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Energy Use Patterns of Pearl Millet (*Pennisetumglaucum* (L.)) Production in Haryana, India

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Abstract: Pearl millet (*Pennisetumglaucum* (L.)) is the fifth most important cereal crop in the world after rice, wheat, maize and sorghum. A resolution adopted by the UN General Assembly on 3 March 2021 decided to declare 2023 as the International Year of Millets. Millet has been promoted due to its nutritional value and low irrigation requirement. In this study, pearl millet was selected for energy auditing, and its production amount is a direct function of energy input. The production of pearl millet needs to be augmented to fulfill an increasing demand. Pearl millet is produced using various sources of energy. This study was conducted to examine the energy use pattern of different categories of farmers, such as small, medium and large, for pearl millet production in Hisar district, Haryana, India. The energy was distributed in different operations, including preparatory tillage, sowing, interculture, fertilizer, irrigation, pesticide, harvesting, threshing and transportation. The source-wise energy (direct and indirect) and operation-wise energy consumption were calculated for all categories of farmers. The average energy input of small, medium and large farmers was 2849.09 MJ.ha^{-1}, 3027.21 MJ.ha^{-1} and 4021.50 MJ.ha^{-1}, respectively. The highest energy was consumed in fertilizer application (52%), with the lowest in seed (2%). The energy ratios of small, medium and large farmers were 3.92, 9.40 and 13.80, respectively. This study could improve the agricultural production systems of pearl millet regarding the energy values of the inputs and outputs.

Keywords: energy use pattern; energy ratio; specific energy; energy productivity; pearl millet

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1. Introduction

Since the age of subsistence agriculture, one of the most precious inputs in the agricultural system has been energy. It is a fact that globally, the production of crops is positively interlinked with energy input [1]. The need for energy in different aspects of agriculture is different owing to variations in the level of technology adopted by farmers and various agro–climatic conditions. In developed countries, the enhancement of crop yields was predominantly due to improved crop varieties and increased commercial energy inputs [2]. Energy is consumed as well as produced in the agriculture sector. It uses massive amounts of locally offered non-commercial energy (seed, manure and animate energy), commercial energy and direct and indirect energy (electricity, diesel, fertilizer, plant protection, chemical, irrigation water and machinery, etc.) [3]. The efficient use of this energy aids in realizing enhanced production and productivity, which shares the benefits and competitiveness of agriculture sustainability in rural living [4]. Energy use in agriculture is increasing in response to the growing global population, restricted supply of cultivable land and the will for higher living standards [5].

Today, the world has reached a peak where energy is becoming the main cost factor in almost all processes in daily life [1]. Apart from this, energy and profit in many organizations are closely related to the fact that energy audits and finance are fully interlinked. Most organizations are vulnerable to tracking energy monitoring and thus consume more energy than the energy required for the ideal work [6].

Pearl millet, also known as Bajra, is one of the main kharif crops in the arid and semi-arid farming regions of India [3]. It is the first in the millet category in India in terms of production, productivity and area. in the states of Rajasthan, Uttar Pradesh, Maharashtra, Haryana and Gujarat, pearl millet accounts for more than 90% of the total area and contributes to similar production levels [7]. According to FAO, millet production in the world is 89.17 million metric tons from an area of 74 million hectares [7]. India is the largest producer of pearl millet in the world, which has an area of 12.53 million hectares and produces 15.53 metric tons per year, with an average productivity of 1237 kg/ha throughout 2021–2022 [8]. In India, pearl millet comprises around 7.4% of the area, while in the case of production, it comprises nearly 3.4% of the total food grain of the country [9]. Pearl millet is examined as a "poor man's" crop, and it is rich in carbohydrates, protein, fat, fiber and mineral content [6]. In Haryana, during 2016–2017, 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 [10]. The states that grow pearl millet in India are Rajasthan, Uttar Pradesh, Maharashtra, Haryana and Gujrat [6]. As an important food crop of Haryana (India), there is an urgent need to assess the energy utilized in producing pearl millet. It also works as a raw material for cattle feed and cattle fodder [6].

The efficient use of available natural resources, proper energy management/conservation and minimization of energy losses throughout different unit operations of pearl millet production could be performed. Pearl millet is grown in the rainfed areas of Mahendergarh, Bhiwani and Jhajar, and in the case of the Hisar and Fatehabad districts of Haryana, it is grown under irrigated conditions.

