Energy and Economic Evaluation of Farm Operations in Crop Production

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We gratefully acknowledge the support for this project by Department of Farm Power & Machinery, Dr. PDKV, Akola

Abstract

The present research work has been carried out at Central Research Station farm of Dr. PDKV, Akola and at Katkheda and Sutala village of the Akola and Bulbhana district respectively. The operations considered were land preparation, sowing, intercultural, harvesting and crop residue management etc. The inputs like human power, bullock power for traditional operation were studied in entire work of the research. Similarly, for the same crops these operations were carried out by the mechanized practice for the exact quantification of the operational energy input. The study reflects the energy use patterns in mechanized and traditional farming and optimized energy efficient cropping system through mechanized farming over traditional farming. The practices evaluated for the crop production which resulted in the high yielding of crop and the crop residues.

On the basis of results obtained, it was observed that the traditional operational energy requirement increases from 2680.78 MJ/ha in traditional method to 3130.72 MJ/ha in mechanized method for green gram crop. While, there is decrease in cost of operation from Rs 8407.5/ha in traditional method to Rs 5147.0/ha in mechanized system. Similar trend was observed in cotton, soybean, sorghum and wheat crop. For all the crops seed bed preparation is done by tractors in traditional as well as mechanized method except in mechanized method land smoothening is done by self propelled tiller instead of bullock drawn blade harrow. In most of the crops the farm operations were mechanized with different implements except harvesting operation, due to unavailability of appropriate machine

for harvesting of crops except wheat crop. Overall it seen that the application of modern implements and machineries for the crop production over the traditional practices reduces the cost of production which surely impact on the crop production and the net income of the farmers.

Keywords: Farm operations, Traditional, Mechanical, Energy, Crop economic

1. Introduction

In development process of mankind energy is playing as key role. Energy is one of the most valuable inputs in production agriculture. It is invested in various forms such as mechanical (farm machines, human labour, animal draft), chemical fertilizer (pesticides, herbicides), electrical, etc. 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 (Stout, 1990). 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 (Faidley, 1992)

Particularly in developing countries, 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 (Jekayinfa, 2006). These can only be done by supplementing the traditional energy input i.e. human labour 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. 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 (Bebendra & Bora, 2008)

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. There is a need to carry out energy analysis of crop production system (practices) 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 (fuel) input and also may reduce the uses of labor and time (Karale *et al,* 2008).

Human and animal energy is predominately used in most of the farming operations in Vidarbha region, starting from land preparation to harvesting of the crops. Due to much involvement of labour 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 produce the 1 kWh of energy of and for draught animal it is estimated as Rs. 29.32 per kWh and for the mechanical it is in the range of Rs. 3 to 10.71 per kWh (Srivastava 2006).

Therefore it needs to quantify the appropriate methods of farm operation, which reduces the energy cost with an increasing energy output for sustainable development of agricultural sector. Keeping in view the above facts the project works taken with objectives (1) To study the energy use patterns in mechanized farming and traditional farming and (2) To optimize energy efficient cropping system through mechanized farming over traditional farming.

2. Materials and Methods

The present experiment was carried out at Central Research Station farm, Dr. PDKV, Akola and nearby farmer's field of village Katkhed and Saturna of Akola and Buldhana district respectively. For mechanized method of crop sowing to harvesting operations, a self-propelled tool bar was used where as for traditional method the farmer's practices were considered. The self-propelled toolbar and its attachments and tractor-operated equipments was procured from the All India Co-ordinated Research Project on Farm Implements & Machinery, Dr. PDKV, Akola. The energy consumption of the various operations of the few crops like green gram, cotton, soybean, sorghum and wheat has been collected. Similarly, the energy consumption in the crop production by using the traditional farm operations has been recorded. Based on the use of self-propelled toolbar and tractor operated equipments operation and traditional farm power source, the economical evaluation of the crop production had been calculated (Karale *et al*, 2008).

2.1 Computation of parameters

Energy analysis was performed based on field operations (like land preparation, sowing, interculture, harvesting, and residue management) as well as on the direct (fuel and human labour) and indirect (machinery) energy sources involved in the crop production process. Under normal circumstances, there is no water pumping involved in the kharif/rainy season. For rabi/winter season only wheat crop observation were recorded.

