

Green manuring:

a sustainable approach to restore the soil fertility in shifting cultivation

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Shifting cultivation or slash and burn agriculture locally called as jhum is the main form of agriculture in north-eastern hills regions. Jhum agriculture is practising in these areas with traditional knowledge. Jhum cultivation drastically declines their soil fertility and became unsustainable primarily due to increase in population that led to increase in food demand. Therefore, green-manuring acts as a restoration factory to maintain the soil fertility for sustainable agricultural production. The green manure crops protect the bare soil against the erosion and improving the physico-chemical and biological properties of soil. However, hills area soils are not only hungry but thirsty too. The problem is serious in jhum lands, where organic matter, nutrients and microbial biota is lost due to burning of the forests, which leads to heating of the soil. The problem can be mitigated to a great extent by growing of green manuring crops, which will improve the organic matter and nutrient status of the soil.

Key words: Green manuring, Shifting cultivation, Soil fertility

JHUM or shifting cultivation is considered as one of oldest practice in north-eastern hills region of India particularly in Nagaland. About 85% of the total cultivation in north-east India is under the shifting cultivation. It is the form of agriculture in which a piece of forest land is slashed, burnt and cropped without tilling soil, cropped land is subsequently fallowed to attain pre-slashed forest status through natural succession. *Jhum* land soil fertility status becomes depleted after years of exploitation with not addition of manures. Shifting cultivators preserved agro-biodiversity through local rules, practices and informal networks for exchange of seeds and knowledge, thus ensuring food security. The hills people have a mind set against use of chemical fertilizers, thus the quality of soils deteriorated under *jhum* areas. However, the green-manuring might just be the best method of saving the north-eastern hills region soil-health in longer perspectives. Soil productivity

is an important concern for the farmers for sustainable agricultural production in this region and green manuring is gaining popularity as a method that improved soil productivity. This crop is generally ploughed or incorporated into soil while they are green or soon after they start flowering. Green manures are forage or leguminous crops that are grown for their leafy materials which is needed for soil nutrient conservation. Value of green-manuring lies in fact that organic matter is incorporated into soil. The organic matter in the soil is recognized as being one of its most valuable constituents for real soil fertility. Soil nitrogen (N) is associated with the organic matter and decay which influences availability of the soil nutrients. Soil organic carbon (SOC) improves the physical, chemical and biological properties of soil.

Status of *jhum* land

The north-eastern hills region

comprises of Asom, Arunachal Pradesh, Manipur, Mizoram, Tripura, Nagaland and Meghalaya is lagging behind despite being endowed with rich natural resources. Low productivity is due to many factors viz. prevalence of shifting cultivation, hills terrain, unpredictable climate changes, use of low input, poor infrastructures. Shifting cultivation still in vogue as a whole in north-eastern hills region and is being extensively practised by more than 100 tribal ethnic minorities. In shifting agriculture, natural vegetation is cut down and burnt as a means of clearing land for cultivation. Tribal people involved in this practice are known as *Jhumias* and are linguistically and culturally distinct from one another with their own languages and cultural characteristics. This region has infinite variety of geographical settings. Out of 26.2 m ha geographical area, 10.8% has an elevation between 300 and 600 m, 17.9 % between 600 and 1,200 m and 28.3% more than 1,200 m.



Table 1. Statistics of shifting cultivation in north-eastern hills region

States	Annual area in shifting cultivation ('000 ha)	Minimum area in <i>Jhum</i> cultivation ('000 ha)	Fallow period (years)	Annual area as % of geophysical area	Total area as % of geophysical area	Family Involved (No.)	<i>Jhum</i> land per tribal family (ha)
Arunachal Pradesh	70.0	210	3-10	1.00	3.04	54,000	1.29
Asoam	69.6	139	2-10	4.56	32.44	58,000	1.20
Manipur	90.0	360	4-7	2.68	4.47	70,000	1.29
Meghalaya	53.0	265	5-7	3.37	18.46	52,000	1.01
Mizoram	63.0	189	3-4	2.94	28.65	50,000	1.26
Nagaland	19.0	191	5-8	4.49	36.87	116,000	0.16
Tripura	22.3	112	5-9	2.16	20.71	43,000	0.51

