RESEARCH PAPER | International Journal of Agricultural Engineering | Volume 10 | Issue 1 | April, 2017 | 146-151

e ISSN–0976–7223 ■ Visit us : *www.researchjournal.co.in* ■ **DOI: 10.15740/HAS/IJAE/10.1/146-151**

Energy requirement for *Kharif* maize cultivation in Panchmahal district of Gujarat

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Received : 08.02.2017; **Revised :** 17.03.2017; **Accepted :** 25.03.2017

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■ **ABSTRACT :** A study was carried out to collect farm operations data of *Kharif* maize cultivation in district Panchmahal of Gujarat and to estimate and analyze the total input energy requirement in *Kharif* maize crop, both source wise and operation wise along with total output energy. To accomplish this, a survey was conducted through structured questionnaire to 93 randomly selected farmers in four rainfed villages of three talukas Kalol, Godhra and Khanpur of the district. The raw data obtained was analyzed after converting data into energy equivalents. It was concluded that total input energy requirement for *Kharif* maize cultivation in Panchmahal district was 13205.10 MJ/ha. Out of which direct energy contributed 45.44 per cent and indirect energy contributed 54.56 per cent. Fuel energy was maximum utilizing direct energy source while fertilizer energy was maximum required indirect energy source. Seed bed preparation consumed maximum operation wise direct energy with a value of 2887.78 MJ/ha. Fertilizer application was maximum indirect energy consuming operation with energy consumption of 3702.59 MJ/ha. Total output energy for *Kharif* maize cultivation was 52873.29 MJ/ha with net energy return of 39668.19 MJ/ha and energy productivity of 0.21 kg/MJ.

■ **KEY WORDS :** Energy, *Kharif*, Maize, Specific energy

■ **HOW TO CITE THIS PAPER :** Patel, P.G., Dineshkumar, Rangapara and Bhut, A.C. (2017). Energy requirement for *Kharif* maize cultivation in Panchmahal district of Gujarat. *Internat. J. Agric. Engg.*, **10**(1) : 146-151, **DOI: 10.15740/HAS/IJAE/10.1/146-151.**

Energy is one of the most valuable inputs in crop production. Energy needed for agricultural production is about 3 per cent of the national energy consumption in developed countries and about 5 to 6 per cent in developing countries (Stout, 1989). Sufficient availability of the exact energy and its effective and efficient use are prerequisites for improved agricultural production and profitability. All the farming operations in crop production require energy inputs in various forms and in varying magnitude. Input energy in agriculture is divided into two categories as direct and indirect. Direct energy is required to perform various tasks related to crop production processes such as land preparation, irrigation, intercultural, threshing, harvesting and transportation of agricultural inputs for farm produce (Singh, 2000). Efficient use of energies helps to achieve increased production and productivity and contributes to the economy, profitability and competitiveness of agriculture sustainability (Ozkan *et al.*, 2004 and Singh *et al.*, 2002).

Although energy consumption is increasing with time, the energy use efficiency is declining constantly. Energy analysis, therefore, is necessary for efficient management of scarce resources for improved agricultural production. It would identify production practices that are economical and effective. Other benefits of energy analysis are to determine the energy invested in every step of the production process (hence identifying the steps that require least energy inputs), to provide a basis for conservation and to aid in making sound management and policy decisions (Debendra and Bora, 2008).

Thus, it is our need to carry out energy analysis of crop production system and to establish optimum energy input at different levels of productivity prevailing in the area. In this regard, a research was aimed to assess the energy analysis of major crop of the area *i.e. Kharif* maize production along with economic analysis with an objective to estimate and analyze the total input energy requirement (direct and indirect energy) in *Kharif* maize crop, both source wise and operation wise along with total output energy.

■ METHODOLOGY

The study was conducted to investigate the energy and economic analysis of *Kharif* maize crop grown in the Panchmahal district. The information was collected from farmers of four villages (Jakharipura, Kandach, Kankanpur and Ganagata) located in three talukas of the Panchmahal district. To conduct the research, district Panchmahal was selected as study area which is one of the highest producer districts of maize in Gujarat. The district is located in semi arid region with latitude of N 22°30' to 23°23' and longitude of E 73°15' to 74°75' and at 119 m above mean sea level.

