Australian Journal of Basic and Applied Sciences, 4(4): 665-672, 2010
ISSN 1991-8178

Pattern of Energy Consumption in Millet Production for Selected Farms in Jigawa, Nigeria

M.S. Abubakar and D. Ahmad

Department of Biological and Agricultural Engineering, Universiti Putra, Malaysia Universiti Putra, Malaysia, 43400 UPM, Serdang Selangor, Malaysia

Abstract: A study was conducted on the evaluation of energy use patterns in millet (Pennisetum glaucum [L.] R. Br.) production for some selected farms in north eastern part of Jigawa State, Nigeria. Millet farmers were categorized into five (5) groups base on the their farm sizes, that is Group I – farmers with farm size greater than or equal to 5 hectares, Group II – farmers with farm size between 3-4 hectares, Group III – farmers with farm size between 2-3 hectares, Group IV – farmers with farm size between 1-2 hectares, Group V – farmers with farm size equal to or less 1 hectare. Fifty (50) farmers were interviewed from each of the groups. Data for energy input resources during millet production from land preparation up to harvesting/threshing were collected using structural questionnaire and oral interviews. A total of 250 sample data were collected. Results show that energy resources used by the farmers in the five groups considered were manual (human labour), animal draft, manure, chemical fertilizer, farmyard manure, mechanical and seed (millet) as biological. The various field operations considered during this study were land clearing, soil tillage, planting, weeding, farmyard manure/fertilizers and harvesting and threshing. The study revealed that all farmers group studied had the least amount of energy input for land clearing that varied between 4-8% and highest intensities of energy used in was soil tillage and weeding that varied between 25-40%. It was shown that group V farmers consumed the highest total energy values of 6078 MJ/ha in their millet production while farmers group I expended the least amount of total energy value of 1705 MJ/ha and total energy output during millet crop production was the highest found in group I farmers and the least total energy output was found in group II farmers with values of 13100 MJ/ha and 2300 MJ/ha respectively. A linear relationship between total energy inputs and outputs was obtained with R^2 values of 0.88 using t-test at 0.05 level of significance it shows significant increase in energy input increases energy output. Energy use ratio values revealed that there was high efficient level of energy use by group III farmers low efficient energy use by group I farmers with values of 2.4 and 1.3 respectively. It is recommended that similar studies be carried out for some other crops commonly produced in north eastern Jigawa State in order to have more data for comparison.

Key words: Energy consumption, millet production, farmer groups, Nigeria

INTRODUCTION

Jigawa State is one of thirty-six States that constitute Federal Republic of Nigeria and is predominantly with agriculture as the major economic activity. Over eighty percent of the population is engaged in subsistence farming and animal husbandry. It is situated in north-western part of the country between Latitudes 11.00°N to 13.00°N and Longitudes 8.00°E to 10.15°E. Energy is one of the most valuable inputs in production agriculture. It is invested in various forms such as mechanical (farm machines, manual labour, and animal draft), chemical fertilizer, pesticides, herbicides, electrical, etc, (Pimentel, 1992). The amount of energy used in agricultural production, processing and distribution should be significantly high in order to feed the expanding population and to meet other social and economic goals. Sufficient availability of the right energy and its effective and efficient use are prerequisites for improved agricultural production. It was realized that crop yields and food supplies are directly linked to energy (Pimentel, 1992; Stout, 1990). Millet (Pennisetum glaucum [L.] R. Br.) production is a direct function of high yield varieties, chemicals, fertilizers, mechanization

