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Effect of fallow age on soil properties of Jhum fields in West Garo Hills District, Meghalaya

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Abstract
Shifting cultivation is an agricultural practice in hilly terrains involving the slashing and burning of vegetation and cropping for few years following a fallow period. It was attempted to study the different fallow Ages effect on soil properties. Six different sites of each fallow ages such as 3, 6, 9, 12 and 15 Years were identified and selected for composite soil sampling. The composite soil samples were collected at two depths (0-15 and 15-30 cm) from the selected 6 sites of each fallow age using a global position system aided with satellite imagery/maps etc. The data were statistically analyzed using one way analysis of variance and means were compared with Duncan test in SPSS 21. Results revealed that in longer fallow ages of Jhum land, 12 -15 years fallow age had relatively higher finer fraction (silt and clay) compared to short term fallow ages (3 years). The amount of organic carbon and available nitrogen was minimum in 3 to 6 years of Jhum fallow age and increased from 9 year onwards and maximum at 15 year Jhum fallow age. The available phosphorus and potassium was minimum at 3 year fallow age and increased from 6 years fallow age. The surface exchangeable Calcium was increased from 6 years of fallow age onwards. From the study, it was concluded that the minimum Jhum fallow period should be atleast 6-7 years in the district at present time.

Keywords: Shifting cultivation, Jhum fallow age, soil properties

Introduction

Shifting cultivation is more traditional and cultural integrated form, ecological and economically viable system of agriculture and Jhum cycles are long enough to maintain soil fertility as long as population densities are low (Datta *et al*., 2014) [8]. It involves the slashing and burning of vegetation and a few years of cropping, followed by a fallow period in which farmers shift to surrounding areas. Shifting cultivation is still practiced by tribal communities in many parts of the world particularly in the wet tropical regions (Li *et al*., 2014) [23] and known by different names such as Roca in Brazil, Chitimene in Central and Southeast Africa, Jhum in India, taungya in Southeast Asia (Fujisaka *et al*., 1996) [15]. In Northeast India, it is known as Jhum, Podu in Orissa, Kumari in Western Ghats. Forest Survey of India reported 1.73 million ha of forest affected by shifting cultivation in Northeast India (FSI, 2000) [14]. National Remote Sensing Centre also reported about 0.76 million ha under shifting cultivation in 2008-09 (NRSC, 2011) [26]. The soil properties of fallow lands after developing secondary forest under shifting cultivation is strongly acidic with decreasing exchangeable bases, organic carbon (OC) and soil nutrients such as calcium (Ca), magnesium (Mg), potassium (K) and nitrogen (N) with increasing soil depth (Borggaard *et al*., 2003) [3]. The soil properties such as pH, organic carbon, available and total major nutrients has been found to decrease due to shortening of Jhum fallow period to 2-3 years in north eastern region (Das and Das, 2014; Devi and Choudhury, 2013) [7, 10]. There is ambiguous relationship between soil properties and fallow period their has been report of negative relationship between soil properties and fallow length (Susanto *et al*., 2016) [37] and a positive relationship between length of fallow with available N and rice yields (Bruun *et al*., 2006) [6]. The Soil OC increased as the fallow cycle increased, i.e., 1.18% in <2 year fallow cycle to 2.33% in >10 years fallow cycle (Mishra and Saha, 2007) [25]. High OC was recorded in twenty years Jhum fallow period (Datta and Bhowmik, 2014) [9]. The slashing and burning of vegetation in shifting cultivation is causing the top soil loss, degradation of soil quality and decrease in crop yield but the management of fallow period is significantly increasing the crop yield (Borthakur *et al*., 1983; Ramakrishnan, 1992; Yadav *et al*., 2012) [4, 32, 44]. Increasing the fallow period (>8 years) with adoption of appropriate land uses could restored the soil fertility of Jhum field and also found the optimum fallow period was 5-7 years in north eastern region (Devi and Choudhury, 2013) [10]. Soil properties such as organic matter, pH, available P, exchangeable cations and nitrate-nitrogen increased gradually with increase in fallow age.

Significant correlation (r^2=0.25) was obtained between soil pH and age of fallow in the forest zone. Significant correlation (r^2=0.01) was obtained between age of fallow and organic matter for both forest and savanna zones thus indicating increase in soil organic matter as fallow age increases. Soils of the forest fallows were more fertile than soils of the savanna. Forest sand decreased with fallow age while there was substantial degradation of clay particles in the savanna. Late and unmonitored burning system in the savanna fallow should be discouraged. Following the rate of depletion of soil properties due to cultivation and shortening of fallow age (Onijigin *et al.*, 2016) [30].

