



Energy requirement for irrigated Boro rice cultivation in Tangail district of Bangladesh

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ABSTRACT

The study was undertaken to estimate the amount of energy used in different farm activities of irrigated boro rice (*Oryza sataiva*) cultivation in the four selected villages of Tangail district. Data was collected from the randomly selected farmers on the basis of pre-tested questionnaire. Input energy was calculated from human, animal, chemical fertilisers, operations of machinery and other input sources. A month-wise energy input calendar was constructed throughout the boro rice cultivation period from January to May. This study revealed that the draught power from power tiller sources was available for land preparation but the availability of human and draught animal power were not sufficient during the peak season. Total input energy was 19624 MJ/ha with fertiliser and irrigation as the major inputs and the output energy was 115659MJ/ha. The energy productivity and energy efficiency were 0.37 kg/MJ and 5.89 respectively.

Rice is the major cereal crop grown widely in Bangladesh. Total rice production in Bangladesh in 1998 was 18.04 million tonnes (Pillai, 1998). The total area under rice has fairly remained stagnant at around 10 million hectares, though there have been considerable seasonal variations in rice area and production (BBS, 1998). For self sufficiency in food, land productivity needs to be increased by intensifying the land use with various types of crops, introducing high yielding varieties and improving management practices.

The adoption of appropriate machinery either hand operated or power operated can increase the working efficiency of the farmers. Maximisation of land productivity and minimisation of

energy inputs are the main aim for modern rice cultivation system. In transition from traditional to modern farming, the commercial energy use has increased sharply. The improved variety and adaptable technology are the key element in modern rice farming that requires commercial energy (Bala and Hussain, 1992; Sarker et al., 1981). Energy economic analysis must be done to identify the ways and means where energy savings can be obtained without impairing grain yield (Singh et al, 1989). In this context, this research was undertaken to study the actual energy use level and to identify the energy use patterns for boro rice cultivation in the selected area of Bangladesh.

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METHODOLOGY

Four villages namely Jhunkail, Pakutia, Sangram - shimul and Golabari were selected (latitude 24.52°N and Longitude 90.43°E) in Tangail district. Primary data were collected randomly from farmers in each week during the period from January to June 1999. Farmer's plots were selected covering various economic groups such as (i) landless, (ii) marginal, (iii) small, (iv) medium and (v) large. The field information was collected by direct interviewing method covering 43.70 hectare of land from 326 plots of 136 farms. The amount of energy inputs from different energy sources such as human, animal, fuel, seed, fertilisers and pesticides were recorded at different stages of their applications. The total energy was calculated from the total material input energy plus their required operational energies. The amount of output energy was calculated from the grain yield and bio-mass residues. Energy inputs for rice production was calculated by using equivalents of energy shown in Table 1. Solar energy was not considered.

Table. 1 Energy equivalent sources

| Source of energy | Equivalent energy, MJ | Reference |
|------------------------------------|-----------------------|----------------------------|
| Human labour, 1 man/h | 0.20 | Sarker, 1997 |
| Draught animal, 1 pair/h | 1.07 | Sarker, 1997 |
| Diesel, l | 56.30 | Singh <i>et al.</i> , 1994 |
| Nitrogen, kg | 60.00 | Singh <i>et al.</i> , 1994 |
| P ₂ O ₅ , kg | 11.10 | Singh <i>et al.</i> , 1994 |
| K ₂ O, kg | 6.70 | Singh <i>et al.</i> , 1994 |
| Super chemical, kg | 120.00 | Singh <i>et al.</i> , 1994 |
| Inferior chemical, kg | 10.00 | Singh <i>et al.</i> , 1994 |
| Zinc sulfate, kg | 20.90 | Singh <i>et al.</i> , 1994 |
| Rice grain, kg | 14.70 | Singh <i>et al.</i> , 1994 |
| Rice straw, kg | 12.50 | Singh <i>et al.</i> , 1994 |
| Farm manure (dry), kg | 0.30 | Singh <i>et al.</i> , 1994 |
| Cow dung, kg | 1.00 | BARC, 1997 |
| Ash, kg | 7.52 | BARC, 1997 |

RESULTS AND DISCUSSION

Energy inputs sources have been classified into two major categories. Energy inputs through human, draught animals and power tillers were included for farming operations. Human labour was involved for land preparation, sowing, seedling transfer, transplanting, weeding, fertiliser and pesticide application, water distribution, harvesting, transporting and threshing. Transplanting, weeding, irrigation water distribution and harvesting operations consumed the highest human energy. Energy content materials were seed, fertiliser, pesticide and fuel for irrigation pump operation. Human and draught animal powers were common and power tillers were used by all categories of farmers. Energy input from the human source was recorded 273.73 MJ/ha for boro rice cultivation (Table 2). Human labour became scarce in peak period mainly during transplanting and harvesting.