Corresponding Author: M.S. Abubakar, Department of Biological and Agricultural Engineering, Universiti Putra, Malaysia Universiti Putra, Malaysia
43400 UPM, Serdang Selangor, Malaysia
E-mail: abubakarms@gmail.com

and other energy inputs (manual labour, animal power, fuels and electricity) (Fluck, 1985). Millet is a cereal grain with good drought tolerance and hardiness commonly grown in the semiarid regions of Africa and Asia on an estimated 26 million hectares are cultivated for millet production primarily for human consumption (Andrews and Kumar, 1992). Millet production increased from 26 million tonnes in 1981 to 31 million tonnes in 1990 in Asia, Africa and the former USSR. The major millets producers' nations in 1990 were India (15%), China (10%), Nigeria (65%) and the former USSR (10%) (FAO, 1996). In developed countries, increases in the crop yields were mainly due to increase in the commercial energy inputs in addition to improved crop varieties (DE Cock and Van Lierde, 1999; Faidley, 1992). Bridges and Smith (Bridges and Smith, 1979) developed a method for determining the total energy input for agricultural practices. Most farmers mainly produce the millet crop using only manual energy. Few farmers of the crop use tractors for tillage during the land preparation stage. Apart from this single mechanical energy use, all other farm operations are executed using manual and animal draft energy.

In Nigeria, like any other developing countries there is the lack of data on energy expenditure and returns in the energy analysis however, the energy-agriculture relationship is therefore becoming more and more important with the intensification of the cropping systems, which is considered to be the only means of raising agricultural output in land scarce situations. This study was intended to determine pattern of energy consumption in millet production for some selected farms in Jigawa state with following specific objectives,

1. To identify the major energy sources in use in millet production.
2. To analyze the input and output energy in millet production
3. To determine energy use ratio.

MATERIALS AND METHOD

Primary data for energy input resources in millet production for the year 2006/07 were collected through administration of structural questionnaire and personal interview to the farmers. Secondary data and energy equivalents for energy input resources and energy output were obtained from the available literatures.

Study Area:

The study was carried out in the eight (8) Local Government Areas in North eastern part of Jigawa state (namely; Hadejia, Auyo, Kafin-Hausa, Kaugama, Malam-Madori, Birniwa, Kiri-Kasamma and Guri). The area and crop were selected because majority of the farmers in the zone produce millet. The area is located on 12^0 26 53N latitude, 10^0 2 37E longitudes and categorized in hot-dry semi-arid climate with hot summers and cold winters. The mean annual rainfall of the area is about 890 mm and evapo-transpiration 1600 mm. The soil was sandy loam (Hadejia, 2006).

Data Collection and Experimental Design:

Millet farmers were categorized into five (5) groups based on the their farm sizes, that is Group I – farmers with farm size greater than or equal to 5 hectares, Group II – farmers with farm size between 3-4 hectares, Group III – farmers with farm size between 2-3 hectares, Group IV – farmers with farm size between 1-2 hectares, Group V – farmers with farm size equal to or less 1 hectare. Fifty (50) farmers were interviewed in each of the groups. The data for energy input resources in all the selected farms during millet production from land preparation up to transportation to market or house were collected using structural questionnaire and oral interviews. A total of 250 sample data were collected. An application program using Microsoft Excel program was used for analyses.

Energy Consumption:

Evaluation of Energy Use:

Energy consumption for different farm field operations was classified on the basis of source and use as direct and indirect energy. The direct energy are the energy which are released directly from power sources in millet production while the indirect energy are those which are dissipated during various conversion processes like energy consumed indirectly in manufacturing, repair and transport, storage, distribution and related activities (Pimentel, 1992; Singh and Mittal, 1992).

Direct Energy Inputs:

The direct energy inputs during millet production were manual (human) labour, draft animal and Mechanical (fuel) energy.

Evaluation of Manual Energy Input:

$EMm = 0.75\ Ta$, MJ (1) (Norman, 1978)
Where, EMm = Male manual energy input, MJ.
0.75 = Energy input of an average adult male, MJ/h.
Ta = useful time spent by a male worker per unit operation, h.
For a female worker the manual energy input was evaluated as;
$EM_F = 0.68\ Ta$, MJ (2) (Norman, 1978)
Where, EM_F = Female manual energy input, MJ.
0.68 = Energy input of an average adult female, MJ/h.
Ta = useful time spent by a female worker per unit operation, h.