Materials and Methods

West Garo Hills district lies between 89°53'-90°25' E longitude and 25°12'-26°0' N latitude and is bounded by the North Garo Hills district on the north east, the East Garo Hills on the east, South Garo Hills on the south east, the Goalpara district of Assam on the north and west, South West Garo Hills towards south west and Bangladesh on the south. The topography is mostly hilly with plains fringe covering the north, west and south-west borders of Tura, Arbella and Ranggira mountain. The total area of the district is 2784 sq. km. The area cover under the forest, net sown area, total cropped area and fallow land are about 1650 sq. km (45%), 953.6 sq. km (26%), 1207.4 sq. km. (about 33%) and 12% of the total geographical area respectively as per undivided the district of West Garo Hills. Principal crops grown in the district are rice, maize, millets, oilseeds, pulses and horticultural crops (include orange, pineapple, banana, jackfruit and other citrus fruits). Vegetables are also grown such as potato, sweet potato, ginger, garlic etc. Important plantation crops are arecanut, cashewnut, coconut, tea, black pepper, betel leaf and rubber. Spices like ginger, turmeric, chilli, large cardamom and cinnamon are also grown. Agriculture pattern is mostly multi-cropping cultivation and Jhum ing (shifting cultivation). About 20% of the population in the district is dependent on Jhum cultivation. About 155.45 sq.km (4.19%) is under Jhum cultivation. The Jhum cycle has been reduced from >25 years to 3 - 5 years at present. Such farming may threat to biodiversity and soil conservation and is no longer sustainable (Duguma *et al.*, 2001) [11].

Soil of the study area

The soil types of West Garo Hills district are mostly red gravelly and red sandy loam in the hilly slopes and clayey loam in the plains. Soils of the hills are moderately deep to deep, loamy skeletal to fine and excessively drained subject to slight to very severe erosion hazards. Soils of hilltops and upper hill slopes are moderately deep-to-deep, fine loamy to fine, excessive drained, subject to very severe erosion hazards and strong stoniness. The soils are acidic in nature and comparatively rich in organic matter and nitrogen but poor in phosphorous.

Site selection for soil sampling

Soil sampling sites from different Jhum fallow years were identified from the digitized year wise Jhum field polygons. For the fallow years of 3, 6, 9, 12 and 15 years, shifting cultivation polygons (both 1st and 2nd year cropping) from the years 2001, 2004, 2007, 2010, 2013 were selected (Fig 1). Then each polygon in the selection for each fallow years were crosschecked with the Landsat imageries and Jhum polygons of the succeeding years. This was done to eliminate the overlapped polygons with respect to cropping/disturbance happened in the years following the fallow period. Thus, care was taken to make sure that the selected sites for the soil collection of different fallow ages does represents the actual fallow period with no other disturbances occurred till the time of soil collection. For location of the sampling sites, the selected polygons for different years were converted to. Kmz file so that it can be '*overlayed'* on the Google earth platform. With the selected target polygons visible in the Google earth, the nearest village and approach roads leading to the site could be planned for field sampling. A hand held GPS (Garmin C64) was used to navigate to the correct position of the sampling site by pre-entering the Geocordinates of the selected polygons and using the '*Goto*' option in the GPS.

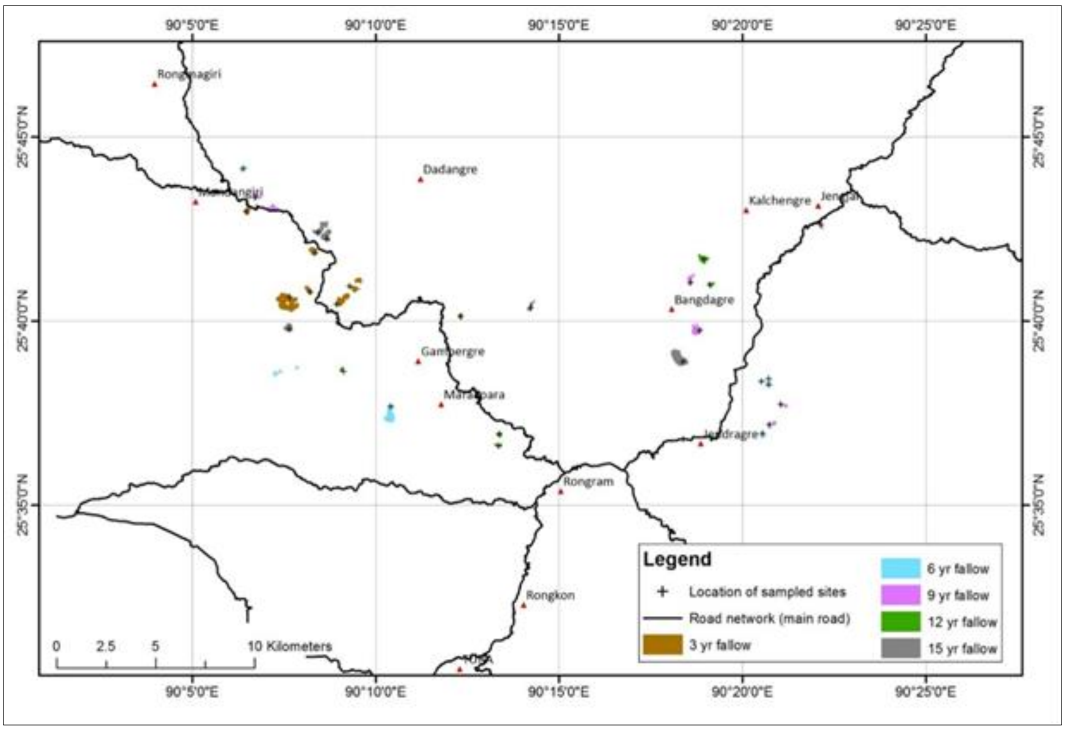

Fig 1: Selection of Jhum fallow sites for soil sampling

Fig 2: Collection of soil samples from different Jhum fallow age (3, 6, 9, 12, 15) fields

Soil sample collection and laboratory analysis

Six replications each for each Jhum fallow years of 3, 6, 9, 12 and 15 years were collected at two different depths. A composite soil samples from each site at two depths (0-15 cm and 15-30 cm) were collected using standard procedure. The soil samples were air dried, crushed and grounded to pass through a 2 mm sieve for physico-chemical properties analysis using standard procedures (Table. 1). The soil samples were grounded and sieved with 1mm for organic carbon.

