# CHAPTER III

*Energy budget of shifting cultivation during first year and second year of cropping in six-year and twenty-year old jhum fallows*

## Introduction

The increasing agricultural yields during the past 50 years could be possible through industrialisation of agriculture involving large fuel energy subsidies, sophisticated chemical control and high yielding crop varieties. Such agricultural systems are efficient in terms of human time and labour but are highly inefficient from an overall energetics point of view as five to ten units of fuel energy are required to produce a single unit of food energy (Steinhard & Steinhard, 1974). The obvious inapplicability of such systems as models for development in an energy-limited world has led to the revival of interest in traditional systems of agriculture which may presumably offer greater ecological efficiency. In particular, shifting cultivation has been held as a model of production efficiency, where, from five to fifteen units of food energy are obtained from each unit of energy used in production (Rappaport, 1971; Steinhard & Steinhard, 1974). The possibility has been suggested (Greenland, 1975; Revelle, 1976; Mutsaer _et al_. 1981) for increased crop production without departing too much from this traditional system, which has been considered as the most evolved system for the forested areas of the tropics and sub-tropics (Conklin, 1957; Carneiro, 1960; Nye & Greenland, 1960; Watters, 1971).

In Mizoram jhuming is the main agricultural system for the production of rice which is the staple food of the local people. It is the source of livelihood for almost about 60% of the state population.

The energy aspects of traditional agriculture in India have been studied by Mitchell (1979). Such a study on slash and burn agriculture and other agro-ecosystems as practiced traditionally in Meghalaya was undertaken by Toky & Ramakrishnan (1982). The present study aims to analyse energetics of jhum cultivation of young and old jhum fallows. The other major aims of this study is the introduction of second year of cropping in the jhum fields which were cultivated for one year by tilling the soil and through application of chemical fertilizers and farm-yard manure separately and in combination. This introduction of second year cropping with various treatments are considered as innovative approaches to the existing system of traditional jhum cultivation prevalent in Mizoram where cropping is commonly done for only one year in jhum fields. The study quantifies the energy input and output in terms of money (Rupees) and Megajoules (MJ) on per hectare basis during the first year and second year of cropping on young and old jhum fallows. This study may reveal as to which system would be more efficient and what improvements could be suggested in order to make the existing practice of jhum cultivation more efficient from the energetic and productivity point of view.

The jhum fallows of two different ages, 6-year and 20-year old, were selected for this study. The cropping on these fallows was done for two successive years. During the second year of cropping the jhum fields were subjected to various treatments such as land tilling, application of chemical fertilizers, application of farm-yard manure and application of combination of the latter two. The sites selected for this study represent the same toposequence and have close similarity in so far as the vegetation is concerned.

**Methods**

The input and output on each study plots were measured in terms of energy (Megajoules) and money (Rupees) taking the mean value of two years experimental data. The energy spent on each of the activities related to jhum cultivation has been expressed as percentage of the total energy input. The agricultural operations during the process of jhuming are slashing (SL), burning (BU), sowing (SO), weeding (W), harvesting (HA) and threshing (TH). Tilling of soil or field preparation (TI) and application of fertilizers (FI) are additional agricultural operations arising out of an endeavour to introduce innovative approaches to jhuming during second year of cropping. Though threshing of rice is not exactly a step involved in jhuming, in this study, it has been included in this category, because this work is also done in the jhum field itself and the determination of energy output through the production of rice is possible only after threshing.

The rice seeds and the fertilizers (used in the second year cropping), both being the materials have not been considered as an integral component of jhum operation and therefore, they have not been included for the purpose of determining relative proportion of energy spent on various activities of jhuming.

Various forms of energy input in each plot were converted into megajoules (MJ) and money (Rs.) by using the values given in Table 3.1 and 3.2 respectively. As far as energy output is concerned rice was the only crop grown in the jhum fields which contributed the total energy output from each plot. The energy value of rice in terms of megajoules (MJ) as given in table 3.1 and in terms of money (Rs.) as given in table 3.2 are used for the determination of energy output.

To determine the energetic efficiency of each system, the ratio between energy output and input was calculated for each plot by dividing the output values with the corresponding input value.

**Table 3.1. Values for various energy input and output components in terms of Megajoules (MJ).**

| Particulars | Unit | MJ | Author |
|---|---|---|---|
| Human labour | Man-hour | 1.046 | Revelle (1976) |
| Chemical Fertilizers | | | Mittal & Dhawan (1989) |
| (a) Nitrogen | Kg | 60.0 | |
| (b) $P_2O_5$ | Kg | 11.1 | |
| (c) $K_2O$ | Kg | 6.7 | |
| Farm-yard Manure | Kg | 0.3 | -do- |
| Rice | Kg | 14.518 | -do- |

**Table 3.2. Local market monetary values for various energy input and output components.**

| Particulars | Unit | Rupees |
|---|---|---|
| Human labour | Man-day | 40.00 |
| Chemical fertilizers | | |
| (a) Urea | Kg | 2.00 |
| (b) Diammonium Phosphate (DAP) | Kg | 2.75 |
| (c) Muriate of Potash (MOP) | Kg | 1.15 |
| Farm-yard manure (FYM) | Kg | 0.15 |
| Rice | Kg | 5.00 |

