared to finer silt and clay fraction in the long jhum fallow cycle as well as in the undisturbed soil (Table 1). The texture of the short jhum and medium jhum soils was found to be mostly sandy loam and sandy clay loam texture, whereas the long jhum and the undisturbed soil were mostly sandy clay loam and clay loam in texture (Table 1). The dominance of coarser fractions (sand) in the initial jhum fallow cycle might be due to anthropogenic disturbance of terrestrial ecosystem. During the practice of jhum cultivation the land was first cleared and vegetation, following by broadcasting the seed or soil till for jhum cultivation. The soil particles therefore remain exposed and were eroded rain water. The finer particles were very sensitive to the rain as compare to coarser particles which may leads to leaching off the finer particles. Eyre [17] too found “the dominance in coarse fraction sand after one year of jhum cultivation and leaching of finer soil particles such as silt and clay with disturbance of terrestrial ecosystem”. “With the increase in jhum fallow cycle gradual increase in silt and clay content was observed under longer jhum fallow cycle this might be due to growth of natural vegetation gradually with increasing the jhum fallow cycle” [8,18]. “The growth of natural vegetation gradually increased with increasing jhum fallow period. There was increasing accumulation of organic matter on the surfaces finer fraction. The finer particles were held together with the plant roots; therefore, silt and clay content were more over coarser fraction (sand) content under longer fallow periods of jhum cultivation” [14].

3.2 Effect of Fallow Cycle on Soil Chemical Properties

3.2.1 Soil Ph

The pH of the studied area varied from very strongly acidic to moderately acidic in nature.High acidity was found in short jhum, medium jhum and the long jhum soils of Dima Hasao district, whereas the pH of undisturbed soil was found mostly moderate acidic(Table 1). Basumatary et al. [19] also reported “the acidic condition in the soils of Dima Hasao”. “The strongly acidic nature of the soil in short jhum fallows cycle might be due to anthropogenic disturbance of the terrestrial ecosystem and burning down of vegetation that exposes the soil to raindrop impacts and leads to leaching of bases from the exchange complex under the prevailing high rainfall and hilly topography” [20,1]. “High exchangeable aluminum and hydrogen ions content under acidic condition might be the cause of lower pH value” [21,22]. “The soil pH increased with increased in jhum fallow which cycle might be attributed to higher deposition of organic matter and in situ-deposition of grasses which resulted in subsequent enrichment with bases” [8]. Increasing pH with increasing fallow length was also reported by Kulmala et al. [23].

3.2.2 Organic carbon (OC)

The practice of jhum cultivation and burning down the vegetation might help in the exposure of OC in the terrestrial ecosystem which drastically reduce organic carbon content after one or two years of jhum cultivation. The depletion of organic matter in the surface soil continued through the early successional fallow cycle. This might be mainly due to low return of litter during the initial colonization and growth of the vegetation in the jhum fallow cycle [24]. The OC content increased with increasing of the jhum fallow cycle, higher content of OC was found in a longer jhum fallow cycle i.e., 7-9 years (Table 1), though a slightly lower level than the undisturbed soil [8,5] in jhum soil of Manipur and Mizoram. Such observation might be attributed to growth of higher plants and trees which creates favorable environment for micro-organism for higher decomposition of plant liter falls and death or decay of above ground biomass [18]. “Increase in organic carbon content through leaf litter addition and decomposition has recently been demonstrated in Italy, where litters from secondary forest successions increased the OC of abandoned agricultural land from 1.5 per cent to 1.9 per cent in the top soil layer and from 1.4 per cent to 1.7 per cent up to a depth of 15 cm” [25]. “The significant increase in OC content in medium jhum and long jhum might be due to an increase in herbaceous layer over a short period of time and bush density that reduces soil erosion and increase in OM content through biomass production, a higher yield of in-situ decomposition to replenish soil nutrients” [26].

The density of trees and bushes provides adequate soil protection, thereby preventing the nullification of soil nutrients by soil erosion. The dense mulch helps to minimize the direct impact of raindrops on the soil, thus keeping the litter stubble to decompose. This observation confirmed the findings of Aweto [27], that “a substantial increase in organic matter occurred in the upper part (10 cm) of soil profiles during the ten years of jhum fallow cycle”. “The large difference in carbon storage between the short jhum fallow cycle and long jhum fallow cycles could be interpreted as rapid carbon buildup due to vegetation development” [28].