Table 1: Methods followed for soil analysis

S. No	Soil parameters	Methods	Reference
Physical properties			
1	Bulk density	Clod Method	Black (1965) [2]
2	Soil texture	International Pipette method	Kroetsch and Wang (2008) [22]
3	Water holding capacity	Pressure plate method	Piper (1966) [31]
Chemical properties			
4	Soil pH and EC	Soil: water ratio (1:2.5)	Jackson (1973) [19]
5	Soil organic carbon	Wet digestion method	Walkley and Black (1934) [41]
6	Available N	Alkaline potassium permanganate method	Subbaih and Asija (1956) [36]
7	Available P	Bray I method	Bray and Kurtz (1945) [5]
8	Available K	Neutral Normal Ammonium acetate method	Hanway and Heidel (1952) [18]
9	Ex. Calcium	Complexometric Titration method	Jackson (1973) [19]
10	Ex. Magnesium	Complexometrc Titration method	Jackson (1973) [19]
11	Available S	Turbidimetric method	Williams and Steinbergs (1969) [43]

Statistical Analysis

The data were statically analyzed using one way analysis of variance (ANOVA) and means were compared with LSD and Duncan test in SPSS 21 version statistical software. Data were tested for homogeneity of variance by means of the multiple comparisons.

Results and Discussion

The Jhum farming is the practice of cultivating crops for 1-2 years after slashing and burning of vegetation in dry season. The result of the study was discussed in the following heads:

Identification of 3, 6, 9, 12 and 15 years of Jhum fallow ages

The 3, 6, 9, 12 and 15 years fallow ages were identified from Jhum fields of 2013, 2010, 2007, 2004, 2001 years of digitized and delineated polygons of both first and second year cropping. After screening the polygons of the above years with the Jhum plots in subsequent years, by cross checking with the landsat imageries of the following years, the fallow fields of above mentioned Jhum fallow ages were identified. The six different polygons (Jhum fields) were selected from each fallow ages for soil sampling. Fig. 3 shows Jhum fields with different fallow ages (3, 6, 9, 12 and 15 years) of West Garo hills district.

Soil physical properties

Soil physical properties like bulk density, sand, silt, clay content and water holding capacity were studied in two depth of soil 0-15 cm and 15-30 cm of different fallow ages of Jhum land (Table. 2). The result showed the dominance of coarser fractions (sand) and the soils qualify for sandy clay loam in texture for both the surface (0-15 cm) as well as subsurface soils (15-30 cm). The dominance of coarser fractions (sand) might be due to disturbance of terrestrial ecosystem. The land for Jhum farming was first cleared and burned the vegetation and following broadcasting the seed or soil tillage for cultivation. The soil particles were washed out with rain. The finer particles are very sensitive to the rain as compare to coarse particles. The loss of finer soil particles such as silt and clay with disturbance of terrestrial ecosystem and increasing the sand content (Eyre, 1968) [13]. The variation in textural size distribution as well as proportion of soil separates (sand: silt+ clay ratio) along with dispersion and erosion ratios serve as a good indicator of soil susceptibility to erosion under different Jhum fallow ages. In Jhum fallow land, intial 3 to 6