The direct energy use per hectare for each field operation was computed by the following equation (Chaudhary, *et al* 2006; Bockari Gevao *et al* 005),

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

where,

ED = Specific direct energy use (fuel) for a field operation, MJ /ha.

h = Specific working hours per run, h/ha.

AFU = Average fuel use per working hour, l/h.

PEU = Specific energy value per litre of fuel, MJ/l.

RU = Runs, number of applications in the considered field operation.

The energy contribution of machinery for each field operation was determined by the following equation,

$$EID = \frac{TW \times CED}{UL} \times h \times RU \quad (2)$$

where,

EID = Specific indirect energy for machinery use for a field operation, MJ/ha.

TW = Total weight of the specific machine, kg.

CED = Cumulative energy demand for machinery, MJ/ kg.

UL = Wear-out life of machinery, h

h = Specific working hours per run, h/ha.

RU = Runs, number of applications in the considered field operations.

The indirect energy per unit area for other production inputs such as fertilizer, pesticides and seed was expressed as,

$$ED = RATE \times MATENF \quad (3)$$

where,

EID = Indirect energy input, MJ/ha

RATE = Application rate of input, kg/ha

MATENF = Energy factor of material used, MJ/ kg.

The rate of labour use in the rice production process was determined for each operation. The labour energy input (MJ/ha) at every stage in the production process was estimated by the following equation,

$$LABEN = \frac{LABOUR \times TIME}{AREA} \times LABENF \quad (4)$$

where,

LABEN = Labour energy, MJ/ha

LABOUR = Number of working labours

TIME = Operating time, h

AREA = Operating area, ha

LABENF = Labour energy factor, MJ/h.

In this study, an average cumulative energy demand value of 109 MJ/kg was used to represent the embodied energy in the piece of equipment. Where as operations which requiring fossil fuel, human and animal inputs were

evaluated by summarizing the equivalent values from the reviewed literature (Bockari Gevao *et al,* 2005; Singh 2004; Ibrahim *et al,* 2005).

3. Result and Discussion

3.1 Mode of energy used operations

Energy input was classified in to major categories. Energy input through human, animals and tractor operated farm implements were included for farming operations. Human labours were involved for land preparation, sowing, weeding, fertilizer and pesticides application, harvesting and threshing. Due to high demand during sowing as well as at the time of harvesting became peak period of human labour scarcity. On the other hand, the number of draught animals has decreased very rapidly in last two decades due to shortage of grazing fields and problem of maintaining them. Moreover, lack of green fodder, dry fodder and concentrate are the other problem on one side and regular work for draught animals could not distributed throughout the year is another once which resulted in shortage of draught animal. Moreover, the availability of tractor-mounted machines might be another cause of ever decreasing population of draught animal. As a result the availability of draught animal power decreased drastically among the farmers level. Thus due to shortage of draught power, farmers chose tractor as it reduced land preparation cost, saves time and comfortable for farm work. Nowadays, new machines powered by self propelled tool bar, tillers, and tractor operated machines available for seedbed preparation, harvesting of crops and also for crop residue management practices. Such improved machines need to be used as per the operational need for energy management. The study was taken in consideration with proper utilization of energy inputs in a farm to compare the traditional one and its effect on cost of production. Venturi & Venturi 2003 determined energy input and output of three energy crops chains in Europe.

3.2 Trend of energy requirement for traditional and mechanized operations for green gram crop

The operational energy input data of mechanized and traditional cropping for various operations for green gram crop were collected from CRS farm, village Katkheda and Sutala. Collected data were analyzed for studying different energy use patterns and results were depicted in Table 1.