2. Materials and Methods

A brief description of study area, methodology adopted for data collection and the procedure used for data analysis are presented in the following sections.

2.1. Selection of Work Area

A village in the Hisar district was selected to study energy use patterns in pearl millet production in an irrigated area of Haryana.

2.2. Selection of the Farmers

The farmers were grouped into three categories, viz., small (0.2–0.4 ha), medium (0.4–1 ha) and large (>1 ha) based on land holdings. Different unit operations for pearl millet production were studied regarding energy use patterns at the selected village of Dhigtana.

2.3. Collection of Data

A questionnaire (Appendix A) was prepared for collecting data through a face-to-face interview schedule from farmers regarding different operations and quantities of each input (i.e., machinery, fuel, fertilizer, pesticide, irrigation water, labor, etc.).

2.4. Tools of Analysis

Source-wise (direct and indirect) and operation-wise energy auditing for pearl millet production were studied in the selected region. Direct energy sources subsumed human, animal and diesel energy, while indirect energy sources included fertilizer, pesticide, seeds and machinery. Energy equivalents of various energy sources are given in Tables 1 and 2.

The following unit operations performed during pearl millet production were observed in the selected village. Different operations performed were preparatory tillage, sowing, interculture, irrigation, fertilizer application, pesticide application, harvesting, threshing and transportation.

2.5. Source-Wise (Direct and Indirect) Energy Inputs

Source-wise (direct and indirect) energy inputs are given in the following sections.

2.5.1. Direct Energy Inputs

Direct energy inputs are defined as input energy per hectare during pearl millet production; i.e., human (manual), animal energy and fuel energy, were calculated using the following equations [11–13].

a. Human energy

$$\text{Human energy } (\text{MJ.ha}^{-1}) = \frac{\text{H} \times \text{T}}{\text{A}} \times \text{HEF}$$

where

H = number of humans
T = operating time, h
A = operating area, ha
HEF = human energy equivalent factor, MJ.h^{-1}

b. Animal energy

$$\text{Animal energy } (\text{MJ.ha}^{-1}) = \frac{\text{N T}}{\text{A}} \times \text{AEF}$$

where

N = number of animals
T = operating time, h
A = operating area, ha
AEF = animal energy equivalent factor, MJ.h^{-1}

c. Fuel energy

$$\text{Fuel energy } (\text{MJ.ha}^{-1}) = \frac{\text{FC} \times \text{FE}_\text{q}\text{F}}{\text{A}}$$

where

FC = average fuel consumption, l
A = planted area, ha
FEqF = fuel energy equivalent factor, MJ.l^{-1}.

2.5.2. Indirect Energy Inputs

Indirect energy inputs per hectare during pearl millet production, i.e., machinery, seed, fertilizer and pesticide (chemical), were computed using the equations under [11–13].

d. Fertilizer energy

$$\text{Energy of N} = \frac{\text{Share of N } \times \text{EE}_\text{N}}{\text{A}}$$

$$\text{Energy of P}_2\text{O}_5 = \frac{\text{Share of P } \times \text{EE}_\text{P}}{\text{A}}$$

$$\text{Energy of K}_2\text{O} = \frac{\text{Share of K } \times \text{EE}_\text{K}}{\text{A}}$$

Total energy input of fertilizer = N (MJ.ha^{-1}) + P_2O_5 (MJ.ha^{-1}) + K_2O (MJ.ha^{-1})

where

N = nitrogen, kg
EE_P = nitrogen energy equivalent factor, MJ.kg^{-1}
P = phosphorus, kg
EE_N = phosphorus energy equivalent factor, MJ.kg^{-1}
K = potassium, kg
$EE_{K\,=}$ potassium energy equivalent factor, MJ.kg^{-1}
A = fertilized area, ha

e. Seed energy

$$\text{Seed energy }(\text{MJ.ha}^{-1}) = \frac{S \times EE_S}{A}$$

where

S = seed, kg
A = seeded area, ha
EE_S = seed energy equivalent factor, MJ.kg^{-1}

f. Pesticide energy

$$\text{Pesticide energy }(\text{MJ.ha}^{-1}) = \frac{Q \times \text{EE}_\text{P}}{A}$$

where

Q = quantity of pesticide, kg
A = operating area, ha
EE_P = pesticide energy equivalent factor, MJ.kg^{-1}

g. Machine energy

$$\text{Machine energy}(\text{MJ.ha}^{-1}) = \frac{\text{W} \times \text{EE}_\text{M}}{\text{UL} \times \text{A}} \times \text{H} \times \text{R}$$

where

W = weight of machine, kg
UL = useful life, h
H = operating time, h
R = no. of passes
A = area
EE_M = machine energy equivalent factor, MJ.kg^{-1}

Table 1. Standard energy equivalents for various sources [14].