Table 3.3. Percentage of elements available in the fertilizers

| Name of fertilizer | N | $P_2O_5$ | $K_2O$ |
|---|---|---|---|
| Urea | 46 | - | - |
| Diammonium Phosphate (DAP) | 18 | 46 | - |
| Muriate of Potash (MOP) | - | - | 60 |

**Results**

**Total energy input:** The total energy input ranges between 140 and 187.5 man-days $ha^{-1}yr^{-1}$ or Rs. 5693.75 and Rs. 7593.75 $ha^{-1}yr^{-1}$ or 1150.85 MJ and 1448.97 MJ $ha^{-1}yr^{-1}$ as given in Table 3.4 (a-c). Lowest energy input was observed in 20 I:C plot and the highest was observed in 20 II:T plot.

Energy input was slightly more in 6 I:C plot than the corresponding plot during second year cropping (6 II:C). But in case of old jhum fallow, energy input in 20 I:C was much lesser than the corresponding sub-plot of 20 II:C and other sub-plots (20 II:T, CF, FYM and 20 II:CF+FYM) during second year of cropping.

Total energy input was exceptionally high in tilled sub-plot of both the jhum fallows. Among the sub-plots, the highest energy input was recorded in chemical fertilizer plus farm-year manure treated sub-plot on both the fallows. Each sub-plot in 6-yr. old jhum fallow during second year of cropping required slightly lesser energy input than their corresponding sub-plots in 20-yr. old jhum fallow.

On 6-yr. old jhum fallow, during second year of cropping, energy input in the control sub-plot was more than energy input in the fertilizer treated sub-plots, but lesser than the tilled sub-plot. However, on 20-yr. old jhum fallow during second year of cropping, energy input in the control sub-plot was lesser than in the fertilizer treated sub-plots as well as tilled sub-plot.

**Seed input:** Amount of seed input was equal in all the plots.

**Energy input in jhuming operations:** Percentage of energy input contributed by various jhuming operations in each plot is shown in Fig. 3.1 (A-L).

The energy input to the system by way of weeding (W) was comparatively very high. The highest and lowest energy input in this operation were recorded in 6 II:C sub-plot and 20 II:T sub-plot respectively (Fig. 3.1 A and F). Energy input in the control plots via weeding was lesser during the first year of cropping than during the second year of cropping on both the jhum fallows. The control plots on 6-yr.

old jhum fallow (6 I:C and 6 II:C), required more energy for weeding than their counterparts on 20-yr. old jhum fallow.

On young jhum fallow, during second year cropping, energy input in weeding was highest in control sub-plot (6 II:C) and the same trend was observed in 20 yr. old jhum fallow. There was not much variation of energy input in weeding among the fertilizer treated sub-plots on 6-yr. old jhum fallow. But in 20-yr. old fallow a slightly higher energy input was recorded in chemical fertilizer plus farm-yard manure treated sub-plot than other fertilizer treated sub-plots. Energy input on weeding operation was lowest in tilled sub-plot on both the jhum fallows.

The energy input in burning operation was equal in all the plots. This operation demanded the least amount of energy among the various jhuming operations.

Energy input in slashing, sowing and harvesting operation was more or less equal in all the plots.

Slashing required slightly more energy during first year of cropping than during second year of cropping. Same trend was observed with increase in age of jhum fallow, i.e. 20-yr. old jhum fallow required higher energy input than 6-yr. old jhum fallow. For this operation energy input was equal in all the plots on 6-yr. old jhum fallow. Similarly, energy required for slashing was also equal in all the plots on 20-yr. old jhum fallow. The maximum and minimum percentage contribution of energy input through slashing were recorded in 20 I:C plot and 6 II:T sub-plot respectively (Fig. 3.1 B and E).

Energy input through sowing operation was same in all the plots during second year cropping regardless of age of the jhum land. Energy input on sowing was slightly more in 6 I:C plot than in 20 I:C plot. In terms of percentage of energy input, this operation contributed maximum in 6 II:CF and 6 II:FYM sub-plots and minimum in 20 II:T sub-plot (Fig. 2.1, G, I, and F).