Evaluation of Draft Animal Energy Input (E_{AD}):

Pair of bullocks have power equivalent of 746 W (1.0 hp) (3) (Singh and Mittal, 1992)

Evaluation of Mechanical (Liquid Fuel) Energy:

$EF_{LD} = 47.8D$, MJ (4) (Pimentel, 1992)
Where, EF_{LD} = liquid fuel energy input for diesel, MJ.
47.8 = Unit energy value of diesel, MJ/L
D = Amount of diesel consumed per unit operation, L.
For petrol,
$EF_{LP} = 42.3\ P$, MJ (5) (Pimentel, 1992)
Where, EF_{LP} = Liquid fuel energy input for petrol, MJ.
42.3 = Unit energy value of petrol, MJ/L
P = Amount of petrol consumed per unit operation, L.

Indirect Energy Inputs:

(a) Evaluation of Manufacture, Transport and Repair (MTR) Energy Input:

Indirect mechanical energy was to be estimated by considering the energy expended to manufacture, transport and repair (MTR) from a unit mass of the tractor and harrow used, the estimated wear out lives of the machine and implement (L) the cultivated farm area (A) and the effective field capacity (C_e). The MTR energy was 100.7 MJ/kg (Bridges and Smith, 1979; Bowers, 1992) and the L values used were 12, 000 hr and 2000 hr for the tractor and harrow respectively (Chamsing *et al.,* 2006). The C_e for harrowing was taken as 1.21 ha/h [15]. Thus, indirect mechanical energy, Em, was determined by:

$$Em = MTR \times m \times A/L\ C_e,\ MJ \quad (6)$$

Where,
MTR = energy used to manufacture, transport and repair machinery (tractor or harrow), MJ/kg
m = mass of machinery, kg
A = size of farm, ha
L = life of machinery, h
Ce = effective field capacity of harrowing, ha/h.

(b) Evaluation of Chemical Energy Input:

Chemical fertilizers, manure and pesticides are main sources for chemical energy inputs. The total chemical fertilizer input was calculated using energy equivalent value of 78.1, 17.4 and 13.7 MJ/kg for N, P_2O_5 and K_2O respectively (Mudahar and Hignett, 1987; Mohanty *et al.,* 2008). Energy equivalents of 120 and 10 MJ/kg were used to calculate energy for granular and liquid pesticides respectively (Singh and Mittal, 1992; Singh *et al.,* 1997).

(c) Evaluation of Biological Energy Input:

Mainly seeds and hormone were included as biological energy inputs. Existing data on hormones was used. The energy equivalent value of 14.00 MJ/kg was used for seed (millet) input and an assumed equivalent value higher than energy (seed) input by 1 MJ/kg of crop (millet) production output was also used (Singh and Mittal, 1992; Singh *et al.,* 1997).

Total Energy Inputs:

This was evaluated from equation below,

$T_{EI} = T_{EOP} + T_{EMI}$ (7)

Where,

T_{EI} = Total energy input (MJ/ha)

T_{EOP} = Total energy input during field operations (MJ/ha)

T_{EM} = Total energy input by machinery and implement (MJ/ha)

Total Energy Outputs:

Energy output was considered as main product and by-product.

Total energy output (T_{EO}) (MJ/ha) = (Yield x Eeq) + (By-product x Eeq) (8)

Where, Eeq = Energy equivalent value of main product or by-product.

Energy Use Ratio:

Energy use ratio was evaluated from the equation below,

$E_{UR} = T_{EI} / T_{EO}$ (9)

Where,

E_{UR} = Energy ratio

T_{EI} = Total energy output (MJ/ha)

T_{EO} = Total energy input (MJ/ha)

RESULTS AND DISCUSSION

Energy Input:

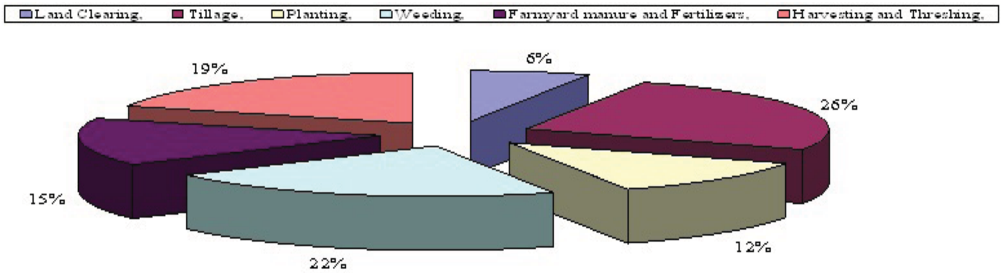
The result obtained from study showed that energy resources used by the farmers in the five groups were manual (human labour), animal draft, manure, chemical fertilizer, farmyard manure, mechanical and seed (millet) as biological. The various field operations considered during this study were land clearing, soil tillage, planting, weeding, farmyard manure/fertilizers and harvesting and threshing. It was also discovered that farmers in group I used manual (human labour) energy in all their field operations, groups II and III farmers used manual energy and animal draft, group IV farmers used manual, animal draft and mechanical energies while manual and mechanical energies were used by farmers in group V. Table 1 showed the values of energy resource input during various field operations for different farmer groups using Equations 1- 6 above. On average the study revealed that all farmer groups studied had the least amount of energy input for land clearing that varied between 4-8% (Figures 1a, b, c, d, and e). Generally the energy needed for this first farm operation was low for all farmer groups because all the farmlands were previously cultivated. There was nothing much to do apart from collecting and burning of dry grasses. Similarly, the field operation that consumed highest intensities of energy used in the farmer groups was soil tillage and weeding that varied between 25-40%. This is because soil tillage was done using excessive energy and weeding was mostly repeated twice in all the farmer groups since herbicides were not used. This was similar to the findings of (Umar, 2003; Nuray, 2009).

Energy Use Pattern:

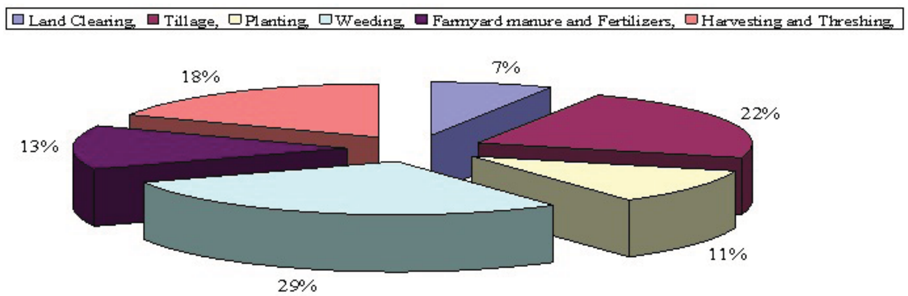
Figure 2 shows the comparative between total energy use and total energy output during millet crop production for different farmers group. It was shown that group V farmers consumed the highest energy values of 6078 MJ/ha in their millet production while farmers in group I expended the least amount of energy value of 1705 MJ/ha using Equations 7 and 8 above. The variation in energy inputs for farm field operations among the farmers group for millet crop production depended on cultivation practices and type of machinery used, especially in land preparation, weeding, harvesting, etc. were considered. Total energy output during millet crop production was the highest found in group I farmers and the least total energy output was found in farmers group II with values of 13100 MJ/ha and 2300 MJ/ha respectively. This is best explained by the principles of agricultural mechanization that is with high energy injection there would be better and high yield.

