ISBN: 978-93-90847-17-4

3. Traditional Shifting Agricultural Systems Practiced by the Idus in Upper Dibang Valley District of Arunachal Pradesh, India

Dr. Goutam Ghosh

Department of Botany,
Bejoy Narayan Mahavidyalaya,
Itachuna, Hooghly, West Bengal, India.

Abstract:

Upper Dibang Valley district of Arunachal Pradesh shows two types of *jhums* as bamboo forest derived and grassland-derived *jhums* were prevalent. The agronomic yield was higher in bamboo forest-derived *jhum* rather than the grassland-derived *jhum*. The yield of different crops declined markedly over the cropping years under different types of jhums particularly in bamboo forest derived *jhum*. The yield increased in the second year of cropping compared to that of the first year in grassland-derived *jhum* due to better crop management practices followed in second year. The use *Fagopyrum cymosum* in the first year cropping mainly for the improvement of grassland-derived *jhum* was commonly practiced facilitating growth of other crops in this soil in the subsequent years. Due to abundance of grasses in this area the tribes particularly the Idus adopted the grassland-derived *jhum.* The adoption of grassland derived *jhum* decreased the percentage of forest destruction, increased the sustainable use of local natural resources efficiently and indirectly saves the ecology, environment and nature of this region.

Keywords: Shifting agriculture, bamboo forest-derived *jhum*, grassland – derived *jhum*, mixed cropping, soil fertility

3.1 Introduction:

The state of Arunachal Pradesh is characterized by 8 forest types like subtropical broad leaved, subtropical pine, temperate broad leaved, temperate conifer, sub alpine scrubs, alpine pastures, bamboo brakes and grassland. It has spare population of approximately 10, 91,200 due to location disadvantages, like the difficult terrain and lack of communication means. The Upper Dibang Valley district is one which is very far away and poorly communicated with state capital Itanagar. The main inhabitants in this district are the *Idus* tribe who belong to the Mongoloid race. Great altitudinal variation with temperature, relative humidity, and high annual rainfall represents distinct types of forest vegetation in the lower parts as sub-tropical to temperate pine, bamboo forests and grass land where as in the upper part leads to snow clad peaks, glacial lakes and traditionally have two types of subsistence agricultural systems, slash and burn agriculture, locally known as *jhum* and rice cultivation in the valley.

Recently, Scientists have started looking at subsistence agriculture or traditional agriculture as a one with high productive efficiency.

The high yields for subsistence agriculture that are often over looked by scientists are now receiving more study (Mitchell, 1979; Gliessman et al., 1981; Ramakrishnan, 1981; Altieri, 1983). *Jhum* cultivation, though with some subtle vitiation (Toky and Ramakrishnan, 1981a; Mishra and Ramakrishnan, 1981; Ramakrishnan, 1983; 84 a), basically involves slashing the forest often by clearing, felling, burning the dried slash and raising crops for one or two years on the temporarily nutrient enriched soil. The plot is abandoned for natural regrowth during the fallow phase before returning to the same plot after a few years. This is referred to as a '*Jhum* cycle'. There is some confusion regarding the yield of crops from *jhum* cultivation with *jhum* cycles. Slaats et al. (1998) compared fallow period, weeding regime and yield and concluded that the longer the land laid fallow, the higher was the maize yield obtained during the first year after clearing. Another study from Laos also corroborated to this conclusion that yield and fallow period did not provide any significant relationship (Pravongviengkham 1998). The study of Roder et al. (1995) and Wadley (1997) with large sample size showed no correlation between fallow period and yield. The model by Rasmussen and Moller Jensen (1999), however, only assumes that a minimum fallow period is needed to build up required nutrients for crop production. Therefore, in this study an effort has been made to study the *jhum* types based on management practices and previous vegetation of the fields.

3.2 Materials and Methods:

Survey works were conducted during 2001 to 2003 at the Upper Dibang valley district of Arunachal Pradesh. Among the two Circles, biggest one and mostly *jhum* cultivated Anini Circle was selected for the study of *jhum* types. In this study the *jhum* systems were evaluated in terms of productivity. The jhum systems in this area consist of two main types such as bamboo forest derived *jhum* (7–10-year cycle) and grassland-derived *jhum* (5–7-year cycle). The bamboo forest-derived jhum is characterized by bamboo species dominated forest and grasses, where herbs and shrubs dominate the grassland-derived *jhum*. The bamboo forest-derived *jhum* and grassland-derived *jhum* were evaluated in the villages of Angrivalley, Dumbin, Gipuling and Anini under Anini Circle. The evaluation of the different *jhum* systems were made on the basis of crop data collected randomly from 15 families of each village. The cultural practices and economic yield (edible or useful products) of crops in the study area were recorded by personal presence at the time of cultural operations, harvesting and processing or on the basis of interview the farmers. Several village headmen and old farmers were interviewed about the various ethnic knowledge of *jhum* cultivation practiced by them in the area. Various data on site selection, cropping systems, soil fertility maintenance and method of cultivation were recorded.