years had relatively higher coarser (sand) over finer (silt and clay) fraction compared to longer duration fallow ages (12 to 15 years). In longer fallow ages of Jhum land, 12 -15 years fallow age had relatively higher finer fraction (silt and clay) compared to short term fallow ages (3 years). The growth of natural vegetation was gradually increased with increasing the Jhum fallow period. There was increasing the accumulation of organic matter on the surface. The fine particles was hold with the organic matter. Therefore, finer fraction (silt and clay) content was more over coarser fraction (sand) content in longer fallow ages of Jhum land. The increasing sand content with increasing the Jhum crop period and decreasing the silt and clay contents with increasing Jhum crop period (Shimrah *et al*., 2015) [35]. BD values were increased at subsurface soils (15-30 cm) as compared to surface soils (0-15 cm) irrespective of Jhum fallow age. The surface (0-15 cm) BD of 3 year Jhum fallow land was significantly higher than the BD values of longer Jhum fallow age, but was par with 6 year fallow age. It was clearly observed that the BD value was lowering with increasing the Jhum fallow period, however, the BD values was not affected with the Jhum fallow age. It might be due to the accumulation of organic matter. Similarly, many authors found the same result and indicating that the content of soil organic carbon (SOC) increased with the increase in the length of fallow age and the differences in SOC contents among fallow ages were significant (Gupta *et al*., 2010; Jia *et al*., 2005) [17]. The carbon status increased with the length of forest succession and that after a sufficient longer period, the site could nearly regain its original status (Tinker *et al*., 1996) [36]. The BD values were increased at subsurface soils (15-30 cm) as compared to surface soils (0-15 cm) irrespective of Jhum fallow age due to more organic matter accumulation in the surface soil. The BD was higher in subsurface than surface soil and negatively correlated with FYM/organic matter (Rupaia, 2013) [33].
The water holding capacity at surface (0-15 cm) was minimum in short term fallow age of 3 year (36.69%) and maximum was recorded in 12 year fallow age (49.68%) while at subsurface (15-30 cm), it was minimum in 3 year fallow age (33.34%) and maximum was recorded in 9 year fallow age (46.93%) at surface (0-15 cm). It seems to be increasing the WHC with increasing the fallow period. There was observed that the WHC was more in the surface soil as compared to that of subsurface soil of Jhum. It might be due to minimum soil disturbances and lack of anthropogenic activity during the fallow period. The natural vegetation were provided optimum surface coverage, deposited substantial amounts of organic matter, and enriched soil surfaces by recycling of bases and other nutrient elements from subsurface through extensive fibrous and deep root systems. In hilly region with steep slopes, grasses with profuse rooting behaviour, can act as potential vegetative barrier to minimise runoff and erosion loss. Therefore, the biggest benefits of these grasses in degraded Jhum land was the improvement in soil health and quality, to act as an effective agent of soil and water conservation under favourable environmental conditions including drought or excess moisture and to improve soil conditions before less robust annual crops can be grown. Similarly, the increasing WHC with increasing Jhum fallow age (Funakawa *et al.*, 1997) [16].

Soil chemical properties

Soil chemical properties such as electrical conductivity (EC), soil organic carbon (OC), available nitrogen (Avl. N), available phosphorus (Avl. P), available potassium (Avl. K) and available sulphur (Avl. S) were studied in Jhum land of different fallow ages such as 3, 6, 9, 12 and 15 years (Table. 3). The result showed that EC (soluble salt) content minimum in 3 year fallow age (36. 39 μS/cm) and maximum in 12 year fallow age (42. 88 μS/cm) of the surface Jhum soil (0-15 cm) and the EC was significantly increased with increasing the fallow period at subsurface soil (15-30 cm). The water soluble salts might be surface runoff in the initial period of Jhum ing. The accumulation of OC and improving of soil structure with longer period of Jhum fallow might help in increasing the soluble salt concentration and also holding more amount of soluble salt in the subsurface soil. Therefore, the EC (soluble salt) content was minimum in 3 year fallow age and increasing with fallow period of Jhum ing. The OC content was increased with increasing of the Jhum fallow period irrespective of the soil depth and the OC content was comparatively higher in the surface soil (Table. 3). The minimum OC content were noticed as 1.22% and 1.18% at 3 year of Jhum fallow age at surface and subsurface soil respectively. The 15 year Jhum fallow soil was significantly superior over the OC content at 3 and 6 years of Jhum fallow period. It might be attributed to the deposition of plant litter falls and death decay of above ground biomass of natural vegetation. The slash and burring procedure of the Jhum ing might help in the exposure of OC in the terrestrial ecosystem. The rain might washed out in the beginning of Jhum ing. Similarly, Many scientists noted the increase OC with increasing of fallow period due to accumulation of OM (Offiong *et al*., 2015; Venkatesh *et al*., 2001) [28, 40]. The density of trees/shrubs provides adequate protection to the soil thereby, preventing unproductive loss of soil nutrient to soil erosion. The dense crown cover helps to attenuate the direct impact of raindrop on the soil, thereby keeping litter stable for decomposition. This observation confirmed the findings of a substantial increase in OM occurred in the upper part (10 cm) of soil profiles during the first ten years of fallow (Aweto, 1981) [1].
The Available nitrogen (Avl. N) Was medium (295.66 to 397.69 kg/ha) in different Jhum fallow fields at the surface soil. The Avl. N was minimum in short term fallow age of 3 year and maximum in 12 year fallow age at both the soil depth, however, Avl. N was more in the surface soil (Table. 3). With the increase in fallow ages, the available nitrogen content increased consistently in Jhum fallow lands. The Available phosphorus (Avl. P) content was low to medium in Jhum soil. The variation in Jhum fallow land were from 9.18 kg/ha (in 3 year fallow age) to as high as 14.34 kg/ha (in 15 year fallow age) at surface (0-15 cm) while at subsurface (15-30 cm), it was varied from 8.13 kg/ha (in 3 year fallow age) to 12.56 kg/ha (in 15 year fallow age). The Avl. P content was more in the surface soil as compare to that of subsurface soil irrespective of the fallow period. The Avl. P content in 15 year Jhum fallow age (14.34 kg/ha at 0-15 cm and 12.56 kg/ha at 15-30 cm) was significantly higher than the short duration fallow age. The Available potassium (Avl. K) content was varied in Jhum soil of different fallow age from 183.68 kg/ha (in 3 year fallow age) to 275.52 kg/ha (in 12 year fallow age) at surface (0-15 cm), while at subsurface (15-30 cm), it was varied from 157.02 kg/ha (in 3 year fallow age) to 238.55 kg/ha (12 year fallow age). The Avl. K content was increased with increasing the Jhum fallow period. The surface Avl. K content at 15 year Jhum fallow soil was significantly higher than the Avl. K content in 3 year Jhum fallow age. The Available sulphur (Avl. S) content of the studied soil were found in medium content (13.90 to 20.97 kg/ha). The surface