3.2.3 Cation Exchange Capacity (CEC)

Cation exchange capacity of the soils of Dima Hasao district of Assam was found low in all the fallow cycle as well as in the undisturbed soil. The lowest CEC in short jhum fallow cycle might be due to lower content of organic carbon and cations as compared to other longer jhum fallow cycle. The highest mean value of CEC was found in the undisturbed soil which might be due to higher content of organic carbon and cations as compared to other jhum fallow cycle (Table 1). The bush fallow increase CEC with progressive fallow period, the difference may be result of the difference in parent material and vegetation composition. Moreover, greater CEC could be as a result of the increase in the accumulation of litter that also increase in organic matter content of the soil [26]. Basumatary et al. [19] also reported that cation exchange capacity of Dima Hasao soil was invariably low [4.5 to 10.25 cmol(p+) kg+] reflecting the dominance of low activity clay (Kaolinite). The variation in clay, OC and free iron and aluminum oxides content of the soils might have resulted in variation in CEC of different soils [29]. The low activity clay with low surface charge dominated by kaolinite in the soil might be the reason for low CEC of soils [30].

3.3 Effect of Fallow Cycle on Primary, Secondary and Micro-nutrients Status

During the first year jhum fallow cycle, soil fertility metrics such as N, P, and K were substantially reduced by 23.05 per cent, 22.44 per cent, and 35.89 per cent, respectively as compared to undisturbed soil [31]. The current findings suggest that available Nitrogen, Phosphorus, Potassium, Sulphur, Calcium and Magnesium improved significantly with a longer fallow cycle (Table 1), presumably due to an increase in OC with prolonged length of secondary forest succession, and the jhum fallow site may regain its previous nutritional status [32]. As reported by several researchers, the OM is fundamental to the maintenance of soil health/fertility because it is essential to the optimal functioning of a number of processes important to sustainable ecosystems. Organic matter is a source and a sink of Carbon and Nitrogen and partly of Phosphorus and Sulphur [33]. With the increase in jhum fallow cycle soil fertility parameters like, available nitrogen, phosphorous, potassium and Sulphur, exchangeable calcium and magnesium and boron significantly increased from short jhum fallow cycle to long jhum fallow cycle. Soil fertility restoring process rapidly increased from medium jhum fallow cycle to long jhum fallow cycle. All soil fertility indicators improved from medium jhum (4-6 years) and long jhum (7-9 years) fallow cycle and such development continue, while there was no significant difference observed between long jhum fallow cycle and the undisturbed soil. Long jhum fallow cycle i.e., 7-9 years revealed relatively stronger restoration capabilities [8,18] than other shorter jhum cycles under investigation.

3.3.1 Primary nutrients

The plant nutrients available N in different jhum cycle and the undisturbed soil were found in low to medium range. The minimum available N content was found in the initial short jhum cycle whereas the highest available N content was found in the undisturbed soil (Table 2). From the result it was found that with the increase in jhum fallow cycle, the available N content in the jhum soil increased consistently in jhum fallow land and the significant increase was found from medium jhum and long jhum fallow cycle. The litter availability in longer jhum fallow cycle increases resource availability on jhum soil that can be colonized, decomposed and mineralized by the microorganisms and also retains moisture on the forest floor which may induce OM decomposition and nutrient mineralization in the soil [34]. The increase in available N content with increase jhum fallow cycle might be due to the increase of OC, which released N into the soil. The findings were substantiated with the positive significant correlation with OC, CEC and clay content (r= 0.384**, 0.417**, 0.406**). Similar result was observed by Basumatary et al. [19] in Dima Hasao district.

