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Energy Economics Assessment of Crops in Traditional and Mechanized Farming

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Abstract

The energy economics of potato and gram crop production operation in Allahabad region is reported in the present study. The main focus of this study was to study the operation and source wise energy inputs for potato and gram crop under traditional and partial mechanized farming system and to analyze and compare the cost benefits of partial mechanised farming over traditional farming. The various operations in the production of crops like sowing, intercultural and harvesting and picking were considered for the operation energy input determination. It was observed that in both crop energy required in sowing, intercultural and harvesting/ picking operation was more in traditional farming. It means that mechanized farming saves the much more energy input in operation and reduces the cost. After analyzing the cost of energy, it was clear that the cost of energy is 1.2 times more in gram crop for traditional farming as compared to mechanized farming. But in potato crop, the cost of energy approx doubles in traditional as compared to mechanized farming. It was also found that mechanized farming of gram crop and potato crop shows the significant saving in operational energy as well.

Keywords: Energy economics, traditional farming, mechanized farming, cost benefit, crop.

Introduction

Power is needed on the farm for operating different tools, implements and various farm operations. Previously, humans and animals are predominately used in most of the farming operations in Allahabad region, starting from land preparation to harvesting of crops. But now days the animal powers have reduced not only because of the reduction in population of animal but also increase in mechanical power. The tractors are use in field for agricultural operations and for transportation off the field. As compare to man and animal power, the machine power is most important for developing countries because it saves time and increase production. The precision in mechanization of farm is very important because of increase in crop production and for best quality product. Due to much involvement of labor in different farm operations, the cost of production of most crops in our country is quite high as compared to developed countries. Also the unavailability of human power due to migration towards town in peak period accounts more expenditure with less productivity[1].

In the Indian economy, agriculture shares near about 28% of the total GDP. The people of India mainly depend on the agriculture and allied field which is near about 65% more or less. So, it is clear that land system of traditional farmers is being change due to pressure of growing population of the country. Now a day, majority of the farmer in our country came under small marginal lands system. These fragmented lands have lower productivity due to the inadequate operation and merger use of the precise farm machineries[2].

In development process of mankind, energy is playing as key role. Energy is one of the most valuable inputs in agricultural production. 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[3]. In the developed countries, increase in the crop yields was mainly due to increase in the commercial energy inputs in addition to improved crop varieties[4].

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. The primary objectives of mechanizing crop production are to reduce human drudgery and to raise the output of farm by either increasing the crop yield or increasing the area under cultivation[5].

These can only be done by supplementing the traditional energy input i.e. human labor with substantial investments in farm machinery, irrigation equipment, fertilizers, soil and water

conservation practices, weed management practices, etc. These inputs and methods represent various energies that need to be evaluated so as to ascertain their effectiveness and to know how to conserve them. In agriculture sector of India, the energy use pattern for unit production of crops has varied under different agro climatic zones. The use of energy in crop production depends on availability of energy sources in particular region and also on the capacity of the farmers[6]. There is a need to carry out energy analysis of crop production system and to establish optimum energy input at different levels of productivity. The appropriate use of energy input to crop production could originate from several types of conservation practices. The reduction, elimination or combination at machinery operation will reduce energy input and also may reduce the uses of labor and time[7].

Human and animal energy is predominately used in most of the farming operations starting from land preparation to harvesting of the crops. Due to much involvement of labor in different farm operations, the cost of production of most of the crops in our country is quite high as compared to developed countries. Also the unavailability of human power due to migration towards town in peak period accounts more expenditure with less productivity. Human energy account Rs. 125 to 156 for production of 1 kWh of energy whereas, for draught animal it is estimated as Rs. 29.32 per kWh and for the machines it is in the range of Rs. 3 to 10.71 per kWh[8]. Therefore it is essential to quantify the appropriate methods of farm operation, which reduces the energy cost with an increasing energy output for sustainable development of agricultural sector[9, 10].