The simple random sampling method was used to determine survey volume (Nabavi-Pelesaraei *et al.*, 2013).

$$n = \frac{N (s \times t)^2}{(N - 1)d^2 + (s \times t)^2}$$

In the formula, the below signs and letters represent: n is the required sample size, s is the standard deviation, t is the t value at 95 per cent confidence limit (1.96), N is the number of holding in target population and d is the acceptable error (permissible error 5%). Farmers were randomly selected and contacted with the help of Gram-Pradhan. After collecting preliminary information's related to their inventory, irrigation sources and type of farming system. It was tried that maximum farmers are contacted to have required information in present Performa. The farmers were classified as marginal, small, medium-sized and large farmers on the basis of their land holding as:

– Marginal farmers (< 1.0 ha)
– Small farmers (1.0-2.0 ha)
– Medium farmers (2.0-4.0 ha)
– Large farmers (> 4.0 ha)

In the present study, the survey work was carried out to randomly select 93 farmers in the 4 villages to know the present status of consumption of various inputs by the farmers in *Kharif* maize production along with the fodder and grain yield. To do this a structured questionnaire was prepared and compiled into a survey performa covering all the needful information required for the energy analysis of maize crop production. The surveyed area is considered under rainfed condition. Since, the data obtained from survey was primary data; it was difficult to obtain required information regarding energy involved in crop production directly from that data.

The working hours of the labour were determined in each operation and pooled to get total human energy. The mechanical energy used on the selected farms included tractor and diesel engines. The mechanical energy was computed on the basis of total fuel consumption (lit./ha) in different operation. The energy consumed was calculated using conversion factors (1 lit. diesel = 56.31 MJ) and the same was expressed in MJ/ha. The electrical energy in the study area was used mostly by motors to run the irrigation pump set for water lifting. The consumption pattern of electrical energy was computed using suitable conversion factor and was expressed in MJ/ha. The fertilizer and chemicals were applied in varying quantity depending upon buying capacity of farmers and their preferences. The quantities of different fertilizer and chemicals used on each farms were pooled and total energy for fertilizer and chemical energy were converted into MJ/ha. The data on energy use have been taken from a number of sources, as indicated in Table A. Energy is primarily used in agricultural operations for tillage, transportation, irrigation, fertilizer application, spraying, harvesting.Total output energy produced by *Kharif* maize production was calculated by adding the energy equivalents to fodder as well as maize grains which were obtained by multiplying their Quantity per unit area to energy equivalent factors (Table A).

Thus, all the data related to various operations was

Table A : Energy equivalents of different parameters

Parameter	Unit	Energy equivalents (MJ)	References
Human labour	hr	1.96	Ozkan *et al.* (2004) and Yilmaz *et al.* (2005)
Animal (bullock)	Pair-hr	8.07	Lal *et al.* (2003)
Machinery	hr	62.7	Erdal *et al.* (2007) and Esengun *et al.* (2007)
Diesel	l	56.31	Kizilaslan(2009); Singh and Mittal (1992) and Erdal *et al.* (2007)
Farm yard manure	kg	0.3	Kizilaslan (2009) and Demircan *et al.* (2006)
Nitrogen	kg	60.6	Mandal *et al.* (2002); De *et al.* (2001); Mani *et al.* (2007) and Shrestha (1998)
Phosphate	kg	11.1	Mandal *et al.* (2002); De *et al.* (2001); Mani *et al.* (2007) and Shrestha (1998)
Small equipment	kg	6 – 8	Kitani (1999)
Fodder	100 kg	293	Lal *et al.* (2003)
Seed	kg	14.7	Ozkan *et al.* (2004) and Mandal *et al.* (2002)

converted into energy requirement on unit area basis for both operation wise and source wise. Energy from inputs and outputs were calculated by converting the physical units of inputs and outputs into respective energy units by using appropriate energy equivalents to find out the energy use pattern.