Table 1. Effect of jhum fallow cycle on soil Physical and chemical properties on jhum soil of Dima Hasao

Jhum cycle	pH	OC (%)	CEC [cmol (p+) kg^{-1}]	Sand %	Silt%	Clay%
Short jhum	4.45^{c}	0.98^{d}	6.53^{c}	54.92^{a}	17.81^{c}	23.24^{c}
Medium jhum	4.64^{b}	1.34^{c}	6.83^{c}	50.19^{b}	21.63^{b}	28.17^{b}
Long jhum	4.96^{a}	1.46^{a}	7.98^{b}	47.12^{c}	25.12^{a}	27.85^{b}
Undisturbed	5.00^{a}	1.55^{ab}	8.64^{a}	46.33^{c}	24.15^{a}	29.60^{a}

Notes: Lower case letters indicate significant ($p < 0.05$) differences among the fallows

Table 2. Effect of jhum fallow cycle on primary, secondary and micronutrients on jhum soils of Dima Hasao

Jhum cycle	Avl. N (kg ha^{-1})	Avl. P (kg ha^{-1})	Avl. K (kg ha^{-1})	Avl. S (mg kg^{-1})	Ex. Ca [cmol(p+) kg-1)	Ex. Ca [cmol(p+) kg-^{1}]
Short jhum	269.30^{b}	9.33^{b}	169..46^{d}	13.43^{c}	1.40^{b}	0.60^{b}
Medium jhum	285.64^{b}	9.55^{b}	217.89^{c}	16.09^{b}	1.37^{b}	0.59^{b}
Long jhum	335.84^{a}	12.61^{a}	244.02^{b}	17.48^{a}	1.46^{b}	1.09^{a}
Undisturbed	350.11^{a}	12.03^{a}	264.40^{a}	17.32^{a}	1.78^{a}	1.19^{a}

Note: Lower case letters indicate significant ($p < 0.05$) differences among the fallows

Table 3. Correlation between the soil properties of the jhum soil

Parameters	pH	SOC	CEC	Clay
N (kg ha^{-1})	0.549**	0.384**	0.417**	0.406**
P (kg ha^{-1})	0.608**	0.286**	0.270**	0.499**
K (kg ha^{-1})	0.491**	0.238**	0.491**	0.318**
S (mg kg^{-1})	0.210**	0.406**	0.266**	0.469**
Ca [cmol(p+) kg^{-1}]	0.371**	0.371**	0.434**	0.470**
Mg [cmol(p+) kg^{-1}]	0.475**	0.402**	0.443**	0.345**
HWS-B (mg kg^{-1})	0.241**	0.413**	0.417**	0.365**

*Note: * indicates significant difference at ($p<0.01$) and ** indicates significant difference at($p<0.05$)*

"The available P content in different jhum cycle and the undisturbed soil increased with the increase in jhum fallow cycle. The less variability in the amount of available P in all the jhum fallow cycle and undisturbed soil indicates that these parameters are less prone to changes in land use and land cover" [35]. "Higher concentration of available P in longer jhum fallows as compared to initial jhum fallow cycle (Table 2) may be attributed to rapid P cycling in young secondary forests by decomposition and the mineralization of more P-rich litter which helps to maintain greater concentrations of P in these soils, until uptake and accumulation in living biomass removes P from this cycle. Acidic soils fix P resulting in low available P in all jhum soils sampled in this study. Plant uptake, erosion, leaching and fixation can be accounted for lower amount of P from the soil system in all the jhum land. The native P was more solubilized with organic acid and root exudates. Similarly, many authors found that soils under long term jhum fallow cycle contain more total N, P and Ca in the surface horizon (0-12 cm)" [27,36,37]. The significant increase in available P was observed from long jhum fallow cycle and statistically at par with undisturbed soil.

The status of available K in the shifting cultivated areas of Dima Hasao district were found to range from medium to high. The highest available K was found in the undisturbed soil and the lowest in the initial jhum fallow cycle (Table 2). The higher content of available K in the longer fallow cycle might be due to creation of favorable soil environment with presence of higher content of organic carbon as compared to shorter jhum fallow cycle [18]. During slashing and burning operation in the jhum field, the ash deposited by burning the biomass release K, resulting in higher availability of K [38,39].