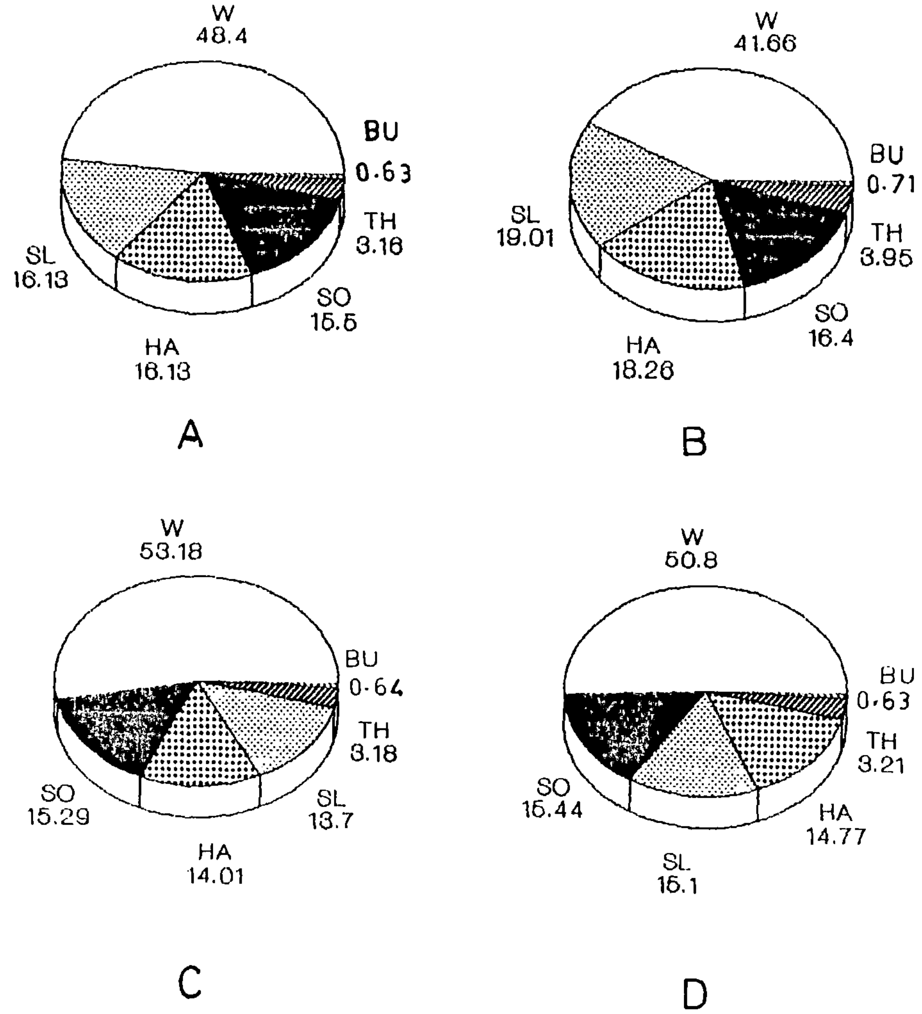
Energy input in harvesting operation was more or less equal in all the plots. Highest input was observed in 6 I:C plot and lowest in 20 I:C plot. The percentage of energy input contributed by this operation was highest in 6 I:C plot and lowest in 6 II:T sub-plot (Fig. 3.1, A and E).

Energy input in tilling or field preparation was highest and equal in 6 II:T and 20 II:T sub-plots. It was equal in all other fertilizer-treated plots on the jhum fallows of both the ages.

Small amount of energy was also expended for the application of fertilizer in fertilizer-treated plots and

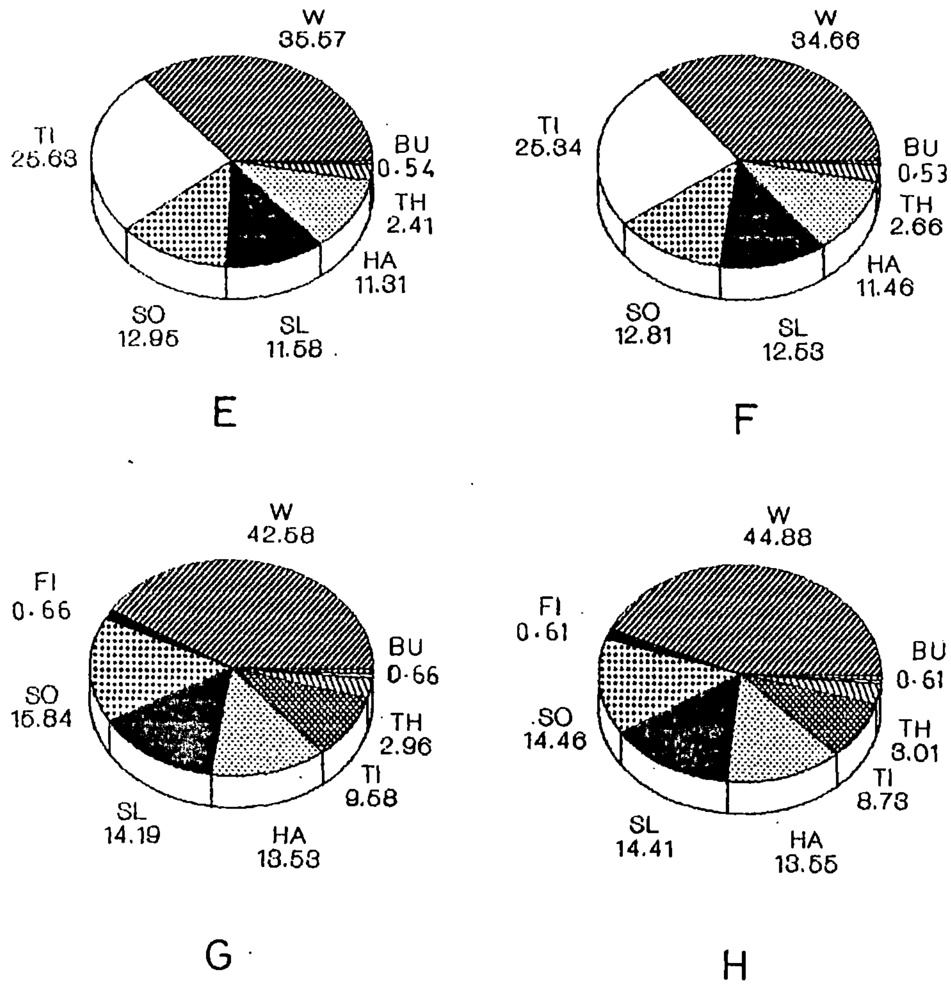
Fig. 3.1 (A-L) Pie chart, showing percentage of energy input contributed by jhuming operations. SL = slashing, BU = burning, TI = tilling or field preparation, FI = fertilizer application, SO = sowing, W = weeding, HA = harvesting and TH = threshing.