In green gram crop seed bed preparation operation was slightly different. In traditional and mechanized method, tractor operated mould board plough was used for opening of land and for smoothening of land bullock drawn harrow was used in traditional method, where as in mechanized method a self propelled tiller was used. It was observed that the energy requirement was observed to be 1178.7 MJ/ha and 1040.8 MJ/ha in mechanized and traditional method respectively. The energy requirement in mechanized method was quite higher than traditional method, but the cost of operation was observed more in traditional method. In traditional method seed bed preparation cost of operation was more i.e. Rs 2125 per ha as compared to mechanized operation i.e. Rs 1775 per ha. This was due to per unit cost of traditional operational energy was observed to be more due to high amount of man and animal power requirement having lesser energy productivity with costly wages. Similarly, sowing and intercultural operation energy requirement was more in mechanized method where as cost of operation was less over the traditional methods (Table 1). Seyed and Singh 2009 determined energy use in paddy crop under different farm categories in India. Singh *et al* 2004a determined operation wise total energy consumption for rainfed kharif crop is minimum (1187.6 MJ/ha) for moth bean and maximum (1261.9 MJ/ha) for cluster bean. In case of traditional intercultural operation hoeing and weeding requirement was more than that of mechanized method. The cost in terms of weeding and hoeing was less for mechanized method than traditional method. This might be due to the precision work done by tractor operated/self propelled inter-row cultivator. In traditional and mechanized method, harvesting operation was carried out by manual labour due to unavailability of appropriate machinery for the harvesting of green gram. Threshing operation was done by power operated threshers in both the methods i.e. traditional and mechanized threshing operation. Crop residue management was carried out by newly developed tractor operated slasher, which required 552.8 MJ/ha of energy which costing to be Rs 368/ha. In traditional method, manual labours were used for the crop residue management. It required 251.2 MJ/ha energy, which was half than required in mechanized method but cost was near about three times more i.e. Rs 1250/ha. Asakereh *et al,* 2010 have evolved input and output energy for wheat in Iran. They have observed input energy contains of 39.6 % of direct energy and 60.4 % of indirect energy. This was due to energy developed by man power costly than the mechanical power.

Overall energy requirement for green gram production in mechanized method was observed to be 3120.72 MJ/ha having cost of Rs 5147.08 per ha. Energy requirement in traditional method was less i.e. 2680.78 MJ/ha but cost of operation was more i.e., Rs 8407.5 per ha. This might be due to more man and animal hours were engaged in traditional farming operation, which required more wages with less energy production capacity. Asakereh *et al*

2010, determined cost of production in hector was 319600 Rials with cost of preparation of seedbed and harvesting was 34 %, and 29% constituting the cost of machine.

3.3 Trend of energy requirement for traditional and mechanized operations for cotton crop

The operational energy requirements in mechanized and traditional cropping method were observed and analyzed for studying different energy use patterns and results were depicted in Table 2. For cotton crop, seed bed preparation operation was similar as discussed in green gram cropping system. It was seen that energy requirement to be 1178.7 MJ/ha and 1040.8 MJ/ha in mechanized and traditional method respectively. The energy requirements in mechanized method were quite higher than traditional method, but the cost of operation were observed to be more in traditional method. In traditional seed bed preparation, cost of operation were more i.e., Rs 2125.0 per ha as compared to mechanized operation i.e. Rs 1775.0 per ha. The per unit cost of traditional operational energy were observed to be more due to high amount of man and animal power requirement having lesser energy productivity with costly wages. Similarly, sowing and intercultural operation energy requirement were more in mechanized method where as cost of operation were less over the traditional method (Table 2). Singh *et al* 2004(a) determined average specific energy for cultivation of wheat, gram, mustard and rocket salad were 11.4, 16.5, 13.2 & 13.7 MJ/ha respectively. In case of traditional intercultural operation hoeing and weeding requirement was more than mechanized method. The cost in terms of weeding and hoeing has saved in mechanized method. This might be due to the precision work done by inter-row cultivator. In traditional and mechanized method, harvesting operation were carried out by manual labour, due to unavailability of appropriate machinery for the harvesting/picking of cotton crop. Crop residue management were carried out by newly developed tractor operated slasher, which required 559.45 MJ/ha energy of cost Rs 368.0 per ha. In traditional method, manual labours were used for cotton residue management of 630 MJ/ha energy was required for operation. Cost of operation were near about three times more i.e., Rs 1250.0 per ha. This is due to energy developed by manpower was most costly than mechanical power. Burhan *et al* 2004, determined consumed in lemon production a total of 62977.87 MJ/ha followed by orange and mandarin with 60949.69 and 48838.17 MJ/ha respectively. Bahattin & Ali 2008, determined energy consume in tomato production of 45.53 GJ/ha of which diesel energy consumption was 34.82 % followed by fertilizer and machinery energy.