Material and Methods

Description of study area and Selection of farmers: The present study has been carried out at Allahabad District in villages Chandapur, Shankargarh, Simra and Dabhoan. The modulus of selection criteria were transport facility, operational land holding distribution, nature and attitude of villagers, performance of agriculture and adaptability to different types of energies. For gram crop data has been collected at Shankargarh and Simra villages and for potato crop data has been collected at Chandapur and Dabhoan villages in farmer's field. The energy consumption of the various operation of partial mechanized in potato and gram crop was collected. Similarly the energy consumption in the crop production by using the tradition farm operation was recorded from Simra and Dabhoan village. Based on the use of semi-mechanized operation and traditional farm power source, the operational energy evaluation of the crop production was calculated.

The profile of the cluster i.e. present land utilization pattern and area under main crops was observed and it was found that total geographical area of the cluster is 3, 69,084 ha, out of which 19,680 ha (5.33 percent) is under forest, 32,107 ha (8.69 percent) under non-agricultural use, 17,806 ha (4.80 percent) barren and uncultivated, 1,065ha (0.28 percent) pasture, 3,085ha (0.83 percent) miscellaneous trees (orchard) and 11,927ha (3.22 percent) cultivable waste. From Allahabad stastical book, it was observed that 73.17 % area was utilized for agricultural activities. Moreover, 3.22% area, which came under cultivable waste could also be utilize for agricultural purpose.

The detail information of farmers who practices traditional and partial mechanized farming in the selected area was collected. Farmers were contacted and selected with the help of Gram Pradhans. After collecting preliminary information related to their inventories, the result was that majority of the farmers used traditional farming due to lack of knowledge about the benefits of the partial mechanized farming system and also due to financial weakness. Hence the farmers were selected on the following conditions: i. Fifty percent of the selected farmers used traditional farming and the rest fifty percent were using partially mechanized farming. ii. The farmers were using both the commercial and non-commercial source of energy. iii. The farmers were literate enough to respond to the questions of the questionnaire.

Traditional Farming: To know the operational energy input in the crop like potato and gram, data were collected from the farmer field of Dabhon and Simra village, for operation like sowing, intercultural and picking / harvesting was recorded . The data percept at the stage of sowing was collected by means of the man power requirement per hectare and bullock power requirement per hector. The data regarding to power or energy used at the stage of inter cultural operations which includes hoeing and weeding at various stage of crop was collected for the exact quantification and assessment of operational energy input on farmers field. Similarly data regarding the traditional power required at picking and harvesting stage of the crop was collected to find out the operational energy input.

Partial Mechanized Farming: To know the operational energy input in the crop like potato and gram data was collected from Chandapur and Shankargarh village respectively. The operational input energy related to the energy in crop production for operation of sowing, inter- culture and picking / harvesting was recorded at every step of operation. The data percept at the stage of sowing was collected by means of man power, machinery working duration and fuel consumption requirement per hectare. Similar way the data of operational input in intercultural operation was recorded for man power and machinery working for the operation. The data regarding picking / harvesting of crop was collected to the exact assessment of operational energy input. In this intercultural and harvesting of gram crop have been carried out by traditional way due to non availability of machinery. Potato crop have been harvested by potato digger. The data of man power, machinery with the fuel consumption was collected for traditional and partial mechanized operation respectively.

Theory for the partial Mechanized Cropping System: The direct energy use per hectare for each field operation like

sowing, intercultural and harvesting/ picking was computed by the following equation.

$$ED = h \times AFU \times PEU \quad (1)$$

Where, ED = Specific direct energy use (fuel) (MJ/ha), h = Specific working hours, AFU = Average fuel use per working hour (*l*/h), PEU = Specific energy value per liter of fuel (MJ/*l*).