Energy Source	Unit	Energy Equivalent (MJ/Unit)
Human labor		
Man	1 h	1.96
Woman	1 h	1.75
Child	1 h	0.98
Animal		
Bullock	pair hour	14.07 (body weight above 450 kg) 10.10 (body weight 350–450 kg)
Fuel		
Diesel	1 L	56.31
Farm Yard Manure	1 kg	0.3
Fertilizer		
Nitrogen	1 kg	60.6
Phosphorus	1 kg	11.1
Potash/Potassium	1 kg	6.70
Chemical application		
Superior	1 kg	120
Inferior	1 kg	10.0
Seed	1 kg	14.7

Table 2. Standard Energy equivalents for farm equipment [15].

Energy Source	Equipment	Energy Coefficient (MJ.kg^{-1})
Manual	Sickle	0.031
	Sprayer	0.502
	Hand hoe	0.314
	Bund former	0.502
Animal	Plough	0.627
	Cultivator	1.881
Tractor	Tractor	10.944
	M B plough	2.508
	Harrow	7.336
	Rotavator	3.762
	Seed drill	8.653
	Cultivator	3.135
	Thresher	7.524
	Leveller	4.703

2.6. Energy Analysis

After collecting data regarding different unit operations in pearl millet cultivation, calculations were made regarding energy use efficiency, energy productivity, energy ratio and net energy gain. The values of these energy sources were obtained from the literature [16–19].

2.7. Energy Use Efficiency

Energy ratio or energy use efficiency was calculated as the ratio of the output and input energy from pearl millet production. After converting the yield into energy, output was calculated by multiplying it with its energy equivalent [19,20].

$$\text{Energy use efficiency} = \frac{\text{Energy output } (\text{MJ.ha}^{-1})}{\text{Energy input } (\text{MJ.ha}^{-1})}$$

2.8. Energy Productivity

Energy productivity (kg.MJ^{-1}) is defined as the ratio of the total amount of grain yield and the total energy input of harvested product.

$$\text{Energy productivity}(\text{kg.MJ}^{-1}) = \frac{\text{Grain yield}(\text{kg.ha}^{-1})}{\text{Total energy input } (\text{MJ.ha}^{-1})}$$

2.9. Net Energy Gain

Net energy gain (MJ.ha^{-1}) is defined as the difference between output and input energy.

$$\text{Net Energy Gain}(\text{MJ.ha}^{-1}) = \text{ Energy output } (\text{MJ.ha}^{-1}) - \text{ Energy input } (\text{MJ.ha}^{-1})$$

2.10. Specific Energy

Specific energy (MJ.kg^{-1}) is the ratio of amount of energy consumed to produced grain yield.

$$\text{Specific Energy}(\text{MJ.kg}^{-1}) = \frac{\text{Energy Input } (\text{MJ.ha}^{-1})}{\text{Pearl Millet Yield } (\text{kg.ha}^{-1})}$$

Cobb–Douglas model was used in the present study to develop a model in Microsoft Excel to analyze the relationship of energy inputs and yield for pearl millet production. The developed model was validated for the pearl millet production data collected for the irrigated region of Haryana. The objective of production function was to analyze the efficiency of all operations utilized in the production process, such as preparatory tillage, sowing, interculture, harvesting, threshing, etc.

The usual form of production function [21,22] is given as:

$$\text{Y} = aX_1^{b1}.aX_2^{b2}\ldots\ldots.aX_7^{b7}.\text{U}$$

The function is easy to estimate in logarithmic form as:

$$logY = \log a + b_1 logX_1 + b_2 logX_2 + b_3 logX_3 + b_4 logX_4 + b_5 logX_5 + b_6 logX_6 + b_7 logX_7 + U$$

where

Y = dependent variable
X_j (1, 2, … 7) indicated independent variables including preparatory tillage (X_1), sowing (X_2), interculture (X_3), irrigation (X_4), fertilizer application (X_5), Pesticide application (X_6), harvesting (X_7)
b_1, b_2, b_7 = regression coefficient of independent variables
U = disturbance term
a = constant