It was observed that the intercultural and picking operation required more energy i.e. near about 1200 MJ/ha next to seed bed preparation. Such type of operations required more manpower. Only cotton picking accounts 768 man-h/ha which account cost of Rs 6000.0 per ha. This indicated that the cotton picking were most costly operation in cotton cultivation and there were a need of cotton picking machine suitable for Indian conditions. This might be useful to reduce cost of cultivation of cotton crop.

Overall energy requirement in cotton crop mechanized method were observed to be 4336.41 MJ/ha having cost of Rs 11439.0 per ha, where as energy requirement in traditional method were less i.e. 4284.28 MJ/ha having cost Rs 14287.5 per ha. This might be due to more man and animal hours were engaged in traditional farming operation, which required more wages with less energy production capacity. Karale *et al 2008*, determined cost of energy of the soybean crop with the mechanized farming is the best option for maximized the net profit of the small farmers in the region. Karale *et al 2008* evaluated operational energy input in traditional farming of soybean and cotton crop was observed more than mechanized farming.

3.4 Trend of energy requirement for traditional and mechanized operations for soybean crop

The operational energy input data of mechanized and traditional cropping for various operations for soybean crop were collected from Central Research Station farm, village Katkheda and Sutala. Collected data were analyzed for studying different energy use patterns and results were depicted in Table 3.

In soybean crop seed bed preparation operation were slightly different. In traditional and mechanized method tractor operated mould board plough was used for opening of land and for smoothening of land bullock drawn harrow was used in traditional method, where as in mechanized method a self propelled tiller was used. It was observed that the energy requirement were observed to be 1178.7 MJ/ha and 1040.8 MJ/ha in mechanized and traditional method respectively. The energy requirement in mechanized method was quite higher than traditional method, but the cost of operation was observed to be more in traditional method. In traditional seed bed preparation cost of operation were more i.e. Rs 2125.0 per ha as compared to mechanized operation i.e. Rs 1775.0 per ha. This was due to per unit cost of traditional operational energy were observed to be more due to high amount of man and animal power requirement having lesser energy productivity with costly wages. Similarly, sowing and intercultural operation energy requirement pattern were more in mechanized method at which cost of operation were less over the traditional methods (Table 3). Baruah & Bora 2008 stated economic analysis considering the prevailing rate of input commodities also fever agricultural mechanization in Assam.

In case of intercultural operation in traditional method number of hoeing and weeding requirement was more than mechanized method. The cost of operation for weeding and hoeing was less for mechanized method than traditional method. This might be due to the precision work done by inter-row cultivator. In traditional and mechanized method, harvesting operation was carried out by manual labour, due to unavailability of appropriate machinery for the harvesting of soybean crop. Threshing operation was carried out by power operated threshers in both the methods. Crop residue management were carried out by newly developed tractor operated slasher, which required 552.8 MJ/ha energy accounting cost of Rs 368 per ha. In traditional method for crop residue management manual labours were used. It required 251.2 MJ/ha energy, which account cost of operation half than in mechanized method (Rs 1250.0 per ha). This was due to energy developed by man power is costly than the mechanical power. Singh *et al* 2004(b) evaluated maximum energy is required for rising cotton crop, followed by wheat, mustard, maize & cluster bean.

Overall energy requirement in soybean crop for mechanized method were observed to be 3417.28 MJ/ha having cost of Rs 6955.0/ha, where as energy requirement in traditional method was less i.e. 2655.36 MJ/ha but having cost Rs 9757.5 per ha. This might be due to more man and animal hours were engaged in traditional farming operation, which required more wages with less energy production capacity. Baruah & Bora 2008, determined operational costs ($/ha) for the three strategic mechanization scenario are 435, 375, & 403 which are lesser than the cost of non-mechanized scenario (491) by 11 %, 24 % & 18 % respectively.

3.5 Trend of energy requirement for traditional and mechanized operations for sorghum crop

The operational energy requirements in mechanized and traditional cropping method were observed and analyzed for studying different energy use patterns and results were depicted in Table 4.