The number of draught animals have decreased very rapidly in recent years in the farmer's level due to high rate of slaughtering, shortage of grazing field and the problems of maintaining them. Moreover, the availability of power tillers might be another cause of ever decreasing population of draught animal. As a result the availability of draught animal power decreased drastically among the farmers level (Sarker, 1997). Due to shortage of draught power, farmers chose power tillers, as it reduced land preparation cost, required less time and was comfortable for farm work. The introduction of power tiller has helped to cultivate more areas of land by individual farmers.

Table 2 Energy required in farm operation , MJ/ha

| Power sources | Landless | Marginal | Small | Medium | Large | Mean |
|---------------|----------|----------|--------|--------|--------|--------|
| Human | 264.71 | 285.28 | 267.81 | 269.72 | 269.72 | 273.73 |
| Animal | 39.16 | 49.68 | 67.08 | 73.10 | 36.85 | 55.51 |
| PT | 488.07 | 450.99 | 378.39 | 365.92 | 440.38 | 415.37 |
| Total | 791.94 | 785.95 | 713.28 | 708.72 | 746.95 | 744.61 |

Medium, small and marginal farmers used more draught animal power because of they rear cattle for draught power with the expectation of milk (Table 3). Landless and large farmers were the highest power tiller user, as they own less number of cattle for land preparation.

Table 3: Relationship between power sources used with farm category

| Power sources | Landless (%) | Marginal (%) | Small (%) | Medium (%) | Large (%) |
|---------------|--------------|--------------|-----------|------------|-----------|
| DA | 19.5 | 23.5 | 25.0 | 27.6 | 6.7 |
| PT | 73.5 | 64.7 | 44.6 | 44.8 | 59.6 |
| DA & PT | 7.0 | 11.8 | 30.4 | 27.6 | 33.7 |
| Total | 100 | 100 | 100 | 100 | 100 |

Large farmers have used power tillers in large scale. Generally Power tillers are used for land tilling and draught animals are used for levelling because presently levelling by power tiller is not suitable. Some farmers presently do the levelling manually for seedbed and main-land preparation. A traditional concept prevailing in the farmer's mind is that draught animal farming system is more productive than power tiller farming system. But, draught animal contributes only 55.17 MJ/ha energy for land preparation. There were variations in power tiller use in different categories of farmers, which might be due to extent of

availability of power tiller in the locality and the availability of draught animals. The observed total energy input from human, animal and power tillers for farming operations was 744.61 MJ/ha of which power tiller share was 415.37 MJ/ha.

Several high yielding varieties of boro rice were cultivated and their seed rates were different for different plots. Plantation-time, topography and soil fertility was also different for different plots. About 1094 MJ/ha energy was used from seed itself. The requirement of rice seeds was about 0.3 million tonnes, of which 4.5 percent of foundation seeds come from Bangladesh Agricultural Development Corporation as high quality seed (Pillai, 1998). Local farmers traditionally produced 96.5 percent seeds, were poor in quality. Farm manure and straw were used as organic fertiliser. Farmers who own cattle applied more manure than the others. In addition farmers are using cow dung and straw as fuel for cooking. Few of the farmers had the interest of applying farm manure in the main field even by purchasing. Farm manure provides energy equivalent to 1253.67MJ/ha. It was observed from the study that there was a general tendency among the cultivator to apply more quantity of commercial fertilisers. Few farmers believed that only nitrogen fertiliser could increase crop yield with addition

of farmyard manure and even they did not apply potash and phosphate in their field. As a result, not only low crop yield was obtained but also a drop in the return and possible adverse effects on the soil environment did occur. Other farmers suggested that application of inorganic fertiliser impaired the capacity of the soil to retain nutrients and deplete the stock of nutrients in soil.

The commercial fertiliser and irrigation energy inputs were the highest input. The total energy input from commercial fertiliser was found to be 7517.26MJ/ha. This finding agreed with Mittal and Srivastara (1993). Fertilizer dose, in case of urea is more than the recommended dose of the department of agricultural extension (5400 MJ/ha), but the other fertilizer doses were less than to the recommended doses. Bala (1996) found similar energy use for rice production in Bangladesh. There was no difference in fertiliser use between the categories of farmers or villages (Table 4).