The rate of labor use in the various crop production operations in study area was determined for each stage. The labor energy input (MJ/ha) at every stage in the production process was estimated by the following equation:-

$$ED_{hm} = TMW \times h \times EE \quad (2)$$

$$ED_{hf} = TFW \times h \times EE \quad (3)$$

Where, ED_{hm} = Direct energy human for male (MJ), TMW = Total male working, h = Specific working hours (h/ha), EE= Energy equivalent (MJ/h), ED_{hf} = Direct energy human for female.

Theory for the Traditional Cropping System: The power requirement at the various stages of traditional cropping system was computed by means of various stage involved in the operation. This included the operations like sowing of crops, intercultural (hoeing and weeding), harvesting/picking of the crops. The formula used to calculate the power or energy requirement has been written below:

$$ED_{hm} = TMW \times h \times EE \quad (4)$$

$$ED_{hf} = TFW \times h \times EE \quad (5)$$

$$ED_H = ED_{hm} + ED_{hf} \quad (6)$$

Where, ED_H = Total Direct energy.

The bullock power requirement in the various operation of the crop production was computed as follows:-

$$ED_b = TBW \times h \times EE \quad (7)$$

Where, ED_b = Direct energy for Bullock, TBW = Total Bullock working, h = Specific working hours, (h/ha), E = Energy equivalent (MJ/h)

The total traditional operation energy is the cumulative function of the human power and bullock power and it was computed as follows:

$$ED = ED_h + ED_b \quad (8)$$

Where, ED = Total direct energy, ED_h = Direct energy for Human, ED_b = Direct energy for Bullock.

The energy input intensity (e) was determined from the summation of equations of all energy inputs in traditional and partial mechanized cropping system by the following expression

$$\boldsymbol{e = E/A} \quad (9)$$

Where, *e* = Operational energy input intensity (MJ/ha), *E* = Total energy consumption (MJ), A =Effective production area (ha).

The operational energy economics of traditional and partial mechanized system was calculated by using the current cost spends on the various parameters. The cost of human power, cost of bullocks and hiring cost of machinery required have been considered for the exact assessment of the cost involvements in crop production operations.

Results and Discussion

The data collected in gram and potato crop production in different farming systems were analyzed for the exact quantification.

Traditional Operational Energy Input: In traditional Field preparation and sowing gram crop energy input was observed to be 1562.56 MJ/ha, Which includes mainly of bullock power of 1292.8 MJ/ha. A preparation data of gram crop from early stage of operation to the mature stage of crop has been collected from the farmer's field. It was observed that bullock and human power is used more for the agricultural operation. A total of power used for the operational energy input to intercultural operations of gram crop. A total of power used for the operational energy inputs in intercultural operations of gram crop was found to be 113.92 MJ/ha. The data penetrating towards the harvesting of the gram crop from the farmers was analyzed for the determination operational energy input. It was found that of 486.36 MJ/ha of energy is required for the harvesting of gram crop. The total operational energy input in gram crop by traditional method was observed to be 2162.84 MJ/ha.

In tradition system of sowing and field preparation for this crop energy input was observed to be 2234.32 MJ/ha which included mainly of bullock power of 969.6 MJ/ha. A preparation data of gram crop from early stage of operation to mature stage of crop data has been collected. The power used by the bullock and human female power was used for sowing and harvesting operation. A total of power used for the operational energy inputs in intercultural operations of potato crop was found to be 1458.72 MJ/ha.

The data penetrating towards the harvesting of the gram crop from the farmers was analyzed for the determination operational energy input. It was found that of 1538.88 MJ/ha of energy is required for the harvesting of potato crop. The total operational energy input in potato crop by traditional method was observed to be 5221.92 MJ/ha. It was realized that sowing operations of the potato and gram crops require more operational energy input and is the interlinked with the various power sources which are human and the livestock. The labor shortage in the traditional crop and the bullock deficiency increases the cost of operational energy input.