3.3.2 Secondary nutrients

The exchangeable calcium and magnesium in different jhum fallow land and undisturbed soil increased with the increase in jhum fallow cycle. The highest exchangeable Ca and Mg was found in the undisturbed soil and the lowest was found in the initial jhum fallow cycle (Table 2). Similar findings were recorded by Manjunatha and Singh [18] in West Garo Hills Meghalaya. The higher value of exchangeable Ca and Mg in the longer jhum fallow cycle might be due to increase in soil pH and organic carbon content as compared to initial jhum fallow cycle [8,18]. Correlation study also showed that both exchangeable Ca and Mg exhibited a significant and positive correlation with pH, OC, and CEC indicating that these properties played an important role in improvement of status of exchangeable Ca and Mg in shifting cultivated areas of Dima Hasao [19] deficit status of exchangeable Ca and Mg in the soils of Dima Hasao.

The available sulphur content of short jhum medium jhum and long jhum fallow cycle and undisturbed soil were medium to high (Table 2). The variation might be due to variation in content of organic carbon in different jhum fallow cycles. This was supported by a highly significant positive correlation of available sulphur with organic carbon (r=0.406**) [40] in soils of Assam. About 6.8 per cent of the soils were found as deficient while 73.2 per cent of the soils were reported as high. This indicates that jhum soils of Dima Hasao district have sufficient amount of available sulphur to meet demands of sulphur by crops in long jhum fallow cycle and the undisturbed soil.

3.4 The Correlation between the Soil Properties of the Jhum Soil

The soil properties like organic carbon, cation exchange capacity, soil pH and clay content were found positively correlated with, available N, P, K, S, exchangeable Ca and Mg (Table 3). Most of plant nutrients were found to be increasing with increase in OC and favorable soil pH. On decomposition the plant residues enhanced the amounts of exchangeable bases as well as cation exchange capacity (CEC) of soil. However, soil pH moderately increased with increasing jhum fallow cycle, which might be attributed to organic acid released on decomposition of organic matter and there by accumulation of OM with longer jhum fallow period [6]. The substantial increase in OC contents was attributed to the increase in the density of trees/shrubs and the higher amount of litter production on in situ decomposes to add nutrient to the soil. The density of trees/shrubs provides adequate protection, releases root exudates to the soil thereby preventing unproductive nutrient losses. Similarly, many authors found that soils under long term fallow cycle contained more N, P and Ca in the surface horizon [27,41,36]. The exchangeable Ca and Mg as well as sulphur were held with colloidal clay particles thereby leading to their subsequent enhanced concentration in soil solution [42,43].

4. CONCLUSION

The soil properties changed with the changing of land covers. Most of the soil properties and fertility parameters improves with longer jhum fallow cycle. Maintenance of soil organic carbon will ensure better soil fertility and it was found that longer jhum fallow cycle (7-9 years) was better in maintaining soil fertility in study area of Dima Hasao. During the fallow cycle, proper scientific intervention could be planned with better knowledge of soil properties in relation to jhum fallow cycle, for sustainable and healthy soil management. Based on the findings of the present study, it could be inferred that 7 to 9 years of jhum fallow cycle might be helpful in reclamation and restoration of soil health.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Kapngaihlian J. Dynamics of shifting cultivation in Churachandpur district of Manipur (Doctoral dissertation, Acharya NG Ranga Agricultural University Rajendranagar, Hyderabad); 2010.
2. Shankar U, Tripathi RS. Evaluating second year cropping on jhum fallows in Mizoram, north- eastern India, Soil fertility. Journal of Biosciences.1996;21:563–575.
3. Yadav PK. Slash-and-burn agriculture in north-east India. Journal of expert Opinion on Environmental Biology. Biol. 2013;2:2-5.
4. Tripathi SK, Vanlalfakawma DC, Lalnunmawia F. Shifting cultivation on steep slopes of Mizoram, India, shifting cultivation policies: balancing environmental and social sustainability. CAB International Wallingford, UK. 2017;393-413.
5. Lungmuana SB, Vanthawmliana SS, Rambuatsaiha AR. Impact of secondary forest fallow period on soil microbial

biomass carbon and enzyme activity dynamics under shifting cultivation in North Eastern Hill region, India; 2017.

