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Energy auditing of pearl millet production system in dry land region of Haryana Agrcultural University in Hisar, India

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■ **ABSTRACT :** Pearl millet, also known as *Bajra* is one of the major *Kharif* food crops of arid and semi-arid cropping region of India. It ranks first under the category of millet in India in terms of area, production and productivity. An on-the-farm evaluation of energy inputs and output was calculated to determine the distribution of main energy sources (*i.e.* human, fuel, machinery, seed and fertilizer) used in pearl millet cultivation. This study was carried out at dryland farm area, C.C.S. Haryana Agricultural University, Hisar, Haryana, India. The results indicated that the total input and output energy use was 4785.52 MJ ha^{-1} and 29400.00 MJ ha^{-1}, respectively. With 56 per cent, the fertilizer had the highest contribution in the energy input followed by diesel fuel (29%) and human (12%). The input-output ratio was observed to be 6.12. The share of indirect energy was found to be higher as compared to direct energy sources.

■ **KEY WORDS :** Energy input-output, Energy ratio, Pearl millet, Yield

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Energy is one of the major inputs for the economic development of any country (Deshmukh and Patil, 2013). Nothing could be completed in our life without the use of energy. Energy has a highly influential role to play in the development of key factors of economic importance like industry and transport. Energy is also one of the most precious inputs in agriculture production and agro-processing for value addition since the age of subsistence agriculture. It is an established fact worldwide that agricultural production is positively correlated with energy input. The energy requirement in various facets of agriculture varies considerably due to variation in the technology level adopted by the farmers and also because of the diverse agro-climatic conditions. Energy consumption in agriculture is done in various forms such as mechanical (human, animal power), chemicals (fertilizer, pesticide, herbicide, etc) and electrical energy. The quantity of energy consumed in agriculture production, processing and distribution should be sufficient enough to fulfill the energy requirements of expanding population and to achieve the other social and economic objectives. Sufficient availability of right energy and its effective use are prerequisites for improved agricultural production. It has been clearly depicted in the past by various studies that crop yield and food supplies are directly linked to energy inputs. In the developed countries, increase in the crop yields was mainly due to the increase in commercial energy inputs in addition to improved crop varieties (Faidley, 1992). Agriculture is a producer as well as consumer of energy.

Estimated of total food grain production of *Kharif* season 2017-18 was 134.67 million tones and course cereals production 31.49 million tones. Pearl millet is one of the major *Kharif* food crop of arid and semi-arid cropping region of India. It ranks first under the category of millet in India in terms of area, production and productivity. India is the largest producer of pearl millet in the world occupying an area of 7.13 million ha, production of 8.07 MT per year with average productivity of 1132 kg/ha during 2015-16. In India, pearl millet occupies around 7.4 per cent of the total food grain area and contributes to nearly 3.4 per cent of the total food grain production of the country. In Haryana, during 2016-17, pearl millet was grown in an area of 0.48 million ha with production and average productivity of 0.98 MT per year and 2017 kg/ha, respectively (Anonymous, 2017). Pearl millet is the fourth most important cereal crop of Haryana after wheat, rice and barley. So there is an urgent need to assess the energy utilized in production and processing of pearl millet. It is sown in the first fortnight of July and harvested in the month of September. Though pearl millet is grown mainly for human consumption, it also uses as fodder for cattle and raw material for cattle feed industries.

The purpose of the present study was to carry out an analysis of energy utilized during various operations, in different sources for pearl millet cultivation and suggest suitable measures for energy conservation and management. It is also essential to conduct such energy related studies in farming sector to provide crucial information to formulate suitable policies on energy management.

■ METHODOLOGY

A field experiment was carried out at dryland farm area, CCS Haryana Agricultural University (HAU), Hisar, Haryana, India during rainy (*Kharif*) season of 2016-17. The crop was grown with standard package of practices given by CCSHAU, Hisar and details of various field operations carried out during pre and post-sowing of pearl millet in the experiment field. Questionnaire was prepared for collecting data in a face to face interview schedule from farmers regarding different operations and quantity of each input (*i.e.* machinery, fuel, fertilizer, chemicals, irrigation water, labour, etc). Energy used was calculated in the production of pearl millet by using energy analysis technique. Various unit operations performed during pearl millet production was observed at HAU farm such as preparatory tillage, seed treatment prior to sowing, sowing, fertilizer application, interculture/hoeing/weeding, plant protection, harvesting, threshing/winnowing and transportation. The data collection

Table A: Energy equivalents of various sources (Chaudhary *et al.*, 2006 and Karimi *et al.*, 2008)

Energy source	Units	Energy equivalent(MJ/ha)
Human labour		
Man	1h	1.96
Woman	1h	1.75
Child	1h	0.98
Animal		
Bullock	pair hour	14.07 (body weight above 450)
		10.10 (body weight 350- 450)
Fuel		
Diesel	1L	56.31
Farm yard manure	1kg	0.3
Fertilizer		
Nitrogen	1kg	60.6
Phosphorus	1kg	11.1
Potash	1kg	6.70
Chemical application		
Superior	1kg	120
Inferior	1kg	10.0
Seed	1kg	14.7