A = 6 I:C, B = 20 I:C, C = 6 II:C, D = 20 II:C, E = 6 II:T, F = 20 II:T, G = 6 II:CF, H = 20 II:CF, I = 6 II:FYM, J = 20 II:FYM, K = 6 II:CF+FYM, and L = 20 II:CF+FYM.



W
48.4
BU
0.63
TH
3.16
SO
15.5
HA
16.13
SL
16.13
A
W
41.66
BU
0.71
TH
3.95
SO
16.4
HA
18.26
SL
19.01
B
W
53.18
BU
0.64
TH
3.18
SL
13.7
HA
14.01
SO
15.29
C
W
50.8
BU
0.63
TH
3.21
HA
14.77
SL
15.1
SO
15.44
D


FIG. 3.1



W
35.57
TI
25.63
BU
0.54
TH
2.41
HA
11.31
SO
12.95
SL
11.58
E
W
34.66
TI
25.34
BU
0.53
TH
2.66
HA
11.46
SO
12.81
SL
12.53
F
W
42.58
FI
0.66
BU
0.66
SO
15.84
TH
2.96
TI
9.58
SL
14.19
HA
13.53
G
W
44.88
FI
0.61
BU
0.61
SO
14.46
TH
3.01
TI
8.73
SL
14.41
HA
13.55
H