6. Powlson DS, Brookes PC, Christensen BT. Measurement of soil microbial biomass provides an early indication of changes in total organic matter due to straw incorporation. Soil Biology and Biochemistry. 2011;19:159–164.
7. Ovung E, Upadhyay KK, Tripathi SK. Soil fertility and rice productivity in shifting cultivation: impact of fallow lengths and soil amendments in Lengpui, Mizoram northeast India. Heliyon. 2021;7(4).
8. Devi NL, Choudhury BU. Soil fertility status in relation to fallow cycles and land use practices in shifting cultivated areas of Chandel district Manipur, India. IOSR Journal of Agriculture and Veterinary Science. 2013;4(4):1-9.
9. Saha R, Chaudhary RS, Somasundaram J. Soil health management under hill agroecosystem of North East India. Applied and Environmental Soil Science; 2012.
10. Luoga EJ, Witkowski ETF, Balkwill K. Subsistence use of wood products and shifting cultivation within a miombo woodland of eastern Tanzania, with some notes on commercial uses. South African Journal of Botany. 2000;66(1):72-85.
11. Mwampamba TH. Forest recovery and carbon sequestration under shifting cultivation in the Eastern Arc Mountains, Tanzania: landscape and land use effects. University of California, Davis; 2009.
12. Karlen DL, Varvel GE, Bullock DG, Cruse RH. Crop rotations for the 21st century. Advance Agronomy. 1994;53:1-45.
13. Ryan J, Pala M. Syria long-term rotation and tillage trials: Potential relevance to carbon sequestration in Central Asia. In climate change and terrestrial carbon sequestration in Central Asia. 2007;241-252.
14. Saplalrinliana H. Plant litter -soil enzyme interactions and biochemical index of soil fertility in jhum agroecosystem. Ph. D. Thesis, Submitted to College of Post Graduate Studies, Central Agricultural University, Imphal, India; 2016.
15. Duguma B, Gockowski J, Bakala J. Smallholder cacao cultivation in agroforestry systems of West and Central Africa: Challenges and opportunities. Agroforestry Systems. 2001;51(3):77–188.
16. Kavadias VA, Alifragis D, Tsiontsis A, Brofas G, Stamatelos G. Litterfall, Litter accumulation and litter decomposition rates in four forest ecosystems in Northern Greece. Forest Ecology Management. 2001;144: 113-127.
17. Eyre SR. Vegetation and soils: a world picture. Edward Arnold Publishers Limited, U.K.; 2017.
18. Manjunatha RL, Singh NJ. Effect of fallow age on soil properties of Jhum fields in West Garo Hills District, Meghalaya. Journal of Pharmacognosy and Phytochemistry. 2020;9(2):591-597.
19. Basumatary A, Kandali G, Bordoloi A, Sarmah T. Spatial variability of fertility status in soils of Dima Hasao district of Assam. Annals of Plant and Soil Research. 2021;23(3):368-374.
20. Granged AJ, Zavala LM, Jordan A, Barcenas MG. Post-fire evolution of soil properties and vegetation cover in a Mediterranean heathland after experimental burning: A 3-year study. Geoderma. 2011;164(1-2):85-94.
21. Bhuyan N, Barua NG, Borah DK, Bhattacharyya D, Basumatary A. Georeferenced micronutrient status in soils of Lakhimpur district of Assam. Journal of the Indian Society of Soil Science. 2014;62:102-107.
22. Basumatary A, Ozah D, Goswami K. Assessment of available macro and micronutrient status in soils of Dhubri district of Assam. Journal of the Indian Society of Soil Science. 2019;67:423-430.
23. Kulmala L, Aaltonen H, Berninger F, Kieloaho AJ, Levula J, Bäck J, Hari P, Kolari P, Korhonen JFJ, Kulmala M, Nikinmaa E, Pihlatie M, Vesala T, Pumpanen, J. Changes in biogeochemistry and carbon fluxes in a boreal forest after the clear–cutting and partial burning of slash. Agricultural on Forest Meteorology. 2014;188: 33-44.
24. Ramakrishnan PS, Toky OP. Soil nutrient status of hill agro-ecosystems and recovery pattern after slash and burn agriculture (jhum) in north-eastern India. Plant and Soil. 1981;60(1):41-64.
25. Novara A, Rühl J, Mantia T, Gristina L, La Bella S, Tuttolomondo T. Litter contribution to soil organic carbon in the processes of agriculture abandon. Solid Earth. 2015;6:425-432.
26. Chase P, Singh OP. Soil nutrients and fertility in three traditional land use systems

of Khonoma, Nagaland, India. Resources and Environment. 2014;4(4):181-189.