3.3 Observations and Discussion:

3.3.1 Site Selection:

The site selection for *jhum* cultivation was mainly based on the indigenous knowledge of the tribal community. For bamboo forest-derived jhum, they select a landslide free area near water sources. The sites should get plenty of available solar radiation '*Manu*' land that have greater than nine hours sunshine per day. They judge the fertility status of the soil through the growth of bamboos and other trees.

When these trees showed vigorous growth with dark green leaves and forest floor became comparatively clean and free from creepers, they use the land for *jhum* cultivation. In selecting sites, they gave priority to the sites dominated by *Alnus nepalensis, Castanopsis* spp. and bamboos and always tried to avoid any existent of pine tree in their *jhum* land. For the grassland-derived *jhum,* the site that was dominated by grasses and more or less in a topography receiving abundant sunlight and nearer to the water sources were generally preferred.

3.3.2 Field Preparation:

The sites are usually selected during winter. They slash the forest vegetation in the month of November to December. During slashing a few small sized trees and bamboos were left in the field to provide support to the climbing crops. Large sized trees were cut above the ground and the stumps were left undisturbed.

After slashing each bamboo was piled and dried during the ensuing winter. Such technique was also followed for other shrubs and small trees. Before burning, a fire line was cleared around the field to protect the forest around the field. They start burning the dried, slashed plants against the direction of wind that helped in slow burning and checked the spreading of fire to the adjacent areas.

Burning was often repeated to destroy any unburned material. A bamboo hut was built for temporary living and protecting the field crops from the wild animals.

3.3.3 Cultivation Practices:

Cultivation methods were more or less similar in both grassland-derived *jhum* and bamboo forest-derived *jhum* systems. First year cropping in the grassland-derived *jhum* started late in the month of August, whereas in bamboo forest-derived *jhum* it started from May. But in the subsequent years, sowing time (Table1), cultural practices and harvesting time did not vary much between the two types of *jhuming* practices.

The seeds of *Zea mays* (maize), *Oryza sativa* (paddy), *pulses like Phaseolus mungo, Glycine max,* (Soybean), *Vinga umbellata* (rice bean), cucurbits like *Cucurbita maxima* (pumpkin) and *Cucumis sativus* (cucumber) were dibbled in order to ensure their optimum germination immediately after burning and cleaning of the field. *Zea mays* was dibbled at regular intervals and mixed with other crops at random with the help of bamboo made pointed stick known as *'Amboliathaba'.*

Two local varieties of *Eleusine coracana* (finger millet)- '*Ambo*' (early variety) and '*Apu*' (late variety) were sown during May-June through broadcasting method and mixed properly with soil with the help of a tool made of local bamboo '*Tabu*' in the middle of August.

Coix lachryma was sown along the periphery of the field, whereas Zea *mays* and *Eleusine coracana* were uniformly distributed in the whole field, *Cucurbita* sp., *Sechium* sp., *Chenopodium album* were sown at random and *Colocasia* sp. and *Dioscorea* sp. were also dibbled at random.

Solanum tuberosum and *Glycine max* were dibbled in patches and *Phaseolus mungo* and *Vigna umbellata* were grows around the small tree or bamboo plants were inter-cropping with *Zea mays* or *Eleusine coracana* or *Solanum tuberosum* or *Oryza sativa.*

Apart from raising food crops, trees like *Alnus nepanensis* and *Castonopsis* spp. were also planted in the field for enriching the soil fertility.

Table 3.a Sowing and harvesting period of different crops in jhum systems.