Source: Anonymous 2009

Average annual rainfall varies from 2,000 to 4,000 mm and received mainly from south-west monsoon. However, yield of different agricultural crops in the region is more unstable in rainfed areas than irrigated ones due to unpredictable climate changes. An estimate showed that about 3.5 m ha lands under rainfed cultivation accounting about 30% of the total area. Renovation crops and pastures are those which are returned to soil with aims of improving fertility status of the soil and reducing the weed burdens. The north-eastern hills region showed great variation in temperature throughout the year from 15° to 32°C in summer and 0° to 26° C in the winter. Scientific community now-a-days is progressively using various regional models to study and analyze local climate changes. Rainfed agriculture suffers from a number of bio-physical and socio-economic restrictions such as low and erratic rainfall, low level of input use and technology, low draft power availability, land degradation, resource poor farmers and inadequate credit availability. On an average,

estimated 38.69 thousand ha area is set under shifting cultivation every year and 4,43,336 families earn their livelihood. However, ~0.3% of total geographical area of India comes under shifting cultivation (Table 1).

IMPACT OF SHIFTING CULTIVATION

Shifting cultivation is characterized as 'cafeteria system of cultivation', where almost all the varieties of cereals and vegetables, together with tree crops are grown in a single field. The development of agriculture and production of food grains in north-eastern hills region is dependent upon the custom, culture and food habit of the tribal people. Shifting cultivators continue to depend on less productive forms of cultivation not because they are backward or ignorant, but they have no viable choice for alternative livelihoods.

Pattern of agricultural growth is uneven all over the country and also there are disparities among regions, sectors and farming communities. Large quantity of forest vegetation is burnt in shifting cultivation

mentioned that forests are in danger of disappearing, if nothing was done to arrest its degradation and destruction, these would vanish in a short period. With burning of the forest vegetation, there is loss of wild life, flora and fauna, wild plant of diverse gene pool and rare orchid. About 300 plant species out of the native flora of north-eastern hills region of India are used for edible purposes. Shifting cultivation is practised in about 386.9 thousand ha annually and on an average 50 to 80 tonne/ha dry matter is burnt, depending on shifting-cycle. About 1.86, 21.51 and 2.22 million tonne of leaves, food and litter containing 137.3, 7.4, 95.9 and 97.5 thousand tonne of N, P, K and Ca, respectively burnt every year causing enormous loss. Besides, creating atmospheric pollution, it causes ecological and soil degradation. Annual soil loss was estimated to be 88,346 thousand tonne and combined loss of NPK is 17.092 thousand tonne. The area under shifting cultivation varies from 2.6% in Asom to 96% in Mizoram of their net sown area. However, existing shifting cultivation practice in north-eastern India is an injudicious form of land use.

Shifting cultivation lead to land degradation

- Severe soil and nutrient losses accompanies land clearing and early stages of plantation.
- Increased the problem of land degradation and ecological imbalance.
- Rapid expanding population pressure has resulted in misuse of land resource.
- Estimates reveal 88.3 to 146



million tonnes of soil is lost annually as a result of *jhumming*.