With the increase of commercial fertiliser usage

weeds are posing major problems on the rice production. Herbicides are becoming popular among the farmers to control weeds though hand-weeding technique is available. However, hand weeding is still the best method of weed control but required high energy. Timely land preparation with appropriate tillage system and timely hand weeding can play a leading role in weed management. The energy input from herbicide was found to be 43.987MJ/ha. Very small amounts of pesticides were used for boro rice cultivation. Irrigation is essential for high yielding varieties of rice and irrigation energy input from diesel fuel was found to be 7705.74 MJ/ha. Material inputs energy was calculated by adding energy inputs from seeds, farm manure, fertilisers and pesticides and fuel for irrigation pump operation. The total material energy inputs from all category sources were 18879.37MJ/ha (Table 4).

Distribution of energy according to farm operation

Farm operation-wise energy usage for boro rice cultivation has been shown in Table 5. The

Table 4: Energy input form material sources in MJ/ha

| Energy sources | Landless | Marginal | Small | Medium | Large | Mean |
|----------------|----------|----------|----------|----------|----------|----------|
| Seed | 1075.44 | 1113.63 | 1086.40 | 1098.84 | 1088.22 | 1094.53 |
| Manure | 1082.56 | 1132.72 | 1350.22 | 1550.88 | 1019.51 | 1253.67 |
| Urea | 6960.48 | 7175.60 | 6211.42 | 6496.81 | 6450.14 | 6611.43 |
| TSP | 18.23 | 100.78 | 135.23 | 123.77 | 60.05 | 97.63 |
| SSP | 247.93 | 205.51 | 177.87 | 183.49 | 218.40 | 200.43 |
| MP | 507.78 | 577.12 | 526.89 | 528.40 | 595.24 | 550.38 |
| Gypsum | 00.00 | 4.79 | 10.29 | 7.14 | 00.00 | 5.38 |
| Zinc | 00.00 | 48.38 | 75.68 | 57.96 | 49.92 | 52.01 |
| Ash | 1422.51 | 1335.45 | 1188.84 | 1430.72 | 812.20 | 1271.96 |
| Pesticide | 37.84 | 30.89 | 40.50 | 42.64 | 32.20 | 36.94 |
| Fuel | 7626.03 | 7892.68 | 7327.19 | 8010.97 | 7639.91 | 7705.74 |
| Total | 18978.8 | 19617.55 | 18130.53 | 19531.62 | 17965.73 | 18879.37 |

Table. 5 Distribution of required energy for Boro rice cultivation

| Farm activities | Energy, MJ/ha | Energy contribution, % |
|--------------------------|---------------|------------------------|
| Land preparation | 8.17 | 0.04 |
| Tilling | 415.37 | 2.12 |
| Seed & Seedling Transfer | 1105.45 | 5.63 |
| Transplanting | 45.53 | 0.23 |
| Irrigation | 7725.74 | 39.37 |
| Weeding | 45.79 | 0.23 |
| Farm manure +Ash | 2554.91 | 13.02 |
| Commercial Fertiliser | 7526.03 | 38.35 |
| Pesticide | 38.87 | 0.20 |
| Harvesting | 43.09 | 0.22 |
| Transporting | 23.33 | 0.12 |
| Threshing | 22.03 | 0.11 |
| Others | 69.67 | 0.36 |
| Total | 19623.98 | 100 |

highest amount of energy was required from irrigation (39.37%) followed by fertiliser (38.35%), tillage, weeding, transplanting, harvesting, transporting, threshing, seedling transfer, land cleaning and others source.

Energy use pattern

A month-wise energy input calendar was prepared for boro rice cultivation. The highest amount of farm operation energy was required in January because of several farm operations

were performed like tilling, laddering, seedling transfer, transplanting, fertiliser application and irrigation (Table 6). Farm manure, cow dung and ash were applied only in the month of January at the time of land preparation. The estimated major renewable energy input from farm manure and ash were 2554.91MJ/ha and applied at the time of soil opening. In February, transplanted, weeding, secondary fertiliser application and irrigation energy was applied. Maximum fertiliser energy was applied in the month of February and March, which were 3430.59MJ/ha and 3035.03MJ/ha respectively. In the month of March and April, major irrigation energy was spent with some additional fertiliser. Rice harvesting began from the last week of April. In the month of May major harvesting, threshing, transporting and some other postharvest operations were carried out. Therefore, energy input record for farm operations increased again in the month of May. The energy spent in farm operations during February to May were 176.4, 55.5, 40.6 and 74.2 MJ/ha respectively. The total energy for farm operational work was found to be 744.6 MJ/ha. Irrigation energy alone demanded 7705.74 MJ/ha. Total amount of energy input for throughout the season was recorded 19623.98 MJ/ha.