Energy Ratio:

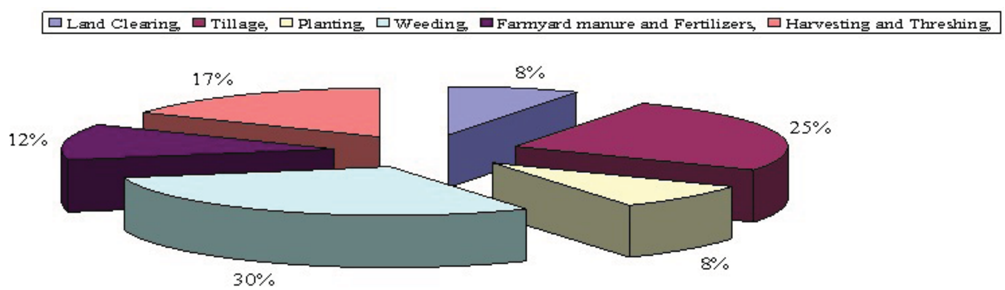
Table 2 shows energy use ratio values for different groups. High energy ratio value was 2.4 found in group III which indicated high efficient level of energy usage. This could be attributed to the fact that group III farmers make use of manual, animal and mechanical energies. The lowest energy use ratio value was 1.3 obtained for group I farmers which indicated low efficient level of energy usage. This could be attributed to the manual energy used by the farmers in this group which was laborious and time consuming, a scenario similar to the findings of (Singh *et al.,* 1997; Ozkan *et al.,* 2004; Alam *et al.,* 2005; Tolga *et al.,* 2009) who conducted similar work for different types of crops in different parts of the world. A linear relationship between total energy input and output in different groups was obtained with values R^2 = 0.88, which indicated that millet crop yield is dependent on energy input.



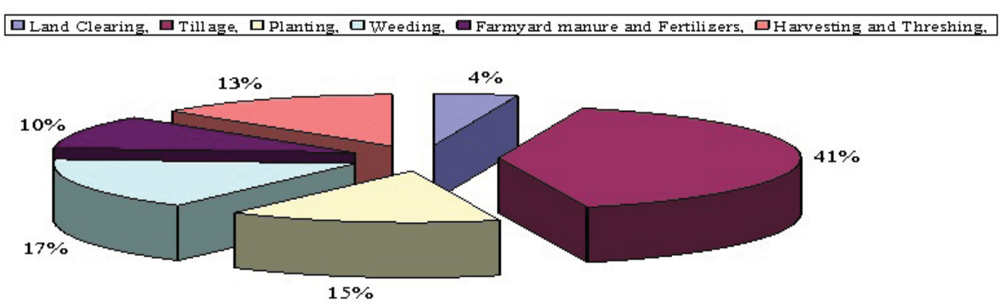
(a) Group I



(b) Group II



(c) Group III



(d) Group IV

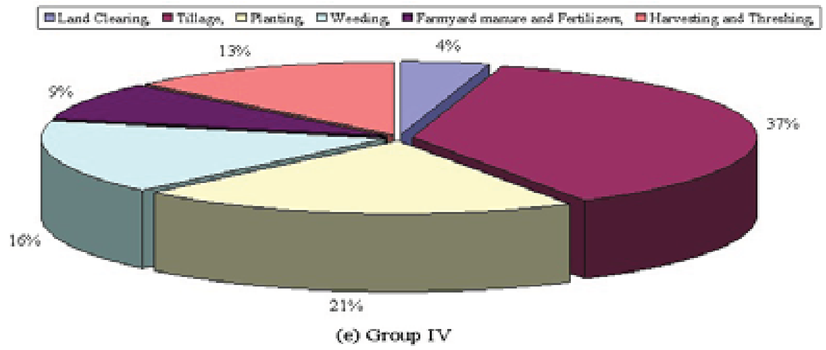


Fig. 1: a,b,c,d and e - Energy resource used for various field operations in different farmer groups