Avl. S content was increased from 13.90 kg/ha in 3 year fallow age to 20.78 kg/ha in 15 year fallow age, while subsurface Avl. S content was also increased from 12.36 kg/ha in 3 year fallow age to 18.45 kg/ha in 12 year fallow age. With the increase in fallow ages, the Avl. N, Avl. P, Avl. K and Avl. S content increased consistently in Jhum fallow land. However, Avl. N, Avl. P, Avl. K and Avl. S was more in the surface soil irrespective of Jhum fallow age. This was attributed to the increase in the density of trees/shrubs, dense crown cover and the higher amount of litter production which *in situ* decomposes to add nutrient to the soil. The density of trees/shrubs provides adequate protection to the soil thereby, preventing unproductive loss of soil nutrient to soil erosion. The dense crown cover helps to attenuate the direct impact of raindrop on the soil, thereby keeping litter stable for decomposition. The native P was more solubilised with organic acid and root exudates. Similarly, many authors found that soils under long term fallow age contain more total N, P and Ca in the surface horizon (Aweto, 1981; Seubert, 1975) [1, 34]. The high plant nutrient content was observed from 6 year Jhum fallow age onwards and not much changed till 15 year Jhum fallow. The nutrients losses were more in short term fallow age (Mishra and Ramakrishnan, 1983; Wallbrink *et al*., 2005) [32, 24].

Soil acidity properties

Soil acidity properties like pH, exchangeable calcium (Ex.Ca) and exchangeable magnesium (Ex. Mg) were studied in different fallow ages of Jhum land (Table 4). The studied soils were found to be highly acidic in reaction (pH<5). There was slightly depression of surface soil pH in the 6 (pH 4.88) and 9 (pH 4.85) years of Jhum fallow period and increasing from 12 and 15 years of Jhum fallow period. However, pH was almost same from the initial to 9 years of Jhum fallow and increasing from 12 years onwards. The soil pH was increased with increasing fallow age due to deposition of organic matter and in situ-deposition of grasses which resulted in subsequent enrichment with the bases (Devi and Choudhury, 2013) [10]. The Ex.Ca content was increased with the increase in age of fallow ages. The highest Ex.Ca content was noted at 12 (2.18 meq/100 gm soil) and 15 (2.14 meq/100 gm soil) year of Jhum fallow period in surface soils (0-15 cm), and highest Ex. Ca content in subsurface soil was noticed at 12 (1.78 meq/100 gm soil) and 15 (1.94 meq/100 gm soil) year Jhum fallow period. The Ex. Mg content was increased with increasing of fallow ages and lowering with increasing soil depth irrespective of fallow ages. The Ex. Mg content was increasing from the 9 years of fallow period onwards (Table 4). The Ex. Ca and Mg content was increased with the increase in age of fallow land and decreasing with increasing soil depth (Nye and Greenland, 1960; Ohta *et al*., 1993) [27, 29]. The biomass of the fallow vegetation is generally a major pool for potassium, calcium and magnesium. The higher contents of exchangeable Ca and Mg in the top soils were due to their biological accumulation through litter supply and their lower mobility in soil. The Ex. Ca and Mg content were taken up from the subsoil by crops and assimilated into the tree biomass eventually accumulate in the surface horizons through litter fall (Vanlauwe, 2005) [39]. The accumulation of soil organic matter was enhanced amounts of exchangeable bases as well as cation exchange capacity (CEC) with fallow length after 3 to 11 year of fallow (Effendi *et al*., 2009; Juo and Lal, 1977) [12, 21].