Feasibility and practice of green manuring

Agriculture is the basis of livelihood for people of Nagaland. Agriculture and allied sector accounts for about 23.4 % of total Net State Domestic Products of the state and 70 % of the total work force. *Jhum* cultivation is a predominant farming system for most of the farmers of Nagaland. Rice, being one of the major crops, is mostly cultivated in the plain area of Dimapur, Wokha, Mokokchung and Mon districts. Mono-cropping of rice is most popular in Bihar. The State still witnessed least development regarding production practices, land and other resource use pattern, technological progress and their adoption rate etc. Therefore, within the existing system of primitive kind of farming, some integrated approach is to be incorporated to attain sustainability. Generally, green-manuring crop is incorporated into the soil while they are at green stages or soon after starting flowering for improving soil-health and conserving moisture *in situ* because organic matter in the soil is recognized as one of the most valuable indicator and constituents for realizing fertility status of soil. The role of N-fixing plants in the cropping systems diminished in 1940s, when relatively inexpensive and abundant fertilizer became available. The growing of legume crop to be worked into soil is an old agricultural practice that is increasing in popularity again. Further, soil N is highly associated with organic matter content and

decaying of its influenced the availability of nutrients in the soil. For these reasons, it has seemed to discuss amount of organic matter in soil, its source and influences, which operates for its increasing as well as part of it plays an important role in the soil. Soil organic carbon improves physical, chemical and biological properties of soil. In hills areas, perennial water sources are available, where these green manuring species can be grown successfully for improving soils health for *jhum* land, where organic matter, NPK and other micro-nutrient contents are deficit in this region. While introducing this practise among the hills farmers, main question that will be raised is 'How and from where it is possible to bring required huge quantity of biomass as green manure'. Green manure crop becomes ready for incorporation into soil between 45 and 50 days after sowing and help in improving production and productivity of subsequent crops. Actually this period will be a good investment for next two seasons of crop. In older days, biomass was generated as 'off-farm' and 'on-farm'. Similar concept was tested under lowland condition for *in situ* biomass generation for fertility management of soil and to reduce dependence on external inputs like fertilizer. The green manures species like *Tephrosia candida*, *Crotalaria juncea*, *Indigofera tinctoria*, *Flemingia macrophylla* and *Cajanus cajan* were grown on alternate raised bunds in the paddy field. A good amount of biomass was produced to supplement the nutrient requirement for these crops. Hence, it is a viable alternative option to

maintain the *jhum* land productivity and sustainability in longer perspectives.

Off-farm green manure

As an off-farm, foliage of shrub and herb type of weeds that grow along roadside, riverside and lake bunds were harvested and brought for *ex-situ* incorporation into the soil. The commonly used weeds are *Pongamia pinnata*, *Cassia auriculata*, *Calotropis gigantea*, *Ipomoea* spp., *Vitex negundo*, and *Eichornea* spp.

On-farm green manure

These are of 3 types of on-farm green manure, as discussed here.

- (i) **Tree green manure:** Biomass at farm can be generated from legume or non-legume trees that are grown along the boundaries of the farm and along the main bunds of the fields at 15 to 20 feet (4.5 to 6 m) intervals. While preparing the main fields for the next crop, foliage from this trees will be lopped and chopped into small pieces and then incorporated by hoeing in garden lands and by puddling in the wet lands. The trees that can be grown for this purpose are *Azadiracta indica*, *Pongamia pinnata*, *Glyricidia* spp., *Thespesia populnea* and *Senna siamea*.
- (ii) **Live fence and hedge rows:** Some shrub species can be grown along the fence as livefence or as hedge rows along pathways and waste patches. These life fences and hedge rows can be trimmed off whenever needed and used as a source of organic manures. The suitable shrubs are: *Vitex negundo*, *Nerium vitifolia*, *Adhatoda vasica*, *Datura stramonium*, *Artimesia*

nilagirica. The non-legume supplies a large amount of energy (carbohydrate) material readily, but the bacteria responsible for the decay of this material must have access to N. If the N carried in the green manure crop is not sufficient (C: N > 30:1 or < 1.5 %), bacteria will draw on available N and newly grown crop will show N deficiency symptom for some time.