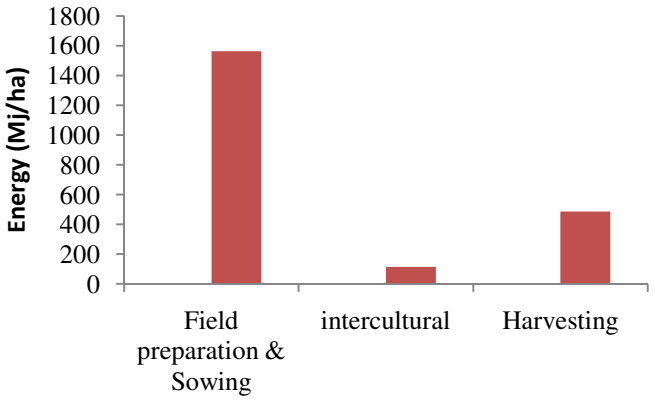
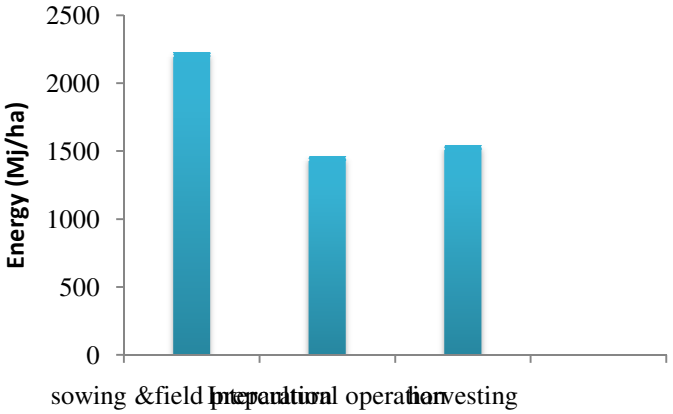


Figure-1
Graphical representation of the operational energy input of various farming operations of traditional farming for Gram crop



Figure–2
Graphical representation of the operational energy input of various farming operations of traditional farming for potato crop

Partial Mechanized Operations Energy Input: In partially mechanized system of sowing and field preparation for this crop energy input was observed to be 1458.26 MJ/ha which included the mainly of fossil fuel power of 1428.86 MJ/ha. A prepational data of gram crop from early stage of operation to the mature stage of crop has been collected from Shankargarh village. It was observed that power was used more for the sowing and field preparation operation. The power used by the human in sowing and field preparation operation of gram crop system was observed to be 29.4 MJ/ha. A total of power used for the operational energy inputs in intercultural operations of gram crop was found to be 100.16 MJ/ha. The data penetrating towards the harvesting of the gram crop from the field was analyzed for the energy inputs in intercultural operations of cotton crop determination operational energy input. It was found that 486.36 MJ/ha of energy is required for the harvesting of gram crop. Gram crop harvesting is done manually because non availability of machinery. The total operational energy input in the gram crop by partially mechanized method was observed to be 2044.78 MJ/ha.

The operational energy input of partial mechanized cropping of potato crops system field preparation and sowing required operational energy input of 2017.29 MJ/ha which included the mainly of fossil fuel power of 1703.37 MJ/ha. Data of potato crop from early stage of operation to the mature stage of crop has been collected from the field. It was observed that mechanized power is used more for the sowing and field preparation operation. The power used by the machine in sowing and field preparation operation of potato crop system was observed to be 2017.29 MJ/ha. A total of power used for intercultural operations of potato crop was found to be 1339.53 MJ/ha. The data penetrating towards the harvesting of potato crop by traditional ways was considered and analyzed for the determination operational energy input. It was found that of 1514.64 MJ/ha of energy is required for harvesting of potato crop. The total operational energy input in potato crop by partial mechanized method was observed to be 4871.96 MJ/ha.