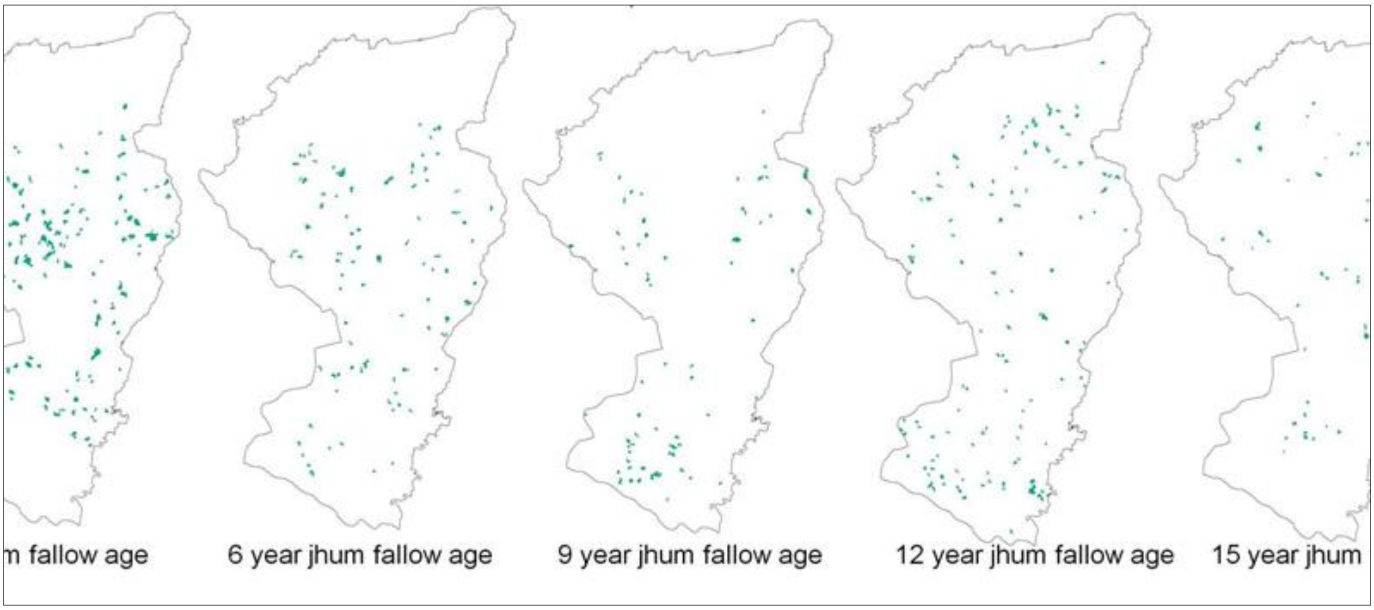

Fig 3: The representation of the 3, 6, 9, 12 and 15 years of fallow age of Jhum field of West Garo hills district

Table 2: Effect of fallow age on soil physical properties of the Jhum soil of West Garo hill district.

Jhum fallow ages	Surface soil (0-15 cm)					Subsurface soil (15-30 cm)				
	Sand (%)	Silt (%)	Clay (%)	BD (Mg/m^3)	WHC (%)	Sand (%)	Silt (%)	Clay (%)	BD (Mg/m^3)	WHC (%)
3 year	60.67[b]	18.63[a]	20.70[a]	1.47[b]	36.70[a]	58.65[b]	19.68[a]	21.67[a]	1.50[a]	33.34[a]
6 year	56.53[ab]	18.73[a]	24.73[ab]	1.43[ab]	42.08[ab]	56.37[b]	18.73[a]	24.90[ab]	1.49[a]	38.81[ab]
9 year	53.28[ab]	19.08[a]	27.63[ab]	1.39[a]	47.56[b]	53.24[ab]	22.90[a]	23.87[ab]	1.47[a]	46.49[b]
12 year	48.18[a]	21.50[a]	30.32[b]	1.42[a]	49.68[b]	51.25[ab]	21.72[a]	27.03[bc]	1.48[a]	43.97[b]
15 year	48.84[a]	20.40[a]	30.76[b]	1.42[a]	43.90[ab]	47.44[a]	22.24[a]	30.32[c]	1.48[a]	38.33[ab]

Different letters in each column indicate a significant difference at 5% level by Duncan's multiple range test.

Table 3: Effect of fallow age on soil chemical properties of the Jhum soil of West Garo hill district.

Jhum fallow ages	Surface soil (0-15 cm)						Subsurface soil (15-30 cm)					
	EC (µS/cm)	OC (%)	Avl. N (kg/ha)	Avl. P (kg/ha)	Avl. K (kg/ha)	Avl. S (kg/ha)	EC (µS/cm)	OC (%)	Avl. N (kg/ha)	Avl. P (kg/ha)	Avl. K (kg/ha)	Avl. S (kg/ha)
3 year	36.40	1.22^{a}	295.66^{a}	9.18^{a}	183.67^{a}	13.90^{a}	32.29^{a}	1.18^{a}	278.14^{a}	8.31^{a}	157.02^{a}	12.36^{a}
6 year	40.30	1.43^{ab}	334.57^{ab}	10.80^{a}	225.57^{ab}	17.68^{b}	36.06^{ab}	1.20^{a}	308.78^{ab}	9.25^{ab}	198.24^{ab}	16.26^{b}
9 year	41.74	1.80^{b}	375.38^{bc}	11.60^{ab}	249.32^{ab}	18.37^{b}	39.30^{b}	1.70^{b}	334.69^{ab}	11.54^{bc}	223.33^{b}	18.21^{b}
12 year	42.88	1.87^{b}	397.70^{c}	11.20^{a}	275.52^{b}	20.98^{b}	40.21^{b}	1.68^{b}	347.66^{b}	9.51^{ab}	238.55^{b}	18.45^{b}
15 year	38.97	1.86^{b}	358.75^{bc}	14.34^{b}	252.67^{ab}	20.78^{b}	36.44^{ab}	1.67^{b}	334.43^{ab}	12.56^{c}	229.01^{b}	15.37^{ab}

Different letters in each column indicate a significant difference at 5% level by Duncan's multiple range test

Table 4: Effect of fallow age on soil acidity properties of the Jhum soil of West Garo hill district.