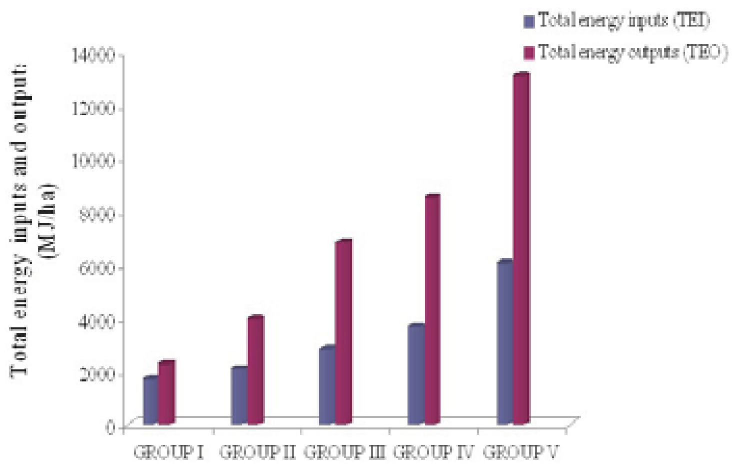


Fig. 2: Total energy input and output against farmer groups

Table 1: Energy resource input during various field operations for different farmer groups

Field Operation	Energy Resource Input (MJ)	Energy Resource Input for Different Farmer Groups (MJ/ha) (Mean values)				
		Group I	Group II	Group III	Group IV	Group V
Land Clearing	EMm	90	120	185	45	60
	EMF	20	32	40	10	25
	EAD	-	-	-	-	-
	EFLD	-	-	-	30	50
	Em	-	-	-	80	120
	Total	110	152	225	165	255
Tillage	EMm	350	35	40	18	15
	EMF	80	15	18	10	08
	EAD	-	420	660	-	-
	EFLD	-	-	-	850	1500
	Em	-	-	-	622	750
	Total	430	470	718	1500	2273
Planting	EMm	145	160	125	90	120
	EMF	60	65	55	22	15
	EAD	-	-	-	-	-
	EFLD	-	-	-	250	350
	Em	-	-	60	180	240
	Total	205	225	240	542	1275
Weeding	EMm	350	480	500	120	180
	EMF	20	-	-	-	-
	EAD	-	120	120	150	240
	EFLD	-	-	-	90	150
	Em	-	-	230	250	415
	Total	370	600	850	610	985

Table 1: Continue

Farmyard manure/Fertilizers	EMm	180	100	120	30	20
	EMF	80	60	80	-	-
	EAD	-	120	140	-	-
	EFLD	-	-	-	110	140
	Em	-	-	-	240	360
	Total	260	280	340	380	520
Harvesting and Threshing	EMm	250	300	420	180	200
	EMF	80	80	50	-	-
	EAD	-	-	-	-	-
	EFLD	-	-	-	85	150
	Em	-	-	-	220	420
	Total	330	380	470	485	770

Table 2: Total Energy Inputs, Energy Outputs and Energy Use Ratios

Energy input/output in all Field Operations	Different Farmer Groups				
	Group I	Group II	Group III	Group IV	Group V
Total Energy Input (TEI) (MJ/ha)	1705	2107	2843	3682	6078
Total Energy Output (TEO) (MJ/ha)	2300	3960	6835	8520	13100
Energy Use Ratio (EUR)	1.3	1.9	2.4	2.3	2.2

Conclusions:

The study on pattern of energy consumption in Millet production for some selected farms in Jigawa state, Nigeria revealed the following:

1. The major energy sources were manual (human labour), animal draft, manure, chemical fertilizer, farmyard manure, mechanical and seed (millet) as biological energies. Soil tillage operation was found to be the highest energy consumed in all farmer groups. It accounted for over 40% total energy inputs. Land clearing operation was found to be the least energy expended in all groups, accounted for less than 10% of the total energy inputs.
2. Energy use ratio values revealed that there was high efficient level of energy use by group III farmers low efficient energy use by group I farmers with values of 2.4 and 1.3 respectively.

It is recommended that similar studies be carried out for some other crops commonly produced in north eastern Jigawa State in order to have more data for comparison.

ACKNOWLEDGEMENTS

The assistance received from Alhaji Ali Mohammed and Mallam Murtala Mohammed is highly appreciated.

REFERENCES

Alam, M.S., M.R. Alam and K.K. Islam, 2005. Energy flow in agriculture: Bangladesh. American Journal of Environmental Sciences, 1(3): 213-220.