3. Results

3.1. Source-Wise Energy Use Pattern

Figure 1 shows the total energy used and yield obtained during pearl millet production for different categories of farmers. It was found that large farmers consumed the highest energy (402.50 MJ.ha^{-1}) while small farmers consumed the least energy (28,493.09 MJ.ha^{-1}), which indicated the dependency of energy utilization on the size of the farms and their level of production activities. The productivity of small, marginal and large farmers in irrigated areas was 19.00 q.ha^{-1}, 21.50 q.ha^{-1} and 23.12 q.ha^{-1}. The productivity depended on variety and seed rate.

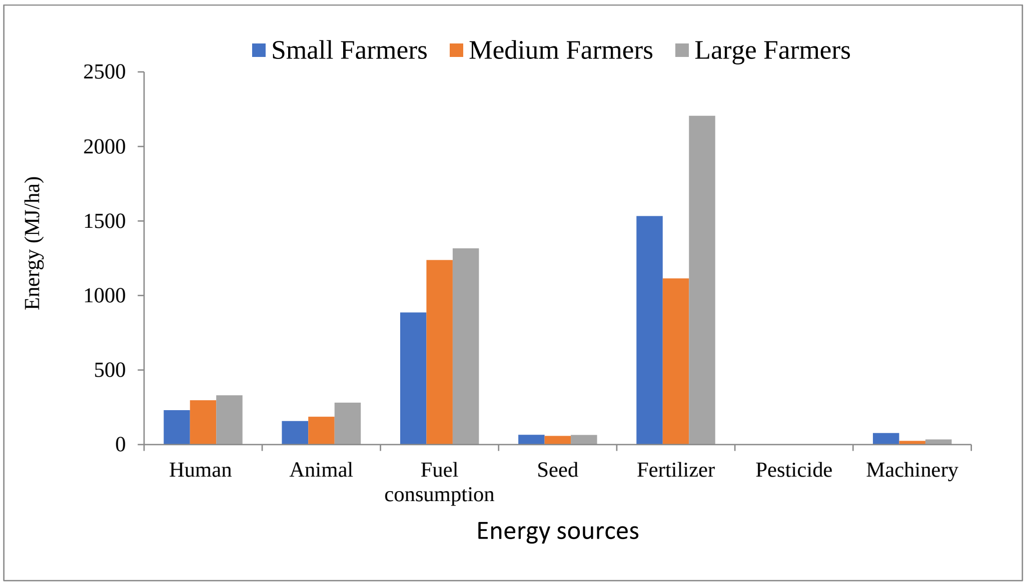

Figure 1. Source-wise energy use pattern in pearl millet production by small, medium and large farmers.

The fertilizer consumption of small, medium and large farmers was 1533.02 MJ.ha^{-1}, 1115.04 MJ.ha^{-1} and 2206.00 MJ.ha^{-1}, which showed that fertilizer application was lower in the case of medium farmers than small and large farmers because a lesser amount of fertilizer (urea) was applied by them than the recommended dose. None of the farmers applied pesticide. Fertilizer consumed 52% of the total energy, followed by diesel (30%), human (8%), animal (5%) and seed (2%). This trend was similar to [12,21,23,24].

The diesel energy consumed by small, medium and large farmers was 886.84 MJ.ha^{-1}, 1238.32 MJ.ha^{-1} and 1316.65 MJ.ha^{-1}, which showed that as the farm size increased, the use of diesel fuel, hence machinery, also increased. The fertilizer and fuel consumption share were similar to the results reported by [12,25].

3.2. Operation-Wise Energy Use Pattern in Pearl Millet Production

Fertilizer energy was highest among all the operations in all categories of farmers, followed by preparatory tillage. It was highest in large farmers, followed by medium and small farmers. This indicated that as farm size increased, fertilizer application increased, followed by preparatory tillage (Table 3).

The energy consumption of fertilizer by medium farmers was lower than by small and large farmers because some marginal farmers did not apply fertilizer in their fields. These findings were similar to the ones reported by Yadav et al. (2013) [19].

Medium farmers consumed more irrigation energy than small and large farmers because all the marginal farmers performed irrigation operations, but some of the small and large farmers performed irrigation while others depended on rain.

Table 3. Operation-wise energy use pattern in pearl millet production by different categories of farmers.