In sorghum crop seed bed preparation operation was slightly different. In traditional and mechanized method tractor operated mould board plough was used for opening of land and for smoothening of land bullock drawn harrow was used in traditional method, where as in mechanized method a self propelled tiller was used. It was observed that energy requirement were observed to be 1178.7 MJ/ha and 1040.8 MJ/ha in mechanized and traditional method respectively. The energy requirement in mechanized method was quite higher than traditional method, but the cost of operation was observed to be more in traditional method. In traditional method, cost of seedbed preparation were more i.e., Rs 2125.0 per ha as compared to mechanized operation i.e. Rs 1775.0 per ha. This is due to per unit cost of traditional operational energy were observed to be more due to high amount of man and animal power requirement having lesser energy productivity with costly wages. Similarly, sowing and intercultural operation energy requirement was more in mechanized method which account cost of operation was less over the traditional method (Table 4). Nautiyal *et al* 2007 determined production cost in term of energy for introduces crops such as tomato, bell pepper cultivation was 90358-320516 MJ/ha as compare to between 19814 & 42380 MJ/ha for traditional crops within Himalaya agroecosystems.

In case of traditional method intercultural operation number of hoeing and weeding requirement was more than in mechanized method. The cost in terms of weeding and hoeing was less for mechanized method than traditional method. This might be due to the precision work done by inter-row cultivator. In traditional and mechanized method harvesting operation were carried out by manual labour due to unavailability of appropriate machinery for the harvesting of sorghum crop and total man-h consumed were found to be 256 man-h/ha of costing Rs 4000.0 per ha. Crop residue management was carried out by newly developed tractor operated slasher of energy requirement was 552.8 MJ/ha having cost of operation Rs 368.0 per ha. In traditional method, manual labours were used for the sorghum crop residue management. It required 251.2 MJ/ha of energy which account half times lesser energy than in mechanized method but cost was near about three times more i.e., Rs 1250.0 per ha. This was due to energy developed by manpower was most costly. Ibrahim *et al* 2005 determined important cost items in field operation were labour, machinery costs, land rent & pesticide costs.

Overall energy requirement in sorghum crop for mechanized method was observed to be 3555.52 MJ/ha having cost of Rs 8320.0 per ha, where as energy requirement in traditional method was less i.e., 2675.28 MJ/ha having cost Rs 11257.5 per ha. This might be due to more man and animal hours were engaged in traditional farming operation which required more wages with less energy production capacity.

3.6 Trend of energy requirement for traditional and mechanized operations for wheat crop

The operational energy input data of mechanized and traditional cropping for various operations for wheat crop was collected from Central Research Station farm, village Katkheda and Sutala. This data was analyzed for studying different energy use patterns and results were depicted in Table 5.

In wheat crop seed bed preparation operation were slightly different. In traditional and mechanized method tractor operated mould board plough was used and for smoothening of land bullock drawn harrow was used in traditional method, where as in mechanized method a self propelled tiller was used. It was observed that the energy requirement were observed to be 1178.7 MJ/ha and 1040.8 MJ/ha in mechanized and traditional method respectively. The energy requirement in mechanized method was quite higher than traditional method, but the cost of operation was observed to be more in traditional method. In traditional method seed bed preparation cost of operation was more i.e., Rs 2125.0 per ha as compared to mechanized operation i.e., Rs 1775.0 per ha. This was due to per unit cost of traditional operational energy were observed to be more due to high amount of man and animal power requirement having lesser energy productivity with costly wages. Similarly, sowing and intercultural operation energy requirement was more in mechanized method where as cost of operation was less over the traditional method (Table 5). Singh *et al* 2004(c) evaluated operation wise, the total energy used values for cultivating the pearl millet crop where found to be 3807.4 MJ/ha compare to 697.9MJ/ha for green gram and 876.3MJ/ha for wheat.

In case of traditional intercultural operation number of hoeing and weeding requirement was more than in mechanized method. The cost in terms of weeding and hoeing was less for mechanized method than traditional method. This might be due to the precision work done by inter-row cultivator. The harvesting operation was carried out by manual labour in traditional method and by harvester in mechanized method**.** Threshing operation was done by power operated threshers in both methods. Crop residue management were carried out by newly developed tractor operated slasher, which required 552.8 MJ/ha energy of costing Rs 368.0 per ha. In traditional method, manual labours were used for residue management in wheat (31.36 MJ/ha). In traditional method, this operation was carried out by burning all residue, due to this land would not get any returns in terms of nutrients and organic matter. De *et al* 2001 studied energy consumption of bullock and tractor power (mixed farming) in rainfed farms of soybean cultivation in Madhya Pradesh.