Jhum fallow age	Surface soil (0-15 cm)			Subsurface soil (15-30 cm)		
	pH	Ex. Ca (meq/100 gm soil)	Ex. Mg (meq/100 gm soil)	pH	Ex. Ca (meq/100 gm soil)	Ex. Mg (meq/100 gm soil)
3 year	4.92	1.47^{ab}	0.98^{a}	4.77	1.15^{a}	0.84^{ab}
6 year	4.88	1.42^{a}	0.96^{a}	4.79	1.10^{a}	0.78^{a}
9 year	4.85	1.83^{bc}	1.26^{b}	4.73	1.38^{a}	1.15^{bc}
12 year	4.96	2.18^{c}	1.38^{b}	4.93	1.78^{b}	1.25^{c}
15 year	4.93	2.14^{c}	1.4^{b}	4.84	1.94^{b}	1.06^{abc}

Different letters in each column indicate a significant difference at 5% level by Duncan's multiple range test.

Conclusion

The burgeoning population growth has imposed an extra pressure on meeting the food demands from the limited land resources and shrunk Jhum cycle. It was leading to severe degradation of soil health in the Jhum farming. Such degradation was controlled by the scientific management with knowledge of Jhum ing practice and its fallow period. The available nitrogen, phosphorus, potassium, sulphur, Ex. Ca and Ex. Mg content more in surface soils compared to subsurface soils. The soil properties changed with the changing of land covers. During the fallow periods, proper scientific intervention could be planned with better knowledge of soil properties in relation to Jhum fallow ages, for sustainable and healthy soil management. It was concluded that the minimum Jhum fallow period should be atleast 6-7 years in the district at present time.

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References

1. Aweto AO. Secondary succession and soil fertility restoration in south western Nigeria. J Ecol. 1981; 69:601-607.
2. Black CA. Methods of Soil Analysis Vol. I. American Society Agronomy. Madison Wisconsin, USA, 1965.
3. Borggaard OK, Gafur A, Peterson L. Sustainability appraisal of shifting cultivation in the Chittagong Hill tracts of Bangladesh. Ambio. 2003; 32(2):118-123.
4. Borthakur DN, Singh A, Awasthi RP, Ghosh SP, Prasad RN, Rai RN *et al*. Shifting cultivation in north east India.ICAR Research Complex for N.E.H. Region, Shillong, 1983, 1-91.
5. Bray RH, Kurtz LT. Determination of total, organic and available forms of phosphorus in soils. Soil Sci. 1945; 59:39-45.
6. Brunn TB, Mertz O, Elberling B. Linking yields of upland rice in shifting cultivation to fallow length and soil properties. Agr. Ecosyst. Environ. 2006; 113:139-149.
7. Das S, Das M. Shifting cultivation in Tripura – a critical analysis. J Agric. Life Sci. 2014; 1(1):48-54.
8. Datta J, Gangadharappa NR, Debnath A. Sustainability of Jhum cultivation as perceived by the tribal people of Tripura. Int. J Social Sci. 2014; 3(2):179-190.
9. Datta M, Bhowmik, SN. Shifting cultivation:chemical properties and mycorrhizal density in soils during the fallow period with a possible approach to remedial measures for improvement. Book of Abstracts of National Seminar on Shifting Cultivation in the 21st Century: Fitness and Improvement. CPGS, CAU, Umiam, Meghalaya, 2014, 32.
10. Devi NL, Choudhury BU. Soil fertility status in relation to fallow cycles and landuse practices in shifting cultivated areas of Chandel district Manipur, India. J Agric. Vet. Sci. 2013; 4(4):01-09.
11. Duguma B, Gockowski J, Bakala J. Smallholder cacao cultivation in agroforestry systems of West and Central Africa: Challenges and opportunities. Agrofor. Syst, 2001; 51(3):77-188.
12. Effendi MBW, Tanaka S, Joseph JK, Logie S, Brangking U, Jonathan LAT *et al*. Vegetation conditions and soil fertility of fallow lands under intensified shifting cultivation systems in Sarawak, Malaysia. Trop. Ecol. 2009; 18 (3): 115-126.
13. Eyre SR. Vegetation and Soils–A World Picture. Edward Arnold Publishers Limited, UK, 1968.
14. FSI. State of Forest Report. Forest Survey of India, Dehradun, 2000, 113.
15. Fujisaka S, Hurtado L, Uribe R. A working classification of slash-and-burn agricultural systems. Agrofor. Syst, 1996; 34:151-169.
16. Funakawa S, Tanaka 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. J Soil Sci. Plant Nutr. 1997; 43(3):695-708.
17. Gupta RD, Arora S, Gupta GD, Sumberia NM. Soil physical variability in relation to soil erodibility under different land uses in foothills of Siwaliks in N-W India. Trop. Ecol. 2010; 51(2):183-197.
18. Hanway JJ, Heidel H. Soil analysis methods as used in Iowa State College, Soil Testing Laboratory. Iowa State College Bull. 1952; 57:1-131.