27. Aweto, AO. Secondary Succession and soil fertility restoration in south western Nigeria. Journal Ecology. 1981;69:601-607.
28. Chaplot V, Khampaseuth X, Valentin CL, Bissonais Y. Interrill erosion in the sloping lands of northern Laos subjected to shifting cultivation. Earth. 2007;32(3):415-428.
29. Maji AK, Reddy GP, Thayalan S, Walke NJ. Characterization and classification of landforms and soils over basaltic terrain in sub-humid tropics of Central India. Journal of the Indian Society of Soil Science. 2005;53(2):154-162.
30. Bhattacharyya D, Sidhu PS. Morphological and physicochemical characteristics of some soils of Assam. Journal of Research Assam Agricultural University. 1984;5:20-29.
31. Tanaka S, Funakawa S, Kaewkhongkha T, Hattori T, Yonebayashi K. Soil ecological study on dynamics of K, Mg, and Ca, and soil acidity in shifting cultivation in northern Thailand. Soil Science and Plant Nutrition. 1997;43(3): 695-708.
32. Tinker PB, Ingram JS, Struwe S. Effects of slash-and-burn agriculture and deforestation on climate change. Agriculture, Ecosystems and Environment. 1996;58(1):13-22.
33. Sharma KL, Mandal B, Venkateswarlu B. Soil Quality and productivity improvement under rainfed conditions – Indian Perspectives, chapter 8, in, Resource management for sustainable agriculture, In Tech. 2012;203-237.
34. Maithani K, Arunachalam A, Tripathi RS, Pandey HN. Nitrogen Mineralization as influenced by climate, soil and vegetation in a subtropical humid forest in Northeast India. Forest Ecology and Management. 1998;109: 91-101.
35. Wubie MA. Impacts of land use system on soil properties and fertility status in the mizewa watershed of lake Tana Basin, North Western Ethiopia. International Journal of Research in Commerce, Economics & Management. 2013;3(9):120-124.
36. Offiong RA, Umoh NE, Ekpe IA, Iwara AI. Effect of secondary succession on the changes in soil physicochemical properties in the Cross River Rainforest, Nigeria. Journal of Emerging Trends in Economics and Management Sciences. 2015;6(3):209-213.
37. Seubert CE. Effects of land clearing methods on crop performance and changes in soil properties in an Ultisol of the Amazon Jungle of Peru (No. Thesis S496). North Carolina State Univ., Raleigh, NC (EUA); 1975.
38. Mishra G, Giri K, Jangir A, Vasu D, Comino JR. Understanding the effect of shifting cultivation practice (slash-burn-cultivation-abandonment) on soil physicochemical properties in the North-eastern Himalayan region. Investigaciones Geograficas (Espana). 2021;76:243-261.
39. Najafi GM, Boostani HR, Hardie AG. Release of potassium from some heated calcareous soils to different solutions. Archives of Agronomy and Soil Science. 2021;1-14.
40. Basumatary A, Das KN, Borkotoki B. Interrelationships of sulphur with soil properties and its availability index in some rapeseed growing Inceptisols of Assam. Journal of the Indian Society of Soil Science. 2010;58:394-402.
41. Bruun TB, Mertz O, Elberling B. Linking yields of upland rice in shifting cultivation to fallow length and soil properties. Agriculture, Ecosystems and Environment. 2006;113(1-4):139- 149.
42. Sarkar R, Bora AK, Sarma T. Shifting cultivation in relation to slope pattern and elevation in Karbi Anglong District of Assam; 2020.
43. Wapongnungsang CM, Tripathi SK. Changes in soil fertility and rice productivity in three consecutive years cropping under different fallow phases following shifting cultivation. International Journal of Plant & Soil Science. 2018;25(6):1-10.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/97942