Overall energy requirement in wheat crop for mechanized method were observed to be 2736.46 MJ/ha having cost of Rs 5083.0 per ha, where as energy requirement in traditional method were less i.e., 1774.88 MJ/ha having cost Rs 6137.5 per ha. This might be due to more man and animal hours were engaged in traditional farming operation, which required more wages with less energy production capacity. Singh *et al* 2004 stated that 1% increase in source wise energy input use would result in increase in production of wheat.

3.7 Overall trend of energy requirements in traditional and mechanized operation

From table 1 to 5, it was observed that the energy requirement for green gram accounts for 2680.78 MJ/ha in traditional methods with cost of operation about Rs 8407.5 per ha where as in mechanized package, the energy input increased up to 3130.72 MJ/ha with cost of operation Rs 5147.0 per ha. Similarly, for cotton, soybean, sorghum and wheat crop, traditional energy requirements were observed to be 4284.28, 2655.36, 2675.36 and 1774.88 MJ/ha respectively. The cost of operations was Rs 14287.0, 9757.0, 11257.0 and 6137.5 per hectare in traditional farming for crop growing operations. In mechanized method the energy requirements increased up to 4336.0, 3417.0, 3555.0 and 2736.0 MJ/ha of costing Rs 11439.0, 6955.0, 8230.0 and 5083.0 per hectare in respect of above-mentioned crops. Ibrahim *et al* 2005 revealed that cotton production consumed a total of 49.73 GJ/ha of which diesel energy consumption was 31.1 % followed by fertilizer and machinery energy. Vecdi *et al* 2006 determined energy and economics of sweet cherry production with energy consumption for diesel fuel was 21.53 % of the total energy input.

From these results, it was observed that the mechanization of farm operations of particular crops increased the energy inputs. Whereas, due to less cost of energy production in mechanized methods, it reduced the cost of cultivation. The most labour and cost consuming operations were the weeding, hoeing and harvesting of crops, which traditionally depends on human power. The cost of operation of weeding and hoeing operations were reduced due to précised intercultural operations, but there were need of appropriate crop harvesting machines for the all crop, which might be useful to reduce the cost of cultivation of all crops studied. Yasin & Ali 2009 determined operational cost of machines /implements, in which rota drill helped in advancing the sowing of wheat and saved time and energy required for the tillage operation to prepared a seedbed with cost of operation 0.28 $/ha. Kathirven *et al,* 2009 determined energy cost for weeding operation was maximum for Balram power weeder and minimum for the TNAU Varun power weeder.

4. Conclusions

In present study, the operational energy input of the crop like green gram, cotton, soybean, sorghum and wheat was collected for traditional and mechanized system. The possible mechanized operations for all above mentioned crops were carried out at CRS farm, Dr. PDKV, Akola where as the data of traditional methods were collected

from Katkheda and Sutala village. The operations considered were land preparation, sowing, intercultural, harvesting and crop residue management etc. The inputs like human power, bullock power for traditional operation were studied in entire work of the research. Similarly, for the same crops these operations were carried out by the mechanized practice for the exact quantification of the operational energy input. The study reflects the energy use patterns in mechanized and traditional farming and optimized energy efficient cropping system through mechanized farming over traditional farming

It seen that traditional operational energy requirement increases from 2680.78 MJ/ha in traditional method to 3130.72 MJ/ha in mechanized method for green gram crop. But the cost were from Rs 8407.5 per ha in traditional method to Rs 5147.0 per ha in mechanized system. Similar trend were observed in cotton, soybean, sorghum and wheat crops. Based on the study results following conclusions could be drawn;

- Mechanization of crop production increases the energy inputs with decrease in cost of operation.
- Weeding and hoeing are the most labour consuming operations, which increases the cost of operation.
- Harvesting of green gram, cotton, soybean and sorghum required more labour energy, which increases cost of operation.
- Mechanization in terms of seed bed preparation, sowing, hoeing and crop residue management shows that there is increase in energy inputs but decrease in cost of operation.
- Précised hoeing operation by the inter row cultivator reduces the number of weeding operation and labour requirement of the studied crops.
- In-situ crop residue management by tractor operated slasher will be support to improve soil health.