FIG. 3.1

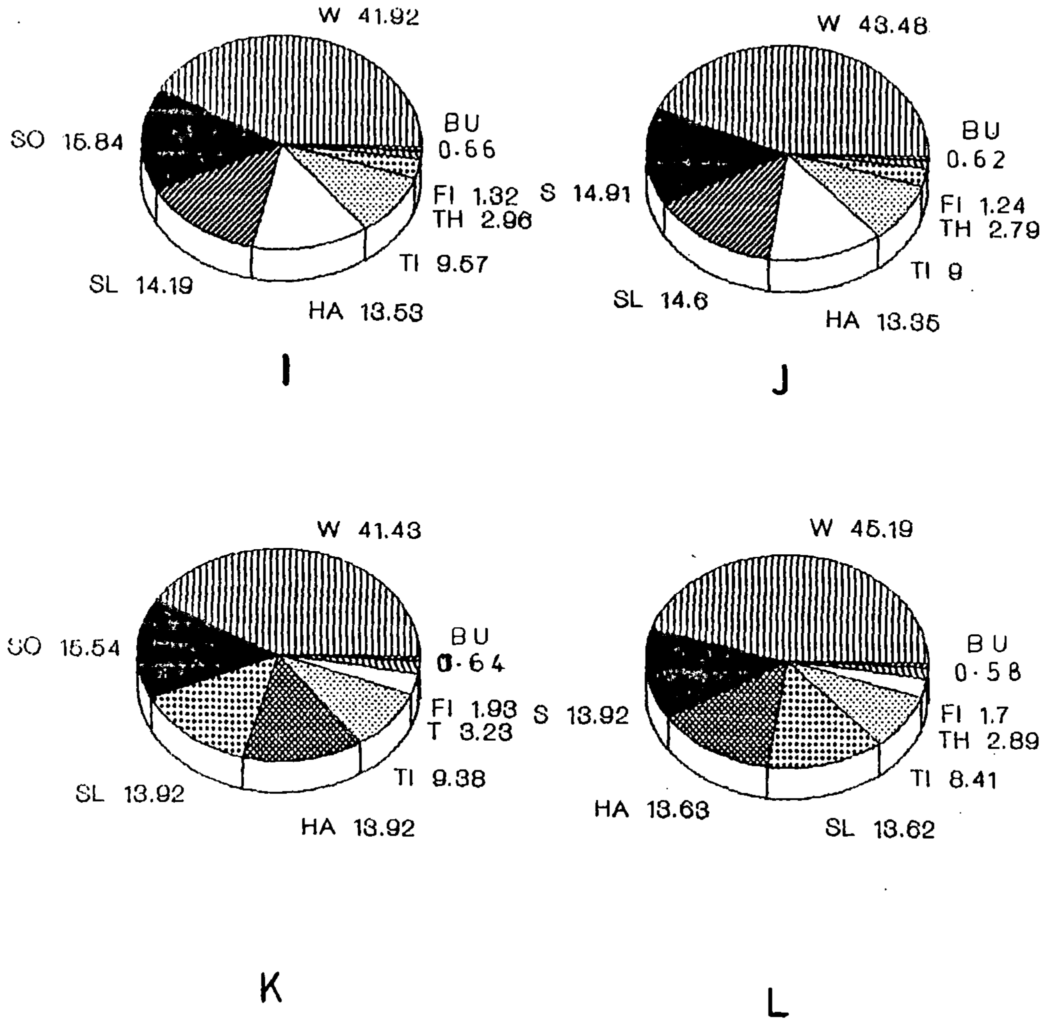

W 41.92
SO 15.84
BU 0·66
FI 1.32
TH 2.96
TI 9.57
SL 14.19
HA 13.53
I
W 43.48
S 14.91
BU 0.62
FI 1.24
TH 2.79
TI 9
SL 14.6
HA 13.35
J
W 41.43
SO 15.54
BU 0·64
FI 1.93
T 3.23
TI 9.38
SL 13.92
HA 13.92
K
W 45.19
S 13.92
BU 0·58
FI 1.7
TH 2.89
TI 8.41
HA 13.63
SL 13.62
L

FIG. 3.1

amounts were same for the similar plots of different ages of jhum fallows.

The energy input through fertilizer application was the lowest and almost equal in 6 II:CF and 20 II:CF sub-plots whereas in 6 II:CF+FYM and 20 II:CF+FYM sub-plots, it was the highest.

There was not much difference in energy input on threshing operation in all the plots. It was recorded highest in 20 I:C plot.

**Energy output:** Total output ranges from 1215 kg $ha^{-1} yr^{-1}$ to 1855 kg $ha^{-1}yr^{-1}$ in terms of production, Rs. 6075 $ha^{-1}yr^{-1}$ to Rs. 9275 $ha^{-1}yr^{-1}$ in terms of money and 17639.95 MJ $ha^{-1}yr^{-1}$ to 26931.78 MJ $ha^{-1}yr^{-1}$ in terms of energy (Table 3.5). Highest and lowest output were recorded from 20 II: CF+FYM and 6 II:T sub-plots respectively.

Energy output was more during first year cropping than during second year cropping from the jhum fallows of both ages. The output was higher from all plots in 20-yr. old jhum fallow than their corresponding plots in 6-yr. old jhum fallow during second year of cropping.

In the case of young jhum fallow the energy output was lowest from the tilled sub-plot. The same trend was true for the 20-yr. old jhum fallow. The sub-plot 20 II:CF+FYM recorded exceptionally high energy output compared to all other sub-plots in the old jhum fallow during second year of cropping. The same trend was observed in the young jhum fallow also during second year of cropping.

**Gain or Loss:** Energetically, there was always a gain, but monetarily it was not so in all the plots (Table 3.5). Maximum gain of Rs. 2281.25 $ha^{-1}yr^{-1}$ or 25576.95 MJ $ha^{-1}yr^{-1}$ was recorded in the 20 II:CF+FYM sub-plot. Maximum monetary loss of rs. 1438.75 $ha^{-1}yr^{-1}$ was incurred in the case of 6 II:T sub-plot.

Monetary loss was also rcorded in the case of control and tilled sub-plots in both the jhum fallows (6 II:C, 20 II:C, 6 II:T and 20 II:T sub-plots) during second year of cropping.

A gain of Rs. 897.75 $ha^{-1}yr^{-1}$ was recorded from the control plot on 6-yr. old jhum fallow, whereas during second year of cropping, a loss of Rs. 173.75 $ha^{-1}yr^{-1}$ was incurred from the same plot. A similar trend was observed in the case of 20-yr. old fallow where a gain of Rs. 2237.50 $ha^{-1}yr^{-1}$ was recorded in the first year of cropping from the control plot (20 I:C) and a loss of Rs. 13.75 $ha^{-1}yr^{-1}$ from the same plot during second year of cropping (20 II:C).

**Output : input ratio**

**Monetary efficiency:** The monetary output : input ratio determines the efficiency of each system in terms of money. The higher the output : input ratio the more efficient the system. The highest recorded ratio was 1.39 in 20 I:C plot and the lowest was 0.8 in 6 II:T sub-plot. Table 3.6 shows that this ratio was more than one in all plots except control and tilled sub-plots in both 6-yr. old and 20-yr. old jhum fallows during second year of cropping (Table 3.6).

**Energy efficiency:** Energy output : input ratio determines the energy efficiency of the system. This ratio was higher in all sub-plots on 20-yr. old jhum fallow than the corresponding sub-plots on 6-yr. old jhum fallow during both first and second year of cropping. The highest ratio recorded was 20.01 in 20 I:C plot and the lowest was 4.41 in 6 II: CF+FYM sub-plot. The control plot during first year of cropping (6 I:C and 20 I:C) recorded higher ratios than the corresponding sub-plots during second year of cropping (6 II:C and 20 II:C). Tilled sub-plots of both young and old jhum fallows recorded exceptionally low ratio as compared with the control sub-plots.