19. Jackson ML. Soil chemical analysis. Prentice - hall of India Pvt. Ltd., New Delhi, 1973.
20. Jia G, Cao J, Wang C, Wang G. Microbial biomass and nutrients in soil at the different stages of secondary forest succession in Ziwulin, northwest China. For. Ecol. Manag. 2005; 217(1):117-125.
21. Juo ASR, Lal R. The effects of fallow and continuous cultivation on the chemical and physical properties of alfisol in Western Nigeria. Plant Soil, 1977; 47:567-564.
22. Kroetsch D, Wang C. Particle size distribution. In: Carter, M.R. and Gregorich, E.G. (eds.) Soil sampling and methods of analysis, 2nd edn. CRC Press, Boca Raton, FL, 2008, 713-727.
23. Li P, Feng Z, Jiang L, Liao C, Zhang J. A Review of Swidden Agriculture in Southeast Asia. Remote Sens, 2014; 6:1654-1683.
24. Mishra BK, Ramakishnan PS. Slash and burn agriculture at higher elevations in north-eastern India II. Soil fertility changes. Agric. Ecosyst. Environ. 1983; 9:83-96.
25. Mishra VK, Saha R. Long term effect of various land use systems on physical properties of silty clay loam soil of NE-hills. J Indian Soc. Soil Sci. 2007; 55(2):112-118.
26. NRSC. Wasteland atlas of India. National Remote Sensing Centre, Hyderabad, India, 2011, 290.
27. Nye PH, Greenland DJ. The soil under shifting cultivation. Common wealth Bureax of Soils Technical Communication No. 51. Commonwealth Agricultural Bureax, Farnham, UK, 1960, 156.
28. Offiong RA, Iwara AI, Umoh NE, Ekpe IA. Effect of secondary succession on the changes in soil physic-chemical properties in the cross river rainforest of Nigeria. J Econ. Mangt. Sci. 2015; 6(3):209-213
29. Ohta S, Effendi S, Tanaka N, Miura S. Ultisols of lowland dipterocarp forest in East Kalimantan, Indonesia III. Clay minerals, free oxides, and exchangeable cations. Soil Sci. Plant Nutr. 1993; 39(1):1-12.
30. Onijigin EO, Fasina AS, Oluwadare DA, Ogbonnaya UO, Ogunleye KS. Influence of fallow ages on soil properties at the forest-savanna boundary in South Western Nigeria. Int. J Plant Soil Sci. 2016; 10(1):1-12.
31. Piper CS. Soil and plant analysis. Hans. Publ., Bombay, 1966, 368.
32. Ramakrishnan PS. Shifting agriculture and sustainable development: an interdisciplinary study from North-Eastern India. MAB Book Ser., UNESCO, Paris and Parthenon Publishing Group, Carnforth, Lancs., UK, 1992, 424.
33. Rupaia S. Effect of integrated nutrient management on soil organic carbon pools and rice productivity. M.Sc.Thesis, submitted to College of Post Graduate Studies, Central Agricultural University, Imphal, India, 2013.
34. Seubert CE. Effect of land clearing methods on crop performance and changes in soil properties in an Ultisol of the Amazon Jungle of Peru. M.S. thesis, Carolina State University, Raleigh, North Carolina, 1975, 152.
35. Shimrah H, Rao RS, Saxena KG. Soil property variations under different land use/Cover types in traditional agricultural landscape in northeast India. J Chem. Environ. Sci. Appl, 2015; 2(1):73-97.
36. Subbiah BV, Asija GL. A rapid procedure for the estimation of available nitrogen in soils. Curr. Sci. 1956; 25:259-260.
37. Susanto D, Ruchiyat D, Sutisna M, Amirta R. Soil and leaf nutrient status on growth of *Macaranga gigantea* in secondary forest after shifting cultivation in East Kalimantan, Indonesia. Bio diversit. 2016; 17(2):409-416.
38. Tinker PB, Ingram JSI, Struwe S. Effects of slash-and-burn agriculture and deforestation on climate change. Agr. Ecosyst. Environ. 1996; 58:13-22.
39. Vanlauwe B. Senna siameatrees recycle Ca from a Ca-rich subsoil and increase the topsoil pH in agroforestry systems in the West African derived Savanna zone. PlantSoil. 2005; 269:285-296.
40. Venkatesh MS, Mishra AK, Satapathy KK, Patiram. Effect of burning on soil properties under bun cultivation in Meghalaya. J Hill Res, 2001; 14(1):21-25.
41. Walkley A, Black IA. An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Sci, 1934; 37:29-38.
42. Wallbrink P, Blake W, Doerr S, Shakesby R, Humphreys G, English P. In: Walling, D.E. and Horowitz, A.J. (eds) Using Tracer Based Sediment Budgets to Assess Redistribution of Soil and Organic material after Severe Bush Fires, Sediment Budgets, IAHS Publication: Wallingford, UK, 2005, 223-230.
43. Williams CH, Steinbergs A. Soil sulphur fractions as chemical indices of available sulpher in some Australian soils. Aust. J Res. 1969; 10:340-352.
44. Yadav PK, Kapoor M, Sarma K. Impact of slash-and-burn agriculture on forest ecosystem in Garo Hills landscape of Meghalaya. J Biodivers Manage For. 2012; 1(1):1-6.