Crops	Sowing period	Harvesting period
Solanum tuberosum	February-March	July-August
Oryza sativa	April-May	October–November
Cucurbita maxima	April-May	August-October
Colocasia esculenta	April-May	November-December
Pogostemon sp.	May	November
Vigna umbellata	May	November-December
Phaseolus mungo	-do-	-do-
Cucumis sativus	-do-	-do-
Sechium edule	May-June	August-November
Glycine max	May-June	November-December
Zea mays	May-June	August-September
Eleusine coracana	-do-	-do-
Dioscorea sp.	-do-	December
Chenopodium album	May-June	November-December
Coix lachryma	June	November-December
Fagopyrum cymosum	1^{st}.week of August	December last

Weeds caused a major problem during monsoon. Frequent slashing by '*Dao*' (Sickle), free hand–hoeing and with U-shaped bamboo made '*Tabu*' was used for weeding. Usually, two times weeding was done by the women-folk during the cropping period. The intensity of weed infestation increased gradually in the subsequent years.

3.3.4 Cropping Systems:

The *Idus* people choose different crop composition for bamboo forest-derived and grass land-derived *jhum* systems. In case of bamboo forest-derived *jhum*, they generally practice maize-based cropping followed by millet-based cropping and paddy-based cropping in the subsequent years.

In case of grassland-derived jhum, the common cropping system was buckwheat-based: *Fagopyrum cymosum, Glycine max and Phaseolus mungo* in the first year, followed by potatobased cropping:

Solanum tuberosum, Colocasia esculenta, Pogostemon sp., *Glycine max, Phaseolus mungo, Coix lachryma* and *Cucumis sativus*, or maize-based and millet-based cropping: *Eleusine coracana, Colocasia esculenta, Glycine max, Phaseolus mungo, Chenopodium* sp., Cucurbita maxima and Cucumis sativus in the second and third year, respectively.

3.3.5 Harvesting and Storage:

The local people generally follow staggered method of harvesting of crops (Table 3.a) in their *jhum* fields. Only the panicles of *Oryza sativa and Eleusine coracana* and economic parts of other plants are harvested, and the remaining parts of the plants are left in the field to allow decomposition.

They store panicles in the granary (*Akka*) for 2-3 months after harvesting and drying in sunlight properly without threshing. Later they thresh, clean and carry it manually to their home.

3.3.6 Soil Fertility Management:

Special care was taken for maintaining the soil fertility in the grassland-derived *jhum*. Buckwheat was cultivated during the first year. The crop quickly covered the ground and thus prevented germination, sprouting and growth of weeds in the field. The crop (buckwheat) being very leafy, succulent and tender in nature, decomposed very quickly after maturity and thus the soil not only became enriched with nutrients, but also became soft. This helps in weeding the field in the subsequent years.

They also took some common measures for maintaining or enriching soil fertility of both bamboo forest-derived and grassland–derived *jhum* systems. The dried leaves and small twigs were burnt *in situ* and large logs and bamboos were piled and fired two to three times to ensure complete burning, which helped in producing better crops in their *jhum* lands. In the subsequent years, all the weeds after removing were kept in heaps in different areas of the *jhum* land, except the thorny plants.

These weeds decomposed naturally by microbial activity and added nutrients to the soil.

The tribals also cultivate legumes like *Glycine max, Phaseolus mungo* and *Vigna umbellata* not only for grain production but also for maintaining soil fertility in the croplands. Further they also plant *Alnus nepalensis* and *Castonopsis* spp. for enriching and maintaining soil fertility status on a long-term basis. Besides, they did not cut their crops at the base of the plant, instead they took only the mature fruits or panicles (economic organ), and the remaining parts of the crops were left in the field and this after decomposition release the nutrient helping the ensuring production.

3.4 Crop Yield:

The yield of various crops grown in different *jhum* types have been presented in the table 3.b. Oryza sativa produced 750 kg ha^{-1} grain yield during third year cropping in bamboo forestderived *jhum*.

It was very close to the rice yield data studied by Wadley (1997) for the period 1979-1993 in West Kalimantan from 14 households in an Iban community on interview and classified fallow vegetation in very broad categories based on vegetation morphology rather than fallow age and thus a 20- year fallow on very poor sandy soil came in the same category as a 4-year fallow on a clay soil (Young fallow of 3 to 20 years old gave average yield of 1042 kg ha^{-1}, young secondary of 10-45 years old gave an average yield of 923 kg ha^{-1}, and old secondary/ mature forest of 20-70 years old gave 1187 kg ha^{-1}).

The yield of different crops declined markedly over the cropping years under different types of *jhums*. This was particularly evident in the case of *Zea mays* in all types of *jhums* in these areas (Table 3.b). This is in conformity with the findings of Arnason et al. (1982) who noticed decline in maize yield in Belize. The yield of *Zea mays* in bamboo forest-derived *jhum* was declined from 1280 kg ha-1to 381 kg ha-1in the second year and 126kg ha-1in third year.