Energy output : input ratio was very low in all the plots that were given fertilizers. Again, among the sub-plots treated with the fertilizers, the ones which received farm-yard manure (6 II:FYM and 20 II:FYM sub-plots) recorded highest followed by the sub-plots treated with chemical fertilizer (6 II:CF and 20 II:CF sub-plots) while the lowest values were recorded for those plots which received both chemical fertilizer and farm-yard manure (6 II:CF + FYM and 20 II : CF + FYM).

## Discussion

The essence of agriculture is the use of energy and material inputs to stimulate productivity of the systems and concentrate it into forms useful to man. The energy output : input ratios in labour intensive agriculture are generally greater than one in contrast to one or less in case of fuel-based agriculture (Rappaport, 1968, 1971). Jhum in north-eastern India has survived all these years chiefly because of the high energy efficiency of the system where human labour is the only energy input. According to Rappaport (1971) the 'Tsembaga' people of the New Guinea Highlands obtained an average of 16 units of food energy for each unit of human energy input during farming and this may increase to 20 under more favourable conditions. Others (Lewis, 1951; Norman, 1978; Uhl & Murphy, 1981) have reported equally high or even higher efficiency. Most of these studies do not mention the length of the jhum cycle and its relationship to energy efficiency.

Table 3.4(a). Labour input (Man-days $ha^{-1}yr^{-1}$) in 6-year and 20-year old jhum fallows during first year and second year of cropping.

| TREATMENT | JHUMING OPERATIONS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| PLOTS | Slashing | Burning | Tilling | Fertilizer application | Sowing | Weeding | Harvesting | Threshing | Total |
| 6 I:C | 25.5 | 1 | - | - | 24.5 | 76.5 | 25.5 | 5 | 158 |
| 6 II:C | 21.5 | 1 | - | - | 24 | 83.5 | 22 | 5 | 157 |
| 6 II:T | 21.5 | 1 | 47.5 | - | 24 | 65 | 21 | 4.5 | 185.5 |
| 6 II:CF | 21.5 | 1 | 14.5 | 1 | 24 | 64.5 | 20.5 | 4.5 | 151.5 |
| 6 II:FYM | 21.5 | 1 | 14.5 | 2 | 24 | 63.5 | 20.5 | 4.5 | 151.5 |
| 6 II:CF+FYM | 21.5 | 1 | 14.5 | 3 | 24 | 64 | 21.5 | 5 | 154.5 |
| 20 I:C | 26.5 | 1 | - | - | 23 | 58.5 | 25.5 | 5.5 | 140 |
| 20 II:C | 23.5 | 1 | - | - | 24 | 79 | 23 | 5 | 155.5 |
| 20 II:T | 23.5 | 1 | 47.5 | - | 24 | 65 | 21.5 | 5 | 187.5 |
| 20 II:CF | 23.5 | 1 | 14.5 | 1 | 24 | 74.5 | 22.5 | 5 | 166 |
| 20-II:FYM | 23.5 | 1 | 14.5 | 2 | 24 | 70 | 21.5 | 4.5 | 161 |
| 20 II:CF+FYM | 23.5 | 1 | 14.5 | 3 | 24 | 78 | 23.5 | 5 | 172.5 |

Table 3.4(b). Monetary input (Rs $ha^{-1}yr^{-1}$) in 6-year and 20-year old jhum fallows during first year and second year of cropping.

| TREATMENT | INPUT COMPONENT | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PLOTS | Slashing | Burning | Tilling | Fertilizer application | Fertilizer | Seeds | Sowing | Weeding | Harvesting | Threshing | Total |
| 6 I:C | 1020 | 40 | - | - | - | 93.75 | 980 | 3060 | 1020 | 200 | 6413.75 |
| 6 II:C | 860 | 40 | - | - | - | 93.75 | 960 | 3340 | 880 | 200 | 6373.75 |
| 6 II:T | 860 | 40 | 1900 | - | - | 93.75 | 960 | 2640 | 840 | 180 | 7513.75 |
| 6 II:CF | 860 | 40 | 580 | 40 | 347.75 | 93.75 | 960 | 2580 | 820 | 180 | 6153.75 |
| 6 II:FYM | 860 | 40 | 580 | 80 | 450 | 93.75 | 960 | 2540 | 820 | 180 | 6153.75 |
| 6 II:CF+FYM | 860 | 40 | 580 | 120 | 797.75 | 93.75 | 960 | 2560 | 860 | 200 | 6273.75 |
| 20 I:C | 1060 | 40 | - | - | - | 93.75 | 920 | 2340 | 1020 | 220 | 5693.75 |
| 20 II:C | 940 | 40 | - | - | - | 93.75 | 960 | 3160 | 920 | 200 | 6313.75 |
| 20 II:T | 940 | 40 | 1900 | - | - | 93.75 | 960 | 2600 | 860 | 200 | 7593.75 |
| 20 II:CF | 940 | 40 | 580 | 40 | 347.75 | 93.75 | 960 | 2980 | 900 | 200 | 6733.75 |
| 20 II:FYM | 940 | 40 | 580 | 80 | 450 | 93.75 | 960 | 2800 | 860 | 180 | 6533.75 |
| 20 II:CF+FYM | 940 | 40 | 580 | 120 | 797.75 | 93.75 | 960 | 3120 | 940 | 200 | 6993.75 |