Operations / Farmers	Energy Utilized (MJ.ha^{-1})		
	Small Farmers	**Medium Farmers**	**Large Farmers**
Preparatory tillage	488.10	706.13	771.37
Sowing	300.22	371.76	357.97
Interculture	98.40	126.63	140.54
Irrigation	5.39	8.82	7.38
Fertilizer application	1543.74	1315.56	2212.01
Pesticide application	0	0	0
Harvesting	92.77	129.43	146.75
Threshing	294.32	284.42	301.00
Transportation	28.15	84.46	84.46
Total Energy	2849.09	3027.21	4021.50

3.3. Variation of Direct and Indirect Energy

Figure 2 indicates that indirect energy played a major role in energy consumed in the total energy consumption compared to direct energy, as small and large farmers used the higher fertilizer application. This was due to their higher dose of fertilizer application than recommended. This was a shared waste of energy, which did not result in higher crop yield. These results were similar to the ones in the literature [19,21,22]. In case of medium farmers, the utility of direct energy was higher due to more fuel consumption than indirect energy. The findings are similar to [26,27].

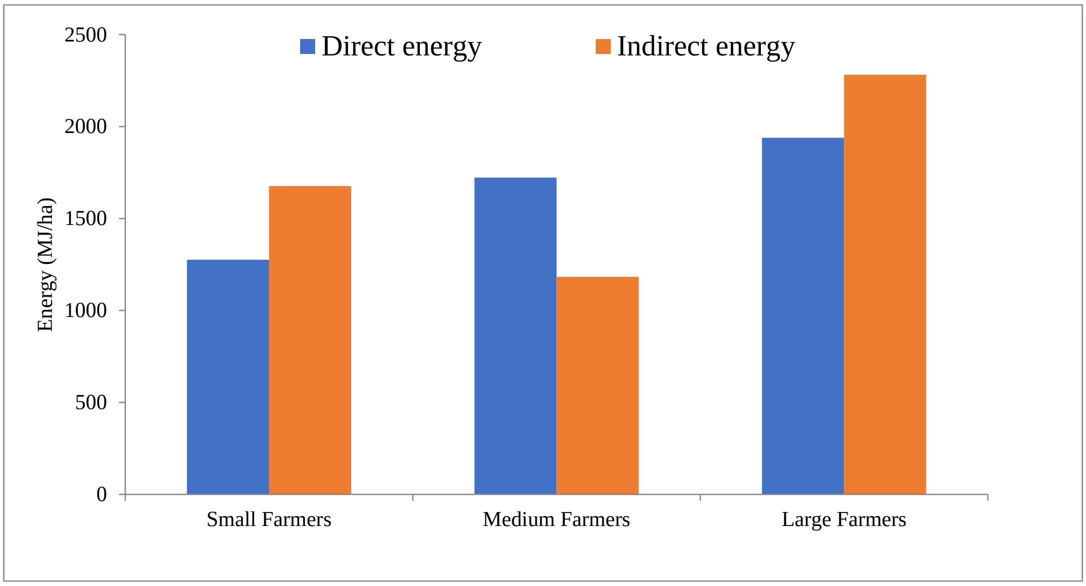

Figure 2. Variation of direct and indirect energy in different categories of farmers.

3.4. Variation Indicators of Energy Use Efficiency

Table 4 indicates that the energy use ratio for different farmers varied from 3.92 to 13.80. High energy ratios of 9.40 and 13.80 in large farmers indicated efficient energy. The findings are similar to [28] since they used a higher utilization of mechanical energy. The lowest energy ratio of 3.92 was found in small farmers, indicating low energy output level as compared to input. The energy productivity of different categories of farmers was computed to be 0.21 kg.MJ^{-1}, 0.65 kg.MJ^{-1} and 0.92 kg.MJ^{-1}. The values of marginal and large farmers are similar to the findings of (Yadav et al. 2013) [19].

Table 4. Variation of indicators of energy use efficiency for different categories of farmers.