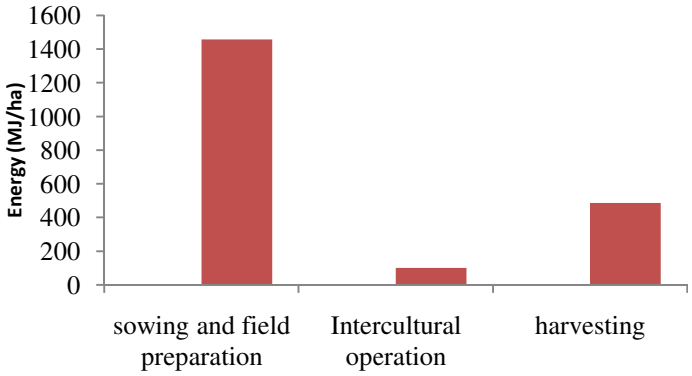


Figure-3
Graphical representation of the operational energy input of various farming operations of partial mechanized farming for gram crop

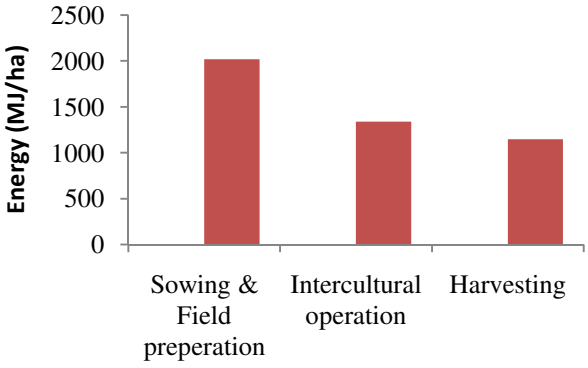


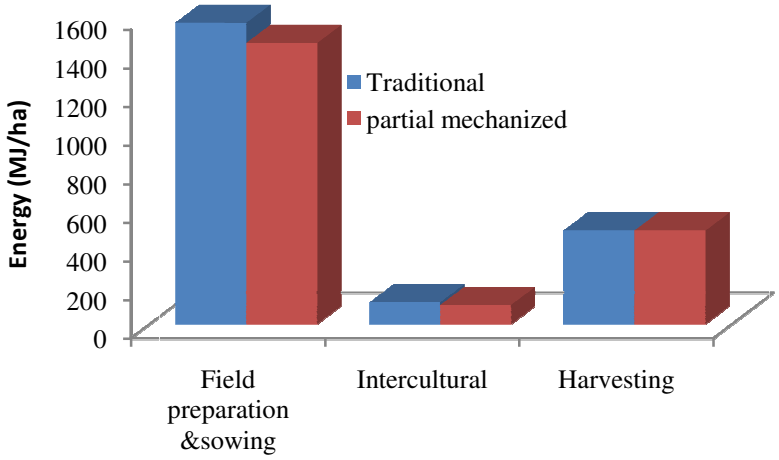
Figure-4
Graphical representation of the operational energy input of various farming operations of partial mechanized farming for potato crop

It was realized that field and sowing operations of potato and gram crop require more operational energy input than other operations. It was observed that he overall operational energy input of potato and gram crop is interlinked of the various power sources which are human and the machine. The labor shortage in the partial mechanized crop production system does not reflect on the cost of operational energy input.

Operational Energy Input Intensity: In traditional operation of gram cropping system operational energy intensity was observed to be 2162.84 MJ/ha. In traditional operation of potato cropping system operational energy intensity was observed to be 5221.92 MJ/ha. In mechanized operation of gram cropping system operational energy intensity was observed to be 2044.78 MJ/ha. In mechanized operation of potato cropping system operational energy intensity was observed to be 4505.44 MJ/ha

Table–1
Comparison of operational energy input intensity of traditional and partial mechanized farming for Gram and Potato crop.