Table 3.4(c). Energy input (MJ $ha^{-1}yr^{-1}$) in 6-year and 20-year old jhum fallow during first year and second year of cropping.

| TREATMENT | INPUT COMPONENTS | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PLOTS | Slashing | Burning | Tilling | Fertilizer application | Fertilizer | Seeds | Sowing | Weeding | Harvesting | Threshing | Total |
| 6 I:C | 160.03 | 6.27 | - | - | - | 272.22 | 153.76 | 480.11 | 160.03 | 31.38 | 1263.38 |
| 6 II:C | 134.93 | 6.27 | - | - | - | 272.22 | 150.62 | 524.05 | 138.07 | 31.38 | 1257.55 |
| 6 II:T | 134.93 | 6.27 | 298.11 | - | - | 272.22 | 150.62 | 414.21 | 131.79 | 28.24 | 3849.35 |
| 6 II:CF | 134.93 | 6.27 | 91.0 | 6.27 | 2626.65 | 272.22 | 150.62 | 404.8 | 128.65 | 28.24 | 2123.0 |
| 6 II:FYM | 134.93 | 6.27 | 91.0 | 12.55 | 900.0 | 272.22 | 150.62 | 398.52 | 128.65 | 28.24 | 2123.0 |
| 6 II:CF+FYM | 134.93 | 6.27 | 91.0 | 18.82 | 3526.65 | 272.22 | 150.62 | 401.66 | 134.93 | 31.38 | 4768.48 |
| 20 I:C | 166.31 | 6.27 | - | - | - | 272.22 | 144.36 | 367.15 | 160.03 | 34.52 | 1150.85 |
| 20 II:C | 147.48 | 6.27 | - | - | - | 272.22 | 150.62 | 495.8 | 144.35 | 31.38 | 1248.13 |
| 20 II:T | 147.48 | 6.27 | 298.11 | - | - | 272.22 | 150.62 | 407.94 | 134.93 | 31.38 | 1448.97 |
| 20 II:CF | 147.48 | 6.27 | 91.0 | 6.27 | 2626.65 | 272.22 | 150.62 | 467.56 | 141.21 | 31.38 | 3940.66 |
| 20 II:FYM | 147.48 | 6.27 | 91 | 12.55 | 900 | 272.22 | 150.62 | 439.32 | 134.93 | 28.24 | 2182.65 |
| 20 II:CF+FYM | 147.48 | 6.27 | 91 | 18.82 | 3526.65 | 272.22 | 150.62 | 489.52 | 147.48 | 31.38 | 4880.65 |

Table 3.5. Output in terms of production (Kg $ha^{-1}yr^{-1}$), money (Rs $ha^{-1}yr^{-1}$) and energy (MJ $ha^{-1}yr^{-1}$) from 6-year and 20-year old jhum fallows during first year and second year of cropping.

| PLOTS | OUTPUT | | |
|---|---|---|---|
| | Production | Money | Energy |
| 6 I:C | 1462.5 | 7312.50 | 21233.27 |
| 6 II:C | 1240.0 | 6200.00 | 18002.91 |
| 6 II:T | 1215.0 | 6075.00 | 17639.95 |
| 6 II:CF | 1375.0 | 6875.00 | 19962.91 |
| 6 II:FYM | 1300.0 | 6500.00 | 18874.02 |
| 6 II:CF+FYM | 1450.0 | 7250.00 | 21051.79 |
| 20 I:C | 1586.25 | 7931.25 | 23029.93 |
| 20 II:C | 1260.0 | 6300.00 | 18293.28 |
| 20 II:T | 1247.5 | 6237.50 | 18111.80 |
| 20 II:CF | 1505.0 | 7525.00 | 21850.31 |
| 20 II:FYM | 1402.5 | 7012.50 | 20362.16 |
| 20 II:CF+FYM | 1855.0 | 9275.00 | 26931.78 |

Table 3.6. Output/input ratio (Rs. and MJ) in 6-year and 20-year old jhum fallows during first year and second year of cropping.

| PLOTS | OUTPUT : INPUT | |
|---|---|---|
| | Rs. | MJ |
| 6 I:C | 1.14 | 16.8 |
| 6 II:C | 0.97 | 12.53 |
| 6 II:T | 0.8 | 12.28 |
| 6 II:CF | 1.11 | 5.18 |
| 6 II:FYM | 1.05 | 8.89 |
| 6 II:CF+FYM | 1.15 | 4.41 |
| 20 I:C | 1.39 | 20.01 |
| 20 II:C | 0.99 | 14.65 |
| 20 II:T | 0.82 | 12.49 |
| 20 II:CF | 1.11 | 5.54 |
| 20 II:FYM | 1.07 | 9.32 |
| 20 II:CF+FYM | 1.32 | 5.51 |

Toky & Ramakrishnan (1982) reported energy output : input ratios of 31.1 to 47.9 under three different jhum cycles in Meghalaya.