Parameter/Farmers	Small Farmers	Medium Farmers	Large Farmers
Total input energy ($MJ.ha^{-1}$)	2849.09	3027.21	4021.50
Energy output ($MJ.ha^{-1}$)	11,172.00	28,518.00	55,566.00
Net energy gain ($MJ.ha^{-1}$)	8323.13	25,490.79	51,545.39
Energy ratio	3.92	9.40	13.80
Specific energy ($MJ.kg^{-1}$)	6.25	1.74	1.16
Energy productivity ($kg.MJ^{-1}$)	0.21	0.65	0.92

The results in Table 5 indicate that 78% (R^2 = 0.78) of the variation in gross return was explained by seven variables in all the categories of farmers. It can also be seen that the sum of elasticities ($\sum b_i$ = 1.45) did not significantly deviate from unity, indicating an increasing return to scale. It showed that for pearl millet production, interculture had the highest impact (0.80) among the other inputs. The elasticity for interculture is 0.80, indicating that a given change (1%) in human energy will conclude in a 0.80% enhancement in yield. Some other important inputs were harvesting, sowing and preparatory tillage with elasticities of 0.56, 0.18 and 0.067, respectively. The sum of the regression coefficients of the energy consumption was examined as 1.45, which implied that a 1% increase in the total input energy would result in a 1.45% increase in the grain yield.

Table 5. Econometric estimation of pearl millet production.

Variables		Irrigated Region	t-Value
Preparatory tillage	X_1	0.067	−0.80 ***
Sowing	X_2	0.18	0.48 ns
Interculture	X_3	0.80	1.70 *
Irrigation	X_4	−0.043	1.14 *
Fertilizer application	X_5	−0.12	−0.14 ns
Pesticide application	X_6	0	0
Harvesting	X_7	0.56	1.03
Return to scale	($\sum b_i$)	1.45	
Constant		17.41	
R^2		0.78	

* Significant at 10%, *** Significant at 1%, ns non-Significant.

This indicated that the production function showed an increasing return to scale, which implied that if total energy inputs specified in the function were increased by 100%, then income would be enhanced by about 78%. The results are similar to the findings of (Wongnaa and Ofori, (2012); Akighir and Shabu, (2011) and Goni et al. (2007)) [29–31], who had observed an increasing return to scale on cashew production, tank command farming system and rice production, respectively, in Ghana, India and Nigeria.

4. Discussion

4.1. Source-Wise Energy Use Pattern

Figure 1 shows fertilizer had the highest energy share, followed by seed and machinery among indirect energy sources. The fertilizer contribution of small, medium and large farmers was found to be 1533.02 MJ/ha, 1115.04 MJ/ha and 2206 MJ/ha, respectively, which shows that fertilizer application was lower in the case of medium farmers than small and large farmers because a smaller amount of fertilizer (urea) was applied than the recommended dose. This is similar to research reported by Abubakar and Ahmad (2010) [32]. Human energy increased with increasing land holding because two operations of interculture and harvesting were performed manually. Diesel had a big share of direct energy sources; it contributed 31%, 39% and 32% of direct energy in the case of small, medium and large farmers. Machine energy also followed the same trend as observed in the case of the rainfed area. Small farmers used higher seed rates as compared to large farmers. There is lot of variation in the variety of seeds used by farmers of the irrigated area. Pesticide application was not performed by any of the farmers of the irrigated area. Machinery consumed more energy in the case of small farmers, as some used less efficient animal-drawn machinery than large farmers who used efficient tractor-drawn machines such as cultivators, harrows and rotavators for tillage.

4.2. Operation-Wise Energy Use Pattern

Table 3 indicates that energy used by fertilizer was also highest among all the operations in all categories of farmers, followed by preparatory tillage and sowing in irrigated regions. These results were similar with the research reported by Abubakar and Ahmad (2010) [32]. The energy consumption of fertilizer in the case of medium farmers was lower as compared to small and large farmers because some medium farmers did not apply fertilizer in their fields. Small and medium farmers applied urea at the rate of 50–60 kg/ha, while large farmers applied urea at the rate of 60–90 kg/ha. Sowing and interculture followed a similar trend as preparatory tillage. Human energy increased with increasing land holdings. Irrigation energy was consumed more by medium farmers than small and large farmers because all the medium farmers performed irrigation operations, but in the case of small and large farmers, some performed irrigation while some left this operation and depended on rain only. Small farmers applied pesticide while the medium and large farmers did not. The energy consumed in harvesting operations increased as the size of the farm increased. A similar trend was also observed in the case of threshing. Large farmers consumed more energy in preparatory tillage, sowing, interculture and harvesting operations than medium and small farmers. This trend was similar to the research findings reported by Shahin et al. (2008); Pimentel and Pimentel (1996) and Walsh et al. (1998) [33–35], who suggested that energy consumption depended on farm size and the level of production activities.