Similarly yield reduction over years in *Phaseolus vulgaris* was recorded from 34 to 14 kg ha^{-1}in bamboo forest-derived *jhum*. Glycine max recorded yield reduction from 71 to 24 in bamboo forest-derived *jhum* and 169 to 19kg ha-1in grassland derived *jhum* respectively. Similarly, vegetables like *Benincasa cerifera, Cucumis sativus, Cucurbita maxima, Sechium edule, Colocasia* and *Dioscorea* also recorded yield reduction over the year to a considerable extent under different *jhums*. There was also evidence of yield increase in grassland-derived *jhum* under this study. The yield increased markedly in the second and third year of cropping compared to that of the first year in grassland-derived *jhum* due to better crop management practices followed in second and third year under this system. The low yield of grassland-derived *jhum* during the first year was mainly due to use of the field for *Fagopyrum* and pulse crops for enriching the soil rather than getting high yield and prepared it for next year cropping of cereals and other crops.

The *Idus* use nitrogen-fixing non-legumes like *Alnus nepalensis* and *Castanopsis* sp. to improve the nitrogen economy of their *jhum* systems during cropping and fallow phases. Ramakrishnan and Toky (1983) and Ramakrishnan (1999) noticed that bamboo sprouts of the species like *Bambusa tulda, B. khasiana, Dendrocalamus hamiltonii and Neohouzeaua dulloa*, in the bamboo forest derived *jhum* increased potassium content in soil when *jhum* cycles decline up to 5 years.One of the major causes for the low yields after first year cropping and onwards was the poor fertility builds up. This became more obvious during the third year cropping in any type of *jhum* systems (Ahlgren and Ahlgren, 1965; Ramakrishnan and Toky, 1981).

Weeds were recognized to be another important cause of declining yield under slash and burn agriculture in many parts of the world. *Epatorium* spp. and *Imperata cylindrical* were found as predominant weeds in the study sites. Freeman (1955), Zinke et al. (1978) and Ramakrishnan et al. (1978) also noticed sever yield loss caused by *Imperata cylindrica* in Sarawak, *Eupatorium odoratum* in Thiland and these along with other weed species in North-Eastern India in different *jhum* systems. Therefore, it is concluded that the yields of different crops in jhum cultivation depends not only for the *jhum* cycle but also on crop management practice and vegetation of the *jhum* field types.

Table 3.b: Yield of crops (kg ha 1) in different jhum systems

Jhum types	Bamboo forest-derived			Grassland-derived		
Crops	Iyr	IIyr	IIIyr	Iyr	IIyr	IIIyr
Cereals						
Chenopodium album	-	35	25	-	41	28
Coix lachryma	-	117	77	-	53	25
Eleusine coracana	-	767	-	-	-	412
Fagopyrum cymosum	-	-	-	180	-	-
Oryza sativa	-	-	750	-	-	-
Zea mays	1280	381	126	-	230	112
Sub-total	1280	1300	978	180	324	577
SD	±107.8	±111.3	±93.9	±17.2	±30.1	±56.2
Pulses						
Glycine max	55	71	24	169	74	19
Phaseolus vulgaris	34	14		16	38	32
Phaseolus vulgaris	73	25	45	65	50	67
Sub-total	162	110	69	250	162	118
SD	±13.3	±10.4	±5.4	±16.4	14.3±	±9.8
Fruit vegetables						
Cucumis sativus	122	76	26		70	43
Cucurbita maxima	158	224	108		224	124
Sechium edule	75	37			54	-
Sub-total	654	337	134	-	348	117
SD	±51.2	±27.5	±12.1	-	±27.5	±8.8
Oil seeds						
Perilla ocimodes	-	21	45	-	23	42
SD	-	±1.8	±3.7	-	±2.1	±3.6

Jhum types	**Bamboo forest-derived**			**Grassland-derived**		
Tubers and Rhizome						
Colocasia esculenta	-	185	63	-	226	28
Dioscorea sp.	117	-	-	-	70	47
Solanum tuberosum	-	-	-	-	860	-
Sub-total	177	185	63	-	1156	75
SD	±10.7	±15.0	±5.0	-	±66.3	±7.1
Total	2213	1953	1289	1289	2013	979

3.5 Conservation and Conclusion:

Yield of staple crops are often quite low, but many other plants are intercropped in this *jhum* field and collected from secondary forest making overall productivity much higher. Precise quantification of total productivity in shifting cultivation is very difficult.