References

Asakereh, A., Rafiee, S., Aadati, S. A. and Aafaee, M. (2010). Dry farming wheat in peasant farming system in Kuhdasht county of Iran: energy consuming and economic efficiency. *Journal of Agricultural Technology*, 6(2), 201-210.

Burhan Ozkan, Handan Akcaoz & Feyza Karadeniz. (2004). Energy requirement and economic analysis of citrus production in Turkey. *Energy Conversion and Management*, 45, 1821–1830.

Bahattin Cetin & Ali Vardar. (2008). An economic analysis of energy requirements and input costs for tomato production in Turkey. *Renewable Energy*, 33, 428–433.

Bockari Gevao, S. M., W. I. Wan Ishak, Y. Azmi and C. W. Chan. (2005). Analysis of energy consumption in lowland rice based cropping system of Malasia. Songklanakarin. *Journal of Science & Technology*, 27(4), 819-826.

Chaudhary, V., B. Gangwar and D. Pande. (2006). Auditing of energy use and output of different cropping systems in India. *Agricultural Engineering International: the CIGR Ejournal,* Manuscript EE05 001, VIII.

D. S. Karale, V. P. Khambalkar, S. M. Bhende, Sharddha B. Amle & Pranali S. Wankhede. (2008). Energy economic of small farming crop production operations. *World Journal of Agricultural Sciences*, 4 (4), 476-482.

Debendra C. Baruah & Ganesh C. Bora. (2008). Energy demand forecast for mechanized agriculture in rural India. *Energy Policy*, 36, 2628– 2636.

De, Dipankar, R.S., Singh & Hukum Chandra. (2001).Technological impact on energy consumption in rainfed soybean cultivation in Madhya Pradesh. *Applied Energy*, 70, 193–213.

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

Gursahib Singh, Surendra Singh & Jasdev Singh. (2004). Optimization of energy inputs for wheat crop in Punjab. *Energy Conversion and Management*, 45, 453–465.

Ibrahim Yilmaz, Handan Akcaoz, Burhan Ozkan. (2005). An analysis of energy use and input costs for cotton production in Turkey. *Renewable Energy*, 30, 145–155.

Jekayinfa, S.O. (2006). Energy consumption pattern of selected mechanized farms in Southwestern Nigeria. *Agricultural Engineering International. The CIGR Ejournal*, Manuscript EE 06 001, VIII.

Kathirvel K., S. Thambidurai, D.Ramesh & D. Manohar Jesudas. (2009). Ergonomics of self propeller power weeders as influenced by forward speed and terrain condition. *AMA*, 40(4), 28-33

Piero Venturia, Gianpietro Venturi. (2003). Analysis of energy comparison for crops in European agricultural systems. *Biomass and Bioenergy*, 25, 235 – 255.

Seyed Mehdi Nassiri & Surendra Singh. (2009). Study on energy use efficiency for paddy crop using data envelopment analysis (DEA) technique. *Applied Energy,* 86, 1320–1325

Singh, H., D. Mishra & N. M. Nahar. (2004). Energy use pattern in production agriculture of a typical village in arid zone—Part III. *Energy Conversion and Management*, 45, 2453–2472.

Singh, H., D. Mishra, N. M. Nahar & Mohnot Ranjan. (2003). Energy use pattern in production agriculture of a typical village in arid zone India: part II. *Energy Conversion and Management*, 44, 1053–1067.

Singh, H., D. Mishra, N. M. Nahar. (2002). Energy use pattern in production agriculture of a typical village in arid zone, India—part I. *Energy Conversion and Management*, 43, 2275–2286.

Sunil Nautiyal, H. Kaechele, K. S. Rao, R. K. Maikhuri & K. G. Saxena. (2007). Energy and economic analysis of traditional versus introduced crops cultivation in the mountains of the Indian Himalayas: A case study. *Energy*, 32, 2321–2335.