The following different energy efficiency parameters were determined to evaluate relationship between energy consumption and total output and production per hectare. Energy ratio, specific energy, energy productivity, energy intensiveness and net energy yield were calculated using the following formula:

Total output energy
= Energy from Maize grains + Energy from fodder (1)

Energy efficiency parameters :

There are different energy efficiency parameters described in equation 2 to 5 below:

$$\textbf{Energy ratio} = \frac{\textbf{Energy output}\left(\frac{\textbf{MJ}}{\textbf{Ha}}\right)}{\textbf{Energy input}\left(\frac{\textbf{MJ}}{\textbf{Ha}}\right)} \quad (2)$$

$$\textbf{Specific energy} = \frac{\textbf{Energy input}\left(\frac{\textbf{MJ}}{\textbf{Ha}}\right)}{\textbf{Output}\left(\frac{\textbf{kg}}{\textbf{Ha}}\right)} \quad (3)$$

$$\textbf{Energy productivity} = \frac{\textbf{Output}\left(\frac{\textbf{kg}}{\textbf{Ha}}\right)}{\textbf{Energy input}\left(\frac{\textbf{MJ}}{\textbf{Ha}}\right)} \quad (4)$$

Net energy yield = Energy output (MJ/Ha) – Energy (MJ/Ha) (5)

RESULTS AND DISCUSSION

Primary data regarding various field operations of *Kharif* maize crop cultivation was collected through survey work in 4 villages. The data were examined and converted into energy equivalents and further analyzed to know the direct and indirect energy, total input energy for both source wise and operation wise along with total output energy.

Input-output energy trends in different villages:

The data collected from the villages was analyzed and it was found out that maximum requirement for energy was in village Gangata was 14469.67 MJ/ha and least in village Kankanpur was 11339.50 MJ/ha.

Fig. 1 shows the direct, indirect, total input and output energy in *Kharif* maize production in different villages. The requirement of direct energy was maximum in Jakhripura village with value of 6949.38 MJ/ha whereas the maximum indirect energy requirement was in Gangta village with value of 8825.80 MJ/ha. Village Jakhripura produced highest value of energy output from

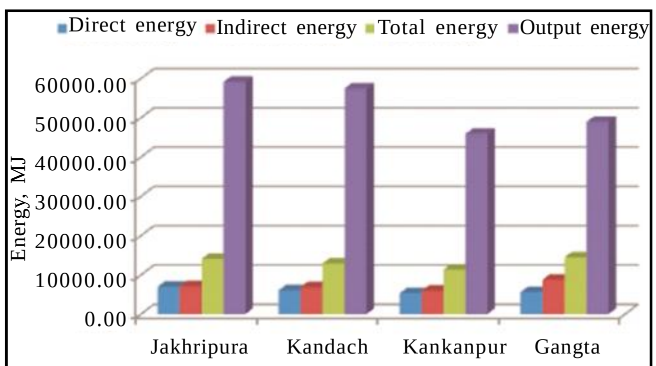

Fig. 1 : Input and output energy pattern in different villages

Kharif maize while Kankanpur village produced lowest.

Operation wise average input energy :

To assess the energy scenario of the area, average of energy input and outputs of all the villages were taken. The maize crop cultivation was divided into different operations and operation wise energy was calculated. The Energy involved in each operation was further divided into direct energy and indirect energy. Seed bed preparation consumed maximum operation wise direct energy followed by threshing with a value of 2887.78 MJ/ha and 1353.22 MJ/ha, respectively. In case of indirect energy, fertilizer application was maximum energy consuming operation with energy consumption of 3702.59MJ/ha. FYM application came next With 1945.64 MJ/ha indirect energy as shown in Fig. 2.

Source wise average input energy :

Among different direct sources, fuel energy was used maximum with the value of 4240.81 MJ/ha (Table 1), whereas in case of indirect energy sources, fertilizer energy was consumed maximum with the average value of 3702.59 MJ/ha (Fig. 3).