However (Mertz 2001) Multiple cropping provides an "insurance" policy to the cultivators because some crops are likely to give a good return even if there is partial or complete failure of other crops. The incidence of pest diseases is also minimized under mixed cropping. The pre-planting burn contributes to controlling harmful ants and other insect pests. After harvesting of early crops, late crops get more space at their peak growth period.

In mixed cropping under *jhum* several crop species with diverse growth habits developed a multistoried canopy with crops would help in efficient capture of light energy and a multi layered root mass distribution below the soil would help in optimal use of nutrients from the soil profile.

They use nitrogen-fixing non-legumes like *Alnus nepalensis* and *Castanopsis* sp. to improve the nitrogen economy of their *jhum* systems during cropping and fallow phases.

Ramakrishnan and Toky (1983) and Ramakrishnan (1999) noticed that bamboo sprouts of the species like *Bambusa tulda, B. khasiana, Dendrocalamus hamiltonii* and *Neohouzeaua dulloa,* in the *jhum* increased potassium content in soil when *jhum* cycles decline up to 5 years.

Land clearing in traditional shifting cultivation had the lowest amount of erosion and sediment loss from the system compared to any other form of land clearing and tillage system (Lal 1987). The reasons for low erosion despite farming on steep slopes are very short periods with exposed soil (after burning, before plant establishment), limited or no tillage, and traditional measures such as placing unburned logs horizontally on the slope.

The canopy also protects the land from excessive soil erosion and leaching once the crop cover is established.

Most of the orthodox tribal cultivators do not adopt new improved crop varieties in their *jhum*, on the contrary, they continue to grow the traditional crop varieties or wild relatives (even less productive) there by maintaining the germplasm. Biodiversity is higher in shifting cultivation systems than in permanent farming system due to fallow and mixed cropping. Compared to climax forest, biodiversity increases in long fallow systems where natural forest patches are maintained along with secondary forest. Some species endemics to climax forests may disappear in shifting cultivation areas, but the small patches of climax forest ensure natural forest biodiversity (Jessup 1981).

3.6 Acknowledgements:

The Author is grateful to his Ph D guide Professor Dr. D. C. Ghosh of Visva Bharati and Dr. Uma Melkinia, ex-Associate Professor of NERIST and Professor of G.B.Pant University of Agriculture and Technology for encouragement and critical suggestions. The study was supported by the Department of Environment and Forests, GOI, New Delhi through research grant and was completed at Forestry Department, NERIST, Nirjuli (Itanagar), Arunachal Pradesh. Special thanks are due to Mr. Bijit Basumatari, village Headman's and local tribal people for their cooperation and help during the field survey.

3.7 Reference:

1. Ahlgren, I. F. and Ahlgren, C. E. 1965. Effects on prescribed burning on soil microorganisms in a Minneesota Jack pine forest. *Ecology* **46:** 306-310.
2. Altieri, M. A., Letourneau, D.K. and Davis, J. R. 1983. Developing sustainable Agro ecosystems. *Bio. Science* **33:** 45-49.
3. Arnason, T., Lambert, J. D. H., Gale J., Cal, J. and Vernon, H. 1982. Decline of soil fertility due to intensification of land use by shifting agriculturists in Belize, Central America. *Agro Ecosystems* **8:** 27-37.
4. Freeman, J. D. 1955. *Iban Agriculture*. A report on the shifting cultivation of hill rice by the Iban of Sarawak. H.M.S.O., London.
5. Ghosh G, Studies on Plant Diversity, Ethnobotany and Ethnoagriculture in Dehang-Debang Biosphere Reserve of India, Ph.D. Thesis submitted to Visva Bharati, Santiniketan, 2005.
6. Gliessman, S. R., Garcia, S. R. and Amador, A. M. 1981. The ecological basis for the application of traditional agricultural technology in the management of tropical agroecosystems. *Agro-Ecosystems* **7:** 173-185.
7. Jessup, T.C. (1981) *Why do Apo Kayan Shifting cultivators move*? Borneo Research Bulletin **13:**16-32.
8. Lal, R. (1987) *Need for, approaches to and consequences of Iand clearing and development in the tropics.* In Tropical Land Clearing for Sustainable Agriculture. Proceedings of an IBSRAM Inaugural Workshop held in Jakarta and Bukittingi, Indonesia 27.8-3.9 1985, pp. 15-27. *Ed IBSRAM. Bangkok: IBSRAM.*
9. Mertz, O. (2001) *Rethinking the fallow-yield relationship in shifting cultivation*? Agroforestry Systems.
10. Mishra, B. K. and Ramakrishnan, P. S. 1981. The economic yield and energy efficiency of hill agro-ecosystems at higher elevations of Meghalaya in north-eastern India. *Acta Oecologica: Oecol. Applic.* **2:** 369-389.