Andrews, D.J. and K.A. Kumar, 1992. Pearl millet for food, feed, and forage. Adv. Agron., 48: 89-139.

Bridges, T.C. and E.M. Smith, 1979. A method of determining the total energy input for agricultural practices. Transactions of the ASAE, 781-784.

Bowers, W., 1992. Agricultural field equipment. In Energy in farm production. Fluck, R.C. (editor). Elsevier Science Publishers B.V., Amterdam, Netherlands, pp: 117-129.

Chamsing, A., V. Salokhe and G. Singh, 2006. Energy Consumption Analysis for Selected Crops in Different Regions of Thailand. Agricultural Engineering International: the CIGR Ejournal. Manuscript EE 00 013, Vol. III. November, 2006.

De Cock, L. and D. Van Lierde, 1999. Monitoring Energy Consumption in Belgian Glasshouse Horticulture. Agricultural Engineering International: The CIGR Journal of Scientific Research and Development, I. November, 1999.

Faidley, L.W., 1992. Energy and agriculture. In: R.C. Fluck (Ed), Energy in Farm Production, Elsevier, Amsterdam, pp: 1-12.

FAO., 1996. Production Yearbook. Statistics Series No. 142, Food and Agriculture Organisation, Rome, pp: 104.

Fluck, R.C., 1985. Energy sequestered in repairs and maintenance of agricultural machinery. Transactions of the ASAE, 738-744.

Hadejia, 2006. Hadejia Encyclopaedia Britannaica

http://www.britannica.com/EBcheched/topic/251075/Hadejia

Haque, M.A. and B. Umar, 1997. Field efficiency of disc harrows in Borno State, Nigeria. Quarterly Journal of International Agriculture, 36(4): 379-386.

Jekayinfa, S., 2006. Energy Consumption Pattern of Selected Mechanized Farms in Southwestern Nigeria. Agricultural Engineering International: the CIGR Ejournal. Manuscript EE 06 001, Vol. III. April, 2006.

Mohanty, S.K., B.K. Behera and G.C. Satapathy, 2008. Ergonomics of Farm Women in Manual Paddy Threshing. Agricultural Engineering International: the CIGR Ejournal. Manuscript MES 08 002, Vol. X. June, 2008.

Mudahar, M.S. and T. P. Hignett, 1987. Energy requirements, technology and resources in fertilizer sector. Energy In Helsel, Z. R (Ed.) Plant Nutrition and Pest Control: Energy in World Agriculture, Vol. 2, Elsevier, Amsterdam, pp: 25-61.

Norman, M.J.T., 1978. Energy Inputs and Outputs of Subsistence Cropping Systems in the Tropics, Agro-Ecosystems, 4: 355-366.

Nuray K., 2009. Energy use and input-output energy analysis for apple production in Turkey.Journal of Food, Agriculture and Environment 7(2): 419-423.

Pimentel, D., 1992. Energy Inputs in Production Agriculture. Energy in Farm Production, Elsevier, and Amsterdam. pp; 13-29.

Singh, S. and J.P. Mittal, 1992. Energy in production agriculture. Mittal Publications, New Delhi, India.

Singh, S., S.R. Verma and J.P. Mittal, 1997. Energy requirements for production of major crops in India. Agricultural mechanization in Asia, Africa and Latin America, 28(4): 13-17.

Stout, B.A., 1990. Handbook of Energy for World Agriculture. Elsevier Applied Science, London.

Ozkan, B., H. Akcaoz, and C. Fert, 2004. Energy input-output analysis in Turkish agriculture. Renewable energy, 29: 39-51.

Tolga T., Ç. Bahattin and A. Vardar, 2009. An analysis of energy use and input costs for wheat production in Turkey. Journal of Food, Agriculture and Environment., 7(2): 352-356.

Umar, B., 2003. Comparison of Manual and Manual-cum-Mechanical Energy Uses in Groundnut Production in a Semi-arid Environment. Agricultural Engineering International: The CIGR Journal of Scientific Research and Development, pp: (5).