Total input energy :

The average value of total input energy was 13205.10MJ/ha. Out of which direct energy contributed 45.44 per cent and indirect energy contributed 54.56 per cent. Total direct energy was 6000.81 MJ/ha while total indirect energy was 7204.29 MJ/ha. Total energy

Table 1 : Details of source wise usage

Sources	Unit	Usage per ha	Total energy (MJ)	Percentage of total energy (%)
Human	hr	795.41	1559.0	11.81
Fuel	l	75.31	4240.8	32.12
Animal	hr	24.91	201.0	1.52
Seed	kg	23.28	342.2	2.59
FYM	kg	6485.47	1945.7	14.73
Nitrogen	kg	55.02	3334.2	25.25
Phosphate	kg	33.18	368.3	2.79
Machinery	hr	18.64	1168.7	8.85
Small/stationary implement (seed drill, sickle)	hr	537.5	45.1	0.34
Total			13205.1	100.00

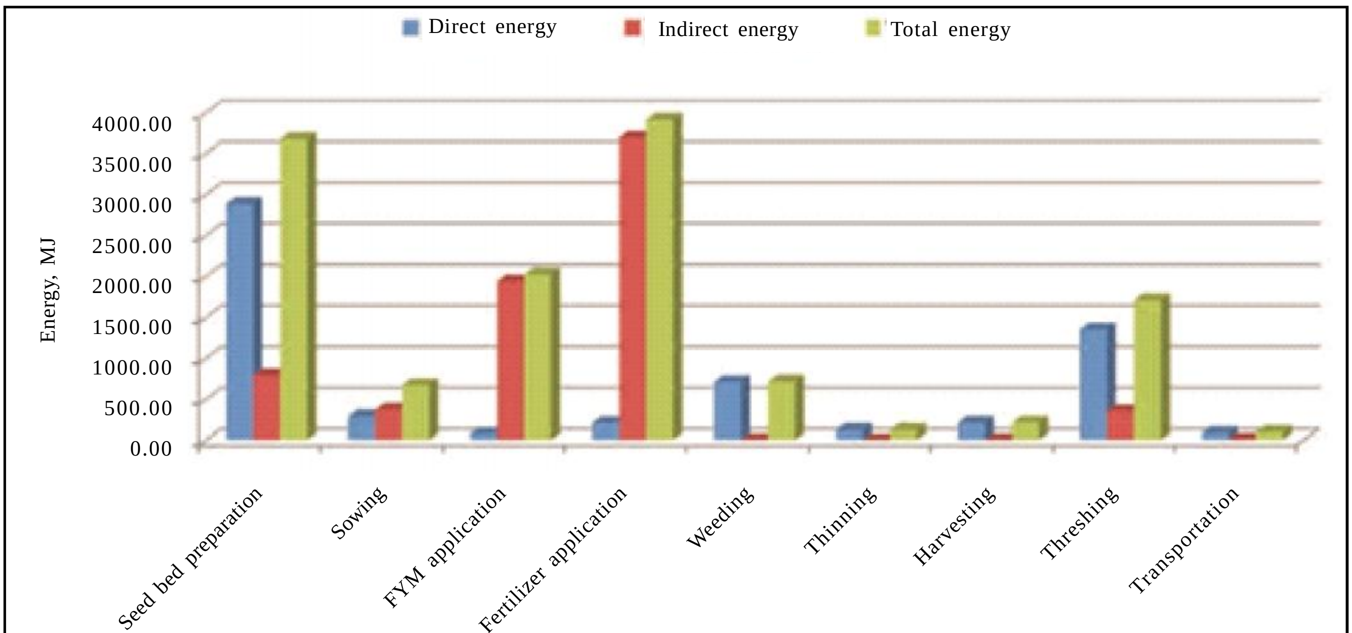

Fig. 2 : Operation wise direct and indirect input energy

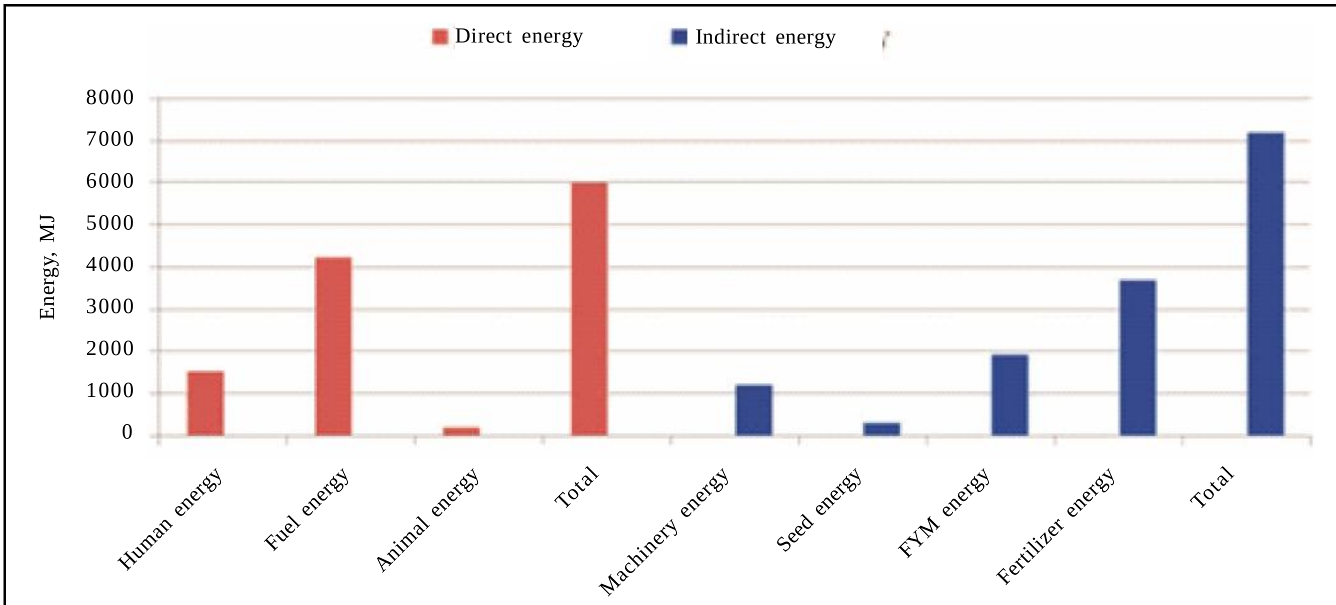

Fig. 3 : Source wise direct and indirect input energy

requirement was maximum in fertilizer application with a value of 3917.42 MJ/ha. It was followed by seed bed preparation 3684.72 MJ/ha.

Total output energy :

The average value of maize grain production in all the villages was 27.90 q/ha and fodder was 40.47 q/ha. Total output energy for *Kharif* maize cultivation was 52873.29 MJ/ha. Out of which main produce *i.e.* maize contributed 41016.72 MJ/ha and rest by the fodder.

Energy efficiency parameters :

Different energy efficiency parameters were calculated to know the usefulness of *Kharif* maize production in the region and to find out the relationship between input and output parameters. The values of different parameters are given in Tab1e 2.

Table 2 : Different energy efficiency parameter

Parameter	Value
Energy ratio	4.01
Specific energy	4.73 MJ/kg
Energy productivity	0.21 kg/MJ
Net energy return	39668.19 MJ/ha

Conclulsion :

Seed bed preparation and fertilizer application were maximum direct and indirect energy consuming operations, respectively. Among different energy sources fuel energy and fertilizer energy were maximum utilized direct and indirect energy sources, respectively.

Total energy requirement was maximum in fertilizer application and followed by seed bed preparation. The average value of total input energy requirement for *Kharif* maize was 13205.10 MJ/ha. Out of which direct energy contributed 45.44 per cent and indirect energy contributed 54.56 per cent.

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