11. Mitchell, R. 1979. The analysis of Indian agroecosystems. *Interprint,* New Delhi, pp.180.
12. *Pravongvienkham, P. P. 1998. The Role of Animal Husbandry and Aquaculture in Improvements of Swidden-Based Livelihood Systems in the Lao PDR. Thesis submitted to School of Environment, Resources and Development, Asian Institute of Technology.
13. Ramakrishnan, P. S. 1978. Observations on biological aspects of Productivity of forest ecosystems. **In** *Glimpses of Ecology* (Ed. Singh, J.S. and Gopal, B.). Internat. Scientific Publ., Jaipur, India. pp. 194-999.
14. Ramakrishnan, P. S. 1981. Jhum- an ecological assessment. In Souvenir, Silver Jubilee Symp. *Internat.* Soc. Trop. *Ecol.*, Bhopal, India. pp.41-49.
15. Ramakrishnan, P. S. 1981. Jhum- an ecological assessment. In Souvenir, Silver Jubilee Symp. *Internat. Soc. Trop. Ecol.*, Bhopal, India. pp.41-49.
16. Ramakrishnan, P. S. 1983. Socio-economic and cultural aspects in the north-east and options for eco-development of tribal areas. **In** *Tribal Techniques, Social Organisation and Development: Disruption and Alternates* (Ed. Chaubey, N.P.). Indian Acad. Social Sci. pp.12-30.
17. Ramakrishnan, P. S. 1984. The science behind rotational bush fallow agriculture systems (jhum). **Proc.** *Indian Acad. Sci.* (Plant Sci.) 93:379-400.
18. Ramakrishnan, P. S. 1984a. The Science behind rotational bush fallow agriculture systems (Jhum). **Proc.** *Indian Acad. Sci. (Plant Sci.)* 93: 397-400.
19. Ramakrishnan, P. S. 1999. The Impact of Globalisation on Agricultural systems of Traditional Societies. Sustainable Agriculture and Environment: globalization and the impact of trade liberalization (Ed. Andrew, K., Dragun and Clem Tisdell). Edward Elgar Publishing. Inc. USA. Pp-185-200.
20. Ramakrishnan, P. S. and Toky, O. P. 1981. Soil nutrient status of hill agroecosystems and recovery pattern after slash and burn agriculture (Jhum) in north-eastern India. *Plant* and *Soil* **60:**41-64.
21. Ramakrishnan, P. S. and Toky, O. P. 1983. Some Aspects of Environmental Degradation in North-Eastern Hill Areas of India. *Studies in Eco-Development Himalayas Mountains and Men* (Ed. Tejvir Singh and Jagdish Kaur). Print House (India), Lucknow. Pp 149-156.
22. Rasmussen, K. and Moller-Jensen, L. 1999. A generic model of shifting cultivation. *Danish Journal of Geography Special Issue* 1: 157-164.
23. Roder, W., Phengchanh, S. and Keoboulapha, B. 1995. Relationships between soil, fallow period, weeds and rice yield in slash-and–burn systems of Laos. *Plant and Soil* **176:** 27-36.
24. Slaats, J. J. P., Janssen, B. H. and Wessel, M. 1998. Crop production in relation to cultural practices in the *Chromolaena odorata* fallow system in South-West Cote d'Ivoire. *Netherlands Journal of Agricultural Science* **46:** 305-317.
25. Toky, O. P. and Ramakrishnan, P. S. 1981a. Cropping and yields in agricultural systems of the north-eastern hill region of India. *Agro-Ecosystems* **7:** 11-25.
26. Uhl, C. and Murphy, P. 1981. A comparison of productivities and energy value between slash and burn agriculture and secondary succession in the Upper Rio Negro region of the Amazon Basin. *Agro-Ecosystems* **7:** 63-83.USA. Pp-185-200.
27. Wadley, R. L. 1997. Circular Labor Migration and Subsistence Agriculture- A case of the Iban in West Kalimantan, Indonesia. Arizona State University.

28. Zinke, P. J., Sabhasri, S. and Kunstadter, P. 1978. Soil fertility aspects of the 'Luas' Forest fallow system of shifting cultivation. **In** *Farmers of the Forest* (Ed. Kunstadter, P., Chapman, E.C. and Sabhasri, S.). East West Centre, Honolulu, Hawaii.