4.3. Variation of Direct and Indirect Energy Sources

Figure 2 indicates that the indirect form of energy was found to be the major contributor of energy in total energy consumption, compared to direct energy, due to the higher doses of fertilizer application. The shares of indirect energy sources were more than direct energy in small and large farmers. Small and large farmers used higher doses of fertilizer compared to medium farmers.

4.4. Variation of Indicator of Energy Usage Efficiency for Different Categories of Farmers

The net energy yield of small, medium and large farmers of irrigated regions was 8339.13 MJ/ha, 25,416.58 MJ/ha and 51,542.39 MJ/ha. This means that the output energy was more than the input energy of pearl millet production. The energy use ratio for different categories of farmers varied from 3.92 to 13.80. A high energy ratio indicates an efficient level of energy usage. The findings are similar to the results of Sidhpuria et al., 2014 [29], who conducted work on resource conservation practices in rainfed pearl millet. This could be attributed to large farmers' higher use of manual and mechanical energies. The lowest energy ratio was obtained for small farmers, indicating low energy output level as compared to input, while the energy productivity of different categories of farmers of irrigated regions was calculated to be 0.21 kg/MJ, 0.65 kg/MJ and 0.92 kg/MJ. The values of medium and large farmers are similar to the findings of Yadav and Khandelwal, 2013 [19], who reported on wheat production in the state of MP (India).

5. Conclusions

The input energy of all farmers (small, medium and large) was 2849.09, 3027.21 and 4021.50 MJ.ha^{-1}, while the output was 11,172.00, 28,518.00 and 55,566.00 MJ.ha^{-1}. The energy ratios were 3.92, 9.40 and 13.80 for small, medium and large farmers. The energy productivity was 0.21 kg.MJ^{-1} (small), 0.65 kg.MJ^{-1} (medium) and 0.92 kg.MJ^{-1} (large). Manual energy increased with the size of land holding, indicating more labor work done by small farmers compared to larger ones. This indicated that large farmers used less labor to perform different operations, which took more time and energy. Based on the source-wise energy use pattern, the fertilizer application source was found to be the most energy-consuming, which increased with the size of land holding. Additionally, as the size of the farm increased, animal energy increased with land holding size, indicating less use of animal-drawn implements. A similar trend was observed for diesel fuel consumption. Seed energy decreased with the size of landholdings in both areas, indicating the higher use of seed by small farmers. None of the farmers applied pesticide (Atrazine) for pearl millet production.

This study will provide valuable information to farmers, scientists and policymakers, allowing them to recommend appropriate changes in agricultural practices that would result in substantial energy savings in the pearl millet production system, reducing the cost of operation and sustainable development. It will also give useful information to decision-makers and farmers, emphasizing the necessity of energy management in crop production. The amount of energy input and output differed by the category of farmers, geographical location and economic condition of farmers.

Author Contributions: R.K.: conceptualization; writing—original draft preparation, methodology, formal analysis; Y.: conceptualization, writing—review and editing, formal analysis, resources; V.K.S.: writing—original draft preparation, A.K.: writing—review and editing, formal analysis. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

General profile

Name of the respondent	:	__________
Age	:	__________
Village	:	__________
Tehsil/Block	:	__________
District	:	__________

a. **Caste hierarchy**

SC/ST	Backward	OBC	General

b. **Family type:**

- Nuclear
- Joint

c. **Family size:**
- 4 member
- 4–6 members
- Above 6 members

d. **Education**
- Illiterate/unlettered
- Can read and write/lettered
- Primary school
- Middle school
- High school
- Senior Secondary school
- Graduate and above

e. **Type of Farmers**
- Small
- Medium
- Large

f. **Total Family income from all sources:**
g. **Cropping pattern**

Crops	Area
Kharif	
Rabi	
Pearl millet	

h. **Occupation of the family**

Main occupation	Farming
	Service
	Business
	Daily wage earner
Subsidiary occupation	Farming
	Service
	Business
	Daily wage earner

i. **Total land holding under pearl millet cultivation (in hectare):**____________________
j. **Livestock ownership**

	Small (1–2)	Medium (3–4)	High (>4)
Bullock			
Buffalo			
Cow			
Goat			
Camel			

k. **Farm Assets**

Assets	Yes	No
Tractor		
Power tiller		
Pump set		
Improved disc plough		
Tractor trolley		
Desi plough		
Sprayer/duster		
Land leveler/patella		
Seed drill/ridger		
Hand tools		
Thresher		
Winnower		
Chaff cutter		
Any other		