Table B: Energy equivalents of farm equipments (Mittal *et al.*, 1988)

Energy source	Equipment	Energy co-efficient
Manual	Sickle	0.031
	Sprayer	0.502
	Hand hoe	0.314
	Bund former	0.502
Animal	Plough	0.627
	Cultivator	1.881
Tractor	M B plough	2.508
	Harrow	7.336
	Rotavator	3.762
	Seed- drill	8.653
	Cultivator	3.135
	Leveler	4.703
Others	Thresher	7.524
	Centrifugal pump	0.502
	Electric motor	0.216
	Tractor	10.944

Table C: Different energy measures (Mani and Patel, 2017)

Energy indices	Formulae
Energy use efficiency or energy ratio	Energy output (MJ/ha)/ Energy input (MJ/ha)
Energy productivity	Grain yield (kg/ha)/ Total energy input (MJ/ha)
Net energy gain	Energy output (MJ/ha) - Energy input (MJ/ha)
Specific energy	Energy input (MJ/ha)/Pearl millet yield (kg/ha)

involved the various operational energy input and output in production system. The data regarding input sources for one hectare pearl millet cultivation were analysed. In order to know the approximate energy input from each sources, number of units of energy sources used were multiplied by respective energy equivalents. The energy equivalents for different sources and farm equipments are shown in the Table A and B. The different energy input sources are divided into direct and indirect forms. The direct energy sources *viz.*, diesel, human, bullocks. Similarly fertilizer, seeds and farm machinery (tractor, mould board plough, cultivator, blade harrow, indigenous plough and threshers) are the indirect energy sources. To analyze the different energy measures, energy parameters such as energy use efficiency, energy productivity, net energy gain and specific energy were calculated using formulae which are shown in Table C. (Avval Mousavi *et al*., 2011; Naveenkumar, 2011 and Chaudhary *et al.*, 2006).

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Source-wise energy use pattern:

The different forms of energy used for pearl millet production are indicated in the Fig. 1. It was observed that among all the sources, fertilizer was the major energy

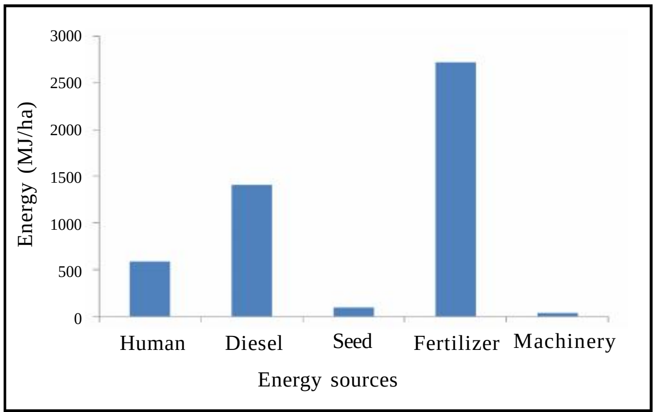

Fig. 1 : Source wise energy use pattern at HAU farm

consuming source followed by diesel, human, seed and machine energy. The direct energy sources utilized for pearl millet production in terms of the diesel and human energy was 1407.75MJha^{-1} and (857.71MJha^{-1}) while in case of indirect energy sources fertilizer used the highest energy (2714.13MJ/ha^{-1}) followed by seed and farm machinery. The contribution of seed and machinery was 4 per cent and 3 per cent, respectively. These results are in accordance with Chilur and Yadachi, 2017 and Vural and Efecan, 2012, hence, justified.

Operation-wise energy use pattern for pearl millet production:

The average operation-wise energy utilized by the farmers for pearl millet production in the dryland farm. The different operations *viz.*, preparatory tillage, sowing, fertilizer application, interculture, harvesting and threshing were performed on farm for pearl millet production are indicated in Table 1. Pearl millet at HAU farm was grown totally under rainfed conditions. Therefore, no energy was spent on irrigation. The major energy consuming operations for pearl millet production were fertilizer application (2733.73 MJ/ha), preparatory tillage (774.26MJha^{-1}), sowing (429.58MJha^{-1}), threshing (307.49MJha^{-1}), harvesting (305.02MJha^{-1}) and interculture (235.44MJha^{-1}). The share of fertilizer application were 57 per cent of total operation-wise energy consumed for pearl millet production followed by preparatory tillage (16%), sowing (9%) and threshing (7%). Harvesting and intercultural operations consumed around 6 per cent and 5 per cent of total operational energy, respectively. These findings are similar to the ones reported by Yadav and Khandelwal (2013).