In the present study, the energy efficiency (output : input ratio) during first year of cropping were 16.8 and 20.01 in young and old jhum fallows respectively. Lower energy efficiency in 6-yr. old jhum fallow is mainly due to relatively greater labour input in weeding operation. In the 20-yr. old fallow, weeding was required to be done twice whereas in the 6-yr. old jhum fallow it was required to be done three times in a year. A high degree of weed infestation associated with short jhum cycle is also reported by Toky & Ramakrishnan (1982). According to Freeman (1955), Cutting et al. (1959), Zinke et al. (1978) and Toky & Ramakrishnan (1982) weeds are the major cause of decline in crop yield under slash and burn agriculture.

Higher energy input and lower production during first year of cropping in 6-yr. old fallow compared to 20-yr. old jhum fallow observed in the present study is also due to greater weed infestation in the former. But, during second year of cropping, there had not been much difference in energy efficiency between the two fields. This condition may be attributed to the non-differentiable problem of weeds between the two fields mentioned elsewhere in the present study. The weeds are thus mainly responsible for the difference in energy efficiency between first year and second year of cropping on the jhum fallow of a given age. The difference was, however, more prominent in case of 20-yr. old than in 6-yr. old jhum fallow. As revealed by the data, weeds are largely responsible for decline in energy efficiency in young jhum fallow during first year of cropping and also in both young and old jhum fallows during second year of cropping.

The high energy efficiency of shifting cultivation systems contrasts sharply with mechanized agriculture (Uhl & Murphy, 1981). For example, Pimentel et al. (1973) estimated that the ratio of food produced to energy input was 2.82 : 1 for mechanized corn cultivation in U.S.A. Mechanized agriculture is relatively less efficient energetically because of the large amount of energy subsidy required in the form of machinery, fertilizer, electricity and transportation. Earth work (terracing and tilling) always requires high labour input in terrace cultivation. Toky & Ramakrishnan (1982) reported that in terrace cultivation in Meghalaya, terracing during first year was one of the major operations involving high energy input. Due to this, even if the output is high, energy efficiency of such systems where extensive earth works are involved could never be high. In the present study also the energy efficiency of the tilled sub-plots is relatively low due to high labour input in tilling of the soil. At the same time, unlike terrace system of cultivation, the output is rather low. This shows that introduction of tilling of soil during second year of cropping as a means of improvement over the existing traditional method of jhuming cannot be recommended as this would not increase production and energy efficiency.

The energy efficiency of fertilizer treated sub-plots are relatively high when only human labour inputs are considered as total energy input in the system. Basing upon this, all the fertilizer treated plots of young and old jhum fallows may be considered relatively more productive and energy efficient systems. At the same time, these fertilizer treated sub-plots are also comparable to mechanized systems, because of high energy input through fertilizers which are not applied under traditional method of jhuming, as is the case with the control plot. Even if the output is relatively high in the fertilizer treated sub-plots, the high energy input brings down the energy efficiency in these plots. Viewed from this angle, the new approaches which were introduced with a view to improve the traditional method of jhum cultivation, can hardly be considered as improvements.

Relatively high monetary input in tilled sub-plots is due to labour input in soil tilling operations. The monetary input in the fertilizer treated sub-plots is pushed up due to the cost of fertilizers and their applications. An additional agricultural operation of field preparation also contributed to increase input in these sub-plots. The increased input caused decline in monetary efficiency of these sub-plots. There has not been much variation in monetary input among the plots on account of various traditional jhuming operations except weeding. Relatively high monetary input in weeding in the control plots of both 6-yr. old and 20-yr. old jhum fallows during second year of cropping is linked with high intensity of weed problem in these plots. The data also indicates that degree of weed infestation and loss in crop yield and monetary input in weeding operation are greater in 6-yr. old than in 20-yr. old jhum fallow.

The output of rice from each study plot (average yield 1408 Kg $ha^{-1}yr^{-1}$) is quite satisfactory when compared with the average yield of 1145 kg $ha^{-1}yr^{-1}$ for the country as a whole. The rice production recorded in the present study is greater than the average yield of 800 to 900 kg $ha^{-1}yr^{-1}$ reported earlier for Mizoram by Borthakur et al (1978). The tilled sub-plots involving highest monetary input recorded lowest output. Further, the untilled control plots on the two jhum fallows during both first year and second year of cropping gave relatively higher output even though the monetary input was low.

On the basis of output in terms of production and monetary gain, the fertilizer treated sub-plots appear to be relatively more sound systems and therefore, fertilizer application during second year of cropping could be suggested as a definite improvement over the method of jhum cultivation hitherto being practiced in the state of Mizoram.

It may be noted that increase in monetary input does not necessarily increase the monetary output.

It is to be noted that the readily available energy input components like solar energy, forest vegetation, soil nutrients and accumulated litter in the system are not accounted for, while computing the energy efficiency of each study plot. At the same time, the 'left behind energy' after harvesting like, litter, vegetation and solar energy are not included in the energy output also. In any case, as all these factors are excluded in all the study plots, the energy budget as worked out in the present study may serve the purpose of comparing the energy efficiency of various kinds of jhum plots representing traditional jhum cultivation and the one modified in the light of suggested improvements and innovative approaches.