- (iii) **Legume green manuring:** Green-manuring is a management tool as worth considering. Role of nitrogen-fixing plants in cropping systems diminished in 1940s, when relatively inexpensive and abundant N-fertilizer became available. Addition of organic material improves soil tilth also. At the same time, the nutrients used in the plant growth are conserved and returned to soil to enhance fertility levels. Almost any crop can be used for green-manuring, but legumes are preferred because of their ability to fix N from the air. Green manuring with legumes (*Sesbania*, cowpea, greengram, lentils, cluster bean) is called legume green-manuring. However, the growing of legume crop as dual purposes to be worked into the soil is an old agricultural practice that is increasing in popularity again. Hence, it is a viable alternative to conventional lean period fallowing and can reduce amount of nitrogen (N) fertilizer required. This crop has to be turned under the soil before plants set seed. It is stated that legume green manuring could be profitably used on lands where it was not possible to add animal manures.

Characteristics of legume green manure crops

The characteristics are: short duration, fast growing, high nutrient accumulation ability, produces abundant and succulent shoots (foliages), well adapted to local conditions, have a high rate of nitrogen-fixation, have high water use efficiency when used in drier regions, wide ecological adaptability, early onset of biological nitrogen-

fixation, timely release of nutrients, photoperiod insensitivity, high seed production and seed viability, ease in incorporation and ability to cross inoculate or responsive to inoculation, pest and disease resistant.

Significance of green manuring

Mixed-farming is practised in *jhum* land where wide varieties of crops are grown in a single season. In intercropping two or more crops are grown at a given time. In the arecanut plantation, tuber crop i.e. elephant yam, colocasia, turmeric and sweet potato are practised. Banana and pineapple are cultivated as intercrops in arecanut gardens. The practice of growing different crops of varying height, rooting pattern and duration is called multi-tier cropping/ multi-storied croppings system and mostly prevalent with coconut and areca nut. Renovation crops and pastures are those which are returned to the soil with the key aims of improving the soil fertility, reducing weed burdens and increasing the soil organic matter. Crops may be returned to the soil by burial and mulching and act as the cover crops.

Advantages

A fundamental goal of growing green manure crop is to avoid the bare soil between cash crop plantings. This not only protects soil but captures sunlight and produces biomass which ultimately enhances soil quality. Numerous side benefits accrue from this approach as well such as improved applicability of fields and reduced compaction, enhanced aesthetics and potential for animal feed production. Potential benefits of green manure crops are numerous: reducing impact of wind and water passing over the soil surface can reduce erosion, adding organic matter, improves physical, chemical and biological properties of the soil, competing for light, water and nutrients with weeds, legume cover crops add 'free' symbiotically-fixed nitrogen (N), crops growing late in the season can capture and 'recycle' soluble nutrients, providing cropping system diversity may create habitats for beneficial insects.

reducing nutrients leaching losses, providing supplementary animal forage, promotes habitat for natural enemies, serves as a good food for the earthworms, increases soil's biodiversity of beneficial microbes by stimulating their growth, increases the water-holding capacity of the soil, increases the nutrient holding capacity of the soil, high rate of production of leaf biomass, dense network of root system, high rate of nitrogen-fixation ability, sturdy in nature and thrive well in adverse situation, tolerant to moisture stress and diseases and pest incidences, high and balanced nutrient content in the foliage, litter of high quality having high nitrogen, low in lignin and polyphenols, rapid litter decay, when nutrient release is desired, absence of toxic substances in the litter or root residues, capable to grow on soils having low fertility, low invasiveness in nature.

Disadvantages

The disadvantages are: direct cost of seed and extra cultivation, Some time is lost opportunities for cash cropping, and extra work at busy times of the year

SUMMARY

In north-eastern hills region people do not apply chemical fertilizers because of believe that chemical fertilizers are very hazardous to the ecosystem. However, the hilly area soils are not only hungry but thirsty also and this problem is seriously associated with *jhum* lands. Where organic matter, nutrients and microbial biota is lost due to burning of forests, which leads to heating of the soil. The problem can be mitigated to a great extent by growing green-manuring crops, which will improve the organic matter and micronutrients status of the soil in longer perspectives for sustainable agricultural crop production.

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