METHOD	Crops	Sowing	Intercultural	Harvesting	Total (MJ/ha.)
Traditional	**Gram**	1562.56	113.92	486.36	2162.84
	Potato	2224.32	1458.72	1538.88	5221.92
Partial Mechanized	**Gram**	1458.26	100.16	486.36	2044.78
	Potato	2017.29	1339.53	1514.64	4505.44



Figure–5
Graphical representation showing the operational energy input comparison of traditional and partial mechanized farming operations for gram crop

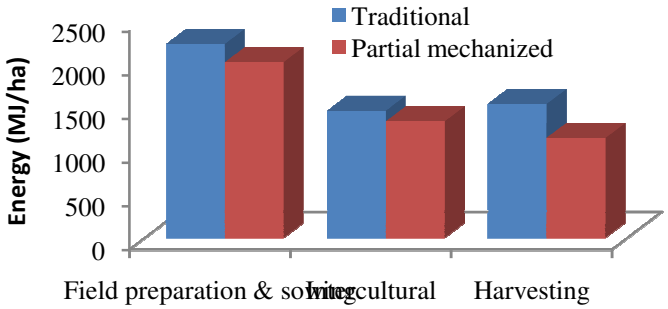


Figure-6
Graphical representation showing the operational energy input comparison of traditional and partial mechanized farming operations for potato crop

Energy Economics of Crops: The input energy economics of various operations have been calculated for exact quantification of energy economics in crop production. In gram and potato crops operational energy required is then transferred into costs. The actual expenses paid for the various power sources have been incorporated in traditional and partial mechanized farming.

Energy Economics of Gram Crop: It is necessary to determine the effect of various operational energy input on the cost of crop production. It was seen that sowing and field preparation of gram crop in traditional farming requires INR 6120 per hectare. In partial mechanized farming cost required for sowing comes to be INR 3400 per hectare. The cost calculated showed that there is possibility of saving cost in sowing operation in partial mechanized farming. The cost of intercultural operations in gram was observed to be 820 and 745 INR per hectare in traditional and mechanized farming, respectively. The cost of harvesting based on the energy input was observed to 4020 INR per hectare in traditional and partial mechanized farming due non availability of machine. The total cost of operation in partial mechanized farming is 8165 INR.

Energy Economics of Potato Crop: The similar way operation energy economics of potato have been carried out. The cost of energy required in sowing and field preparation operation came to be 12820 and 5450 INR per hectare in traditional and partial mechanized farming. The intercultural operation of the potato crop has required 11610 and 10290 INR per hectare in traditional and partial mechanized farming respectively. The harvesting required 9540 and 3700 INR per hectare. Overall in potato crop operation cost of energy is double for traditional farming as compare to partial mechanized farming has been carried for crop production operation. The total cost of operation in partial mechanized farming is 19440 INR.

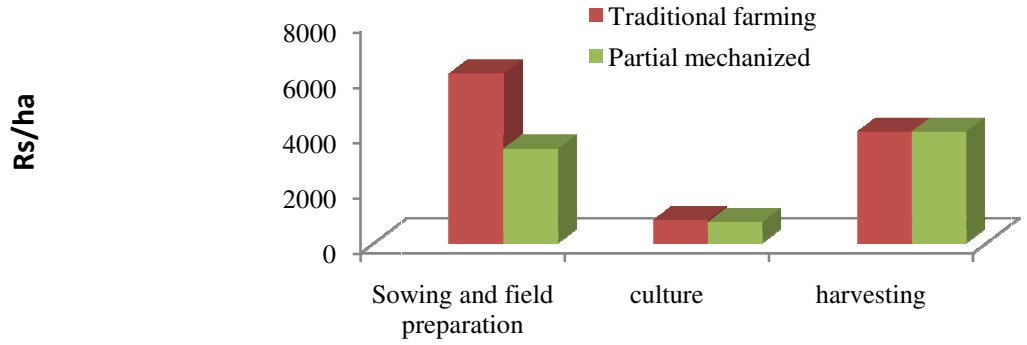


Figure-7
Graphical representation showing the energy economics comparison of traditional and partial mechanized farming operations for gram crop