Table. 6 Energy uses pattern for boro rice cultivation, MJ/ha.

| Month | Farm Operation | Seed | Farm manure +Ash | Commercial fertiliser | Fuel | Total |
|----------|----------------|------|------------------|-----------------------|---------|----------|
| January | 398.00 | 1094 | 2554.91 | 866.31 | 1499.74 | 5811.77 |
| February | 176.30 | - | - | 3430.59 | 1582.50 | 5227.01 |
| March | 55.50 | - | - | 3035.03 | 1874.00 | 5526.80 |
| April | 40.60 | - | - | 194.10 | 2470.00 | 2704.70 |
| May | 94.20 | - | - | 0.00 | 279.50 | 373.70 |
| Total | 744.60 | 1094 | 2554.91 | 7526.03 | 7705.74 | 19623.98 |

Energy balance

Total energy output was calculated from the grain and straw yield (Table 7). The calculated energy output from grain and straw were 79690.5MJ and 35968.1MJ per hectare, respectively.

The total calculated energy output was 115660.38 MJ/ha (Table 8) and the input energy was 19623.98 MJ. Energy productivity was 0.37kg/ MJ and energy efficiency was 5.89.

CONCLUSIONS

The following conclusions are drawn for boro rice cultivation on the basis of the results obtained in this study:

1. Power tillers are the major draught power source for boro rice cultivation.
2. Landless and large farmers were the highest PT users.
3. The highest energy demand was in the month of March.

4. Commercial fertiliser and irrigation consumed 38.35 and 29.37 percent energy respectively.
5. Energy input and output figures were 19623.98 MJ/ha and 115658.6 MJ/ha respectively.
6. Energy productivity and efficiency were 0.37kg/MJ and 5.89 respectively.

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REFERENCES

- BARC. 1997. Fertilizer Recommended Guide. pp. 180
- BBS. 1998. Bangladesh Bureau of Statistics. Statistical Year Book of Agriculture, Ministry of Planning, Govt. of Peoples Republic of Bangladesh.
- Bala BK. 1996. Computer Modeling of National Energy Policy Planning. The Case of Bangladesh. Final Report of Strengthens of

Table: 7 Energy output by farm category in MJ/ha

| Source | Landless | Marginal | Small | Medium | Large | Mean |
|------------|-----------|-----------|-----------|-----------|-----------|----------|
| Yield | 78692.61 | 82717.92 | 79449.64 | 79984.85 | 7755.57 | 79690.5 |
| Bi-product | 37035.71 | 36810.51 | 35116.16 | 35450.26 | 35427.70 | 35968.1 |
| Total | 115728.32 | 119528.44 | 114615.80 | 115435.12 | 112985.27 | 115658.6 |

Table.8 Energy Balance

| Energy input, MJ/ha | | | Energy output, MJ/ha | | | Energy efficiency | Energy productivity MJ/kg |
|---------------------|-----------|----------|----------------------|---------|----------|-------------------|---------------------------|
| Farming Operations | Materials | Total | Crop | Straw | Total | | |
| 744.6 | 18879.38 | 19623.98 | 79690.5 | 35968.1 | 115658.6 | 5.89 | 0.37 |

- Energy Mode and Economics Wing Project. Planning Commission, Govt. of Bangladesh.
- Bala BK. and Hussain MD. 1992. Energy Use Pattern for Crop Production in Bangladesh. *Journal of Engineering for International Development*. vol.1 no.3. pp.41-47
- Mittal JP and Srivastava NSL 1993. Role of Human and Animal Power in Crop Production. *Proceedings of the Workshop on Human and Draught Animal Power in Crop Production*. Harare, January 18-22. pp 50-59.
- Pillai KG. 1998. Thana Cereal Technology Transfer and Identification Project. (GOB/UNDP/FAO/PROJECT: BGD/89/045)
- Sarker RI. 1997. Agricultural Mechanization in Bangladesh: Selection of Technology. In *Proceedings of Joint International Conference of Agricultural Engineering and Technology*. vol. 1. pp.1-9, Dhaka, Bangladesh.
- Sarker RI, Ziauddin ATM and Hossain M. 1981. Energy Input Output Relation in Traditional and Mechanized Rice Cultivation in Bangladesh. AMA, Summer.
- Surendra Singh, Sarjinder Singh, JP Mittal, CJS Pannu and BS Bangoo. 1994. Energy Inputs and Crop Yield Relationships for Rice in Punjab, *Energy*: Vol. 19, pp.1061-1065.
- Singh S, M Singh, RS Rana, VK. Mittal and R Bakhshi. 1989. Energy and Cost Requirements for Cultivation of Rice Wheat and Maize Rotations. *Indian Journal of Agricultural Sciences*: 59(9). pp.558-60.