Table 1: Operation wise energy use pattern for pearl millet production

Operations	Energy utilized (MJHa^{-1})
Tillage	774.26
Sowing	429.58
Interculture	235.44
Fertilizer application	2733.73
harvesting	305.02
Threshing	307.49
Total energy	4785.52

The details of different energy forms and output structure are indicated in the Table 2. The share of direct and indirect energy in total energy utilized for pearl millet production was 42 per cent and 58 per cent, respectively. The highest energy ratio of 6.14 was obtained, which indicated efficient level of energy usage. The findings are similar with the results of Sidhpuria *et al*. (2014) who conducted work on resource conservation practices in rainfed pearl millet. The 410 g of maize grains were grown per unit of MJ of energy input. The specific energy requirement was 2.39 MJ per kg. The net energy gain from the main product was 24614.48 MJ per hectare. Similarly Mittal and Dhawan (1992) also worked on the related topic and the results found were more or less similar to the present investigation

Table 2: Variation of indicators of energy usage efficiency for pearl millet production

Energy measures	Energy
Total input energy (MJ/ha)	4785.52
Energy output (MJ/ha)	29400.00
Net energy gain (MJ/ha)	24614.48
Energy ratio	6.14
Specific energy (MJ/kg)	2.39
Energy productivity (kg/MJ)	0.41
Yield (q/ha)	20.00

Conclusion:

In conclusion the average energy consumed per hectare for the pearl millet production in dryland farm was about 4785.52 MJ per hectare. Fertilizer application was found to be 2733.73 MJ/ha which was the major energy consuming operation followed by preparatory tillage, sowing, threshing, intercultural and harvesting. The share of fertilizer application was 57 per cent of total operation-wise energy consumed for pearl millet production. The contribution of direct and indirect energy in total energy utilization for pearl millet production was 1993.46 MJha^{-1} (42%) and 2802.06 MJha^{-1} (58%), respectively. The highest energy ratio was obtained 6.14, which indicated efficient level of energy usage. With 71 per cent, of diesel fuel had the highest share in the direct energy sources for pearl millet production.

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■ REFERENCES

Anonymous (2017). *Agricultural statistics division directorate of economics & statistics.* Department of Agriculture, Cooperation and Farmers Welfare First Advance Estimates of Production of Foodgrains for 2017-18.

Avval Mousavi, S.H., Rafiee, S., Jafari, A. and Mohammadi (2011). Energy storage in field operations of maize production using data envelopment analysis approach. *Internat. J. Energy & Environ.*, **2** (5) : 933-944.

Chaudhary, V.P., Gangwar, B. and Pandey, D.K. (2006). Auditing of energy use and output of different cropping systems in India. *Agricultural Engineering International:* The CIGR e-journal, ManuscriptbEE05 001,8.

Chilur, Rudragouda and Yadachi, Shiddanagouda (2017). Energy audit of maize production system of selected villages of North Karnataka, India. *Internat. J. Curr. Microbiol. & Appl. Sci.*, **6** (8) : 3564-3571.

Deshmukh, S.C. and Patil, V.A. (2013). Energy conservation and audit. *Internat. J. Scient.& Res. Public.*, **3**(8) : 2250-3153.

Faidly, L.W. (1992). Energy and agriculture. In: Fluck RC, editor. *Energy in farm production*. Amsterdam: Elsevier; p. 1e12.

Karimi, M., Rajabi, P.A., Tabatabaeefar, A. and Borghei, A. (2008). Energy analysis of sugarcane production in plant farms: a case study in Debel Khazai Agroindustry in Iran. *American-Eurasian J. Agric. & Environ. Sci.*, **4**(2):165-171.

Mani, I. and Patel, S.K. (2017). Energy consumption pattern in production of paddy crop in Haryana state in India. *Agricultural Mechanization in Asia, Africa & Latin America*, **43** (2) : 39-42.

Mittal, J.P. and Dhawan, C.K. (1992). Research manual, All India co-ordinated research project on energy requirement in agricultural sector, college of Agricultural Engineering, Panjab Agricultural University, Ludhiana (Punjab) India.

Naveen Kumar, D.B. (2011). Modification and evaluation of power operated maize (Zea *mays* L.) sheller. M. Tech. (Ag. Engg.) Thesis, University of Agricultural Sciences, Bengaluru (Karnataka) India.

Sidhpuria, M.S., Sangwan, P.S., Jhorar, B.S., Mittal, S.B., Sharma, S.K. and Kumar, A. (2014). Resource conservation practices in rainfed rearl millet-energy input-output analysis. *Indian J. Dryland Agric. Res. & Develop.*, **29**(2) : 83-86.

Vural, Hasan and Efecan, Ibrahim (2012). An analysis of energy use and input costs for maize production in Turkey. *J. Food Agric. & Environ.*, **10** (2) : 613-616.

Yadav, R.S. and Khandelwal, N.K. (2013). Effect of various energy inputs on energy requirement for wheat production in agro-climatic region (Kamore plateau and Satpura Hill), M.P. India. *Internat. J. Engg. Res. & Applic.*, **3**(3): 531-536.