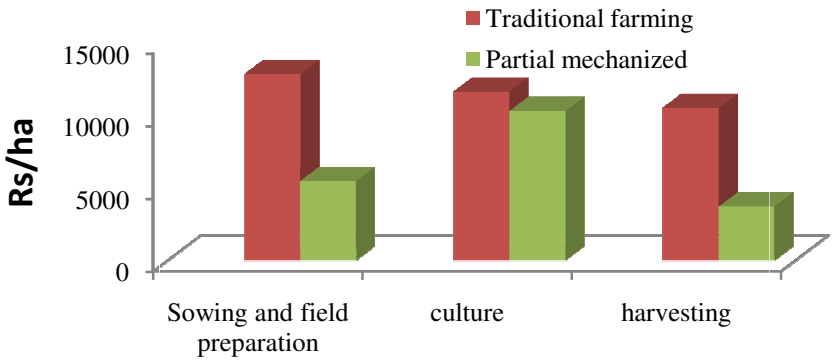


Figure-8
Graphical representation showing the energy economics comparison of traditional and partial mechanized farming operations for potato crop

Table–2
Energy economics assessment of gram crop in traditional and mechanized farming

Items	Field operation andSowing						Intercultural						Harvesting						TOC (Rs/ha)
	TC			MC			TC			MC			TC			MC			
	M	W	B	M	W	T	M	W	B	M	W	T	M	W	B	M	W	T	
No	7	2	8	2	-	-	2	2		2	2		6	3	-	6	3	-	-
OD	2	2	4	2	-	-	2	2		2	1.5		4	3	-	4	3	-	
R/U	130	75	125	150	-	-	130	75		130	75		130	75	-	130	75	-	
Fuel (Lit.)	-	-	-	-	-	26.25	-	-	-	-	-	-	-	-	-	-	-	-	
Tractor + Implement hiring cost/ha	-	-	-	-	-	2800	-	-	-	-	-	-	-	-	-	-	-	-	
TTC	6120			-			820			-			4020			-			10960
TMC	-			3400			-			745			-			4020			8165

Note: **TC** is the traditional cropping, **MC** is the mechanized cropping, **M** is for man power, **B** is for bullock power, **W** is for woman power, **T** is for tractor power, **R/U** is the rate per unit (Human/ bullock), **TTC** is the traditional operational cost, **TMC** is the mechanized operational cost.

Table–3
Energy economics assessment of potato crop in traditional and mechanized farming

Items	Field operation andSowing						Intercultural						Harvesting						TOC (Rs/ha)
	TF			MF			TF			MF			TF			MF			
	M	W	B	M	W	T	M	W	B	M	W	T	M	W	B	M	W	T	
No	16	5	8	4	-	-	12	5		9	4	-	12	6	6	4	4	-	-
OD	4	4	3	1	-	-	6	6		7	7	-	4	4	2	1	4	-	
R/U	130	75	125	150	-	-	130	75		130	75	-	130	75	125	150	75	-	
Fuel(Lt.)	-	-	-	-	-	30.25	-	-	-	-	-	-	-	-	-	-	-	20	
Tractor + Implement hiring cost/ha.	-			4850			-			-			-			1900			-
TTC	12820			-			11610			-			9540			-			33,970
TMC	-			5450			-			10290			-			3700			19440

Conclusion

In present study we have analysed traditional and partial mechanized farming system for the small farm. Farmers of the studied area grew gram and potato thereby these two crops have been taken for knowing the operational energy. It was observed that in both crop energy required in sowing, intercultural and harvesting/ picking operation was more in traditional farming. It means that mechanized farming saves the much more energy input in operation and reduces the cost. After analyzing the cost of energy, it is clear that the cost of energy is 1.2 times more in gram crop for traditional farming as compared to mechanized farming. But in potato crop, the cost of energy approx doubles in traditional as compared to mechanized farming.

It is now concluded that mechanized farming of gram crop and potato crop shows the significant saving in operational energy as well.

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