Specific information

1. **Pearl millet cultivation**

a. **Participation of the respondent in Pearl millet cultivation**

Sr. No.	Farm Activities	Yes	No
1	Seed selection		
2	Seed treatment		
3	Sowing		
4	Fertilizer application		
5	Interculture		
6	Weeding		
7	Crop care and nurturing		
8	Water management		
9	Watching birds		
10	Threshing		
11	Winnowing/Processing		
12	Cleaning/Grading		
13	Storing		
14	Marketing		

b. Adoption level of respondent about Pearl millet cultivation

Sr. No.	Adoption Statements	Yes	No
1. Pre- production			
1	Recommended Cultivar to your area		
2	Area grown for seedling		
3	Followed methods for seed treatment and seed selection		
2. Production			
1	Do you practice Green manuring crop		
2	Used the recommended quantity of NPK and FYM		
3	Used biofertilizers in Pearl millet cultivation		
4	Do you apply the recommended micro- nutrient?		
3. Plant protection			
1	Do you use weedicide?		
2	Do you apply weedicide as per recommendation		
3	Control measures taken to control the pests		
4	Control measures taken to control the disease		
5	Used recommended quantity of chemical.		
4. Post harvesting			
1	It is necessary to clean the Pearl millet before milling		
2	Thorough Drying is important		
3	Post harvest processing of produceHousehold level:Commercial level:		
4	Follow traditional storage methods		
5	Follow modern storage methods		
5. Marketing			
1	Sell Pearl millet at the major Pearl millet markets in Haryana		
2	Rate of Pearl millet/quantity at present		

c. Improved farm implements

Name of the Implement/Tool (List out)	Are you Aware		Do you Use	
	Yes	No	Yes	No
Rotary weeder				
Sprayer				
Pearl millet thresher				

Energy equivalent of input in pearl millet production

1. Preparatory tillage

Method	Time Taken	Fuel Consumption	No. of Person Engaged	No. of Bullock	Weight of Machine	NP
Power operated						
Tractor						
Rotavator						
Harrow						
Cultivator + planker						
Bullock/Camel drawn planker						
Animal drawn cultivator(Trifali)						

2. Pre-sowing Irrigation

Method	Time Taken	Fuel Consumption	No. of Person Engaged	Water Requirment	Depth of Ground Water
Rain fed					
Canal Irrigation					
Pump-set for Irrigation					

3. Seed Treatment

Method	Time Taken	Fuel Consumption	No. of Person Engaged	Amount of Chemical	Amount of Seed
Manually					
By Machine					
Integrated Approach					

4. Sowing

Method	Time Taken	Fuel Consumption	No. of Person Engaged	No. of Bullock	Weight of Machine	NP *
Manually						
By Tractor						
Seed-drill						
By Bullock						

* = No. of passes for application of considered field operation.

5. Intercultural/weeding

Method	Time Taken	Fuel Consumption	No. of Person Engaged	Weight of Machine	NP *
Tractor					
Implement					
By Bullock					
Manual					
Hand tools					

* = No. of passes for application of considered field operation.

6. Irrigation

Method	Time Taken	Fuel Consumption	No. of Person Engaged	Water Requirement	Depth of Ground Water
Rainfall					
Canal Irrigation					
Pump-set for Irrigation					

7. Fertilizer

Method	Time Taken	Fuel Consumption	No. of Person Engaged	Amount of Fertilizer	Weight of Machine
Manually					
Tractor					
Seed-cum-fertilizer drill					

8. Chemical Application

Method	Time Taken	Fuel Consumption	No. of Person Engaged	Amount of Chemical	Weight of Machine
Manually					
Tractor					
Hand tools					

9. Harvesting

Method	Time Taken	Fuel Consumption	No. of Person Engaged	Weight of Machine
Manually				
Tractor				
By Machine				

10. Threshing

Method	Time Taken	Fuel Consumption	No. of Person Engaged	Weight of Machine
Manually				
Tractor				
Tractor drawn thresher				

11. Transportation

Method	Time Taken	Fuel Consumption	No. of Person Engaged
By truck			
Tractor-Trolly			

12. Thinning & gap Filling

Method	Time Taken	No. of Person Engaged
Manually		

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