Srivastava, N. S. L. (2006). Farm power sources their availability and future requirement to sustain agricultural production status of farm mechanization in India, IASRI, ICAR, PUSA, New Delhi: 57-58.

Stout, B. A. (1990). Handbook of energy for world agriculture. *Elsevier Applied Science*, London.

Vecdi Demircan, Kamil Ekinci, Harold M. Keener, Davut Akbolat & Caglar Ekinci. (2006). Energy and economic analysis of sweet cherry production in Turkey: A case study from Isparta province. *Energy Conversion and Management*, 47, 1761–1769.

Yasin Muhammad & Muhammad Anjum Ali. (2009). Design, development and performance evaluation of rota drill. *AMA*, 40 (3), 35-40.

Table 1. Traditional and mechanized inputs for various farm operations of green gram crop

S N	Various Operations	Mechanized energy MJ/ha	Cost of Operation Rs./ha	Traditional energy MJ/ha	Cost of Operation Rs./ha
1	Seed bed preparation	1178.7	1775.0	1040.48	2125.0
2	Sowing Operations	249.95	289.0	144.32	812.5
3	Intercultural operations	819.67	1315.0	915.18	2820.0
4	Harvesting Operations and threshing	329.6	1400.0	329.6	1400.0
5	Crop residue management	552.8	368.0	251.2	1250.0
	Total operational energy(MJ/ha)	**3130.72**	**5147.00**	**2680.78**	**8407.5**

Table 2. Traditional and mechanized inputs for various operations of cotton crop

S N	Various Operations	Mechanized energy MJ/ha	Cost of Operation Rs./ha	Traditional energy MJ/ha	Cost of Operation Rs./ha
1	Seed bed preparation	1178.7	1775.0	1040.48	2125.0
2	Sowing Operations	220.03	535.0	175.72	812.5
3	Intercultural operations	1172.47	2761.0	1232.32	4100.0
4	Harvesting and threshing	1205.76	6000.0	1205.76	6000.0
5	Crop residue management	559.45	368.0	630	1250.0
	Total operational energy (MJ/ha)	**4336.41**	**11439.00**	**4284.28**	**14287.5**

Table 3. Traditional and mechanized inputs for various operations of soybean crop

S N	Various Operations	Mechanized energy MJ/ha	Cost of Operation Rs./ha	Traditional energy MJ/ha	Cost of Operation Rs./ha
1	Seed bed preparation	1178.7	1775.0	1040.48	2125.0
2	Sowing Operations	258.18	278.0	144.32	812.5
3	Intercultural operations	1114	1884.0	905.76	2920.0
4	Harvesting and threshing operations	313.6	2650.0	313.6	2650.0
5	Crop residue management	552.8	368.0	251.2	1250.0
	Total operational energy (MJ/ha)	**3417.28**	**6955.00**	**2655.36**	**9757.5**

Table 4. Traditional and mechanized inputs for various operations of sorghum crop

S N	Various Operations	Mechanized energy MJ/ha	Cost of Operation Rs./ha	Traditional energy MJ/ha	Cost of Operation Rs./ha
1	Seed bed preparation	1178.7	1775.0	1040.48	2125.0
2	Sowing Operations	258.18	255.0	144.32	812.5
3	Intercultural operations	1114	790.0	787.44	3070.0
4	Harvesting and threshing operations	451.84	4000.0	451.84	4000.0
5	Crop residue management	552.8	1500.0	251.2	1250.0
	Total operational energy (MJ/ha)	**3555.52**	**8320.00**	**2675.28**	**11257.5**

Table 5. Traditional and mechanized inputs for various operation of wheat crop

S N	Various Operations	Mechanized energy MJ/ha	Cost of Operation Rs./ha	Traditional energy MJ/ha	Cost of Operation Rs./ha
1	Seed bed preparation	1178.7	1775.0	1040.48	2125.0
2	Sowing operations	233.94	390.0	144.32	812.5
3	Intercultural operations	188.32	550.0	150.72	550.0
4	Harvesting and threshing operations	582.7	2000.0	408	2550.0
5	Crop residue management	552.8	368.0	31.36	100.0
	Total operational energy (MJ/ha)	**2736.46**	**5083.00**	**1774.88**	**6137.5**

 ISSN 1916-9752 E-ISSN 1916-9760