The Pharma Innovation Journal 2022; SP-11(7): 4355-4362

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(7): 4355-4362

www.thepharmajournal.com
Received: 08-05-2022
Accepted: 09-06-2022

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Energy requirement in different farm operation

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Abstract
Energy use in agriculture has been increasing since green revolution in the late sixties. The pattern and rate of growth of demand for energy sources is influenced by a number of factors such as increasing population, growing urbanization, rising house hold income and changing life style. The power necessary for agricultural production is provided by human labour, draught animals and engine-driven machinery. Energy analysis is based on field operations (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. Animal energy was found maximum (439.07 MJ/ha) for small farmers and minimum (68.03 MJ/ha) for large farmers in various farm categories. Human energy was found maximum (343.44 MJ/ha) for marginal farmers and minimum (145.83 MJ/ha) for large farmers in various farm categories and for machine energy was found maximum (4148.65 MJ/ha) for large farmers and minimum (900.40 MJ/ha) for small farmers.

Keywords: Energy, draught animal, energy equivalent, crop production

Introduction

In India, energy use in agriculture has been increasing since green revolution in the late sixties with increasing use of high yielding seed varieties, synthetic fertilizers, agro-chemicals, as well as diesel and electricity in farm operations. The pattern and the rate of growth of demand for energy sources is influenced by the number of factors as increasing population, growing urbanization, rising house hold income, changing life style and structural changes taking place in the economy.

Energy plays a central role in national development process and in providing major vital services that improve human condition, in agricultural sector, energy is used in every form of inputs seed, fertilizer, agrochemical for plant protection, machinery use for various operations, and is directly linked with the technological progress. In modern agriculture, commercial energy sources contribute bulk of the energy supplies to the production system. The extents of uses of agricultural inputs have been increasing over years leading to higher productivity.

With increasing demand of commercial energy resources in production and processing of agro product energy management would play a key role in developing regional/national coherent an Implementable Strategies for energy conservation, adopting energy efficient technologies as well as determining an appropriate energy resource-mix of conventional and renewable energy resources for minimizing energy cost.

A reliable supply of energy, in the right form, at the right time and at affordable prices, is an essential prerequisite for high agricultural productivity. During the past two decade lots of study has been conducted around the world with the general goals of

1. Improving the efficiency of input energy.
2. Developing alternative fuels to liquid fuels petroleum or natural gas for use in agriculture.

The power necessary for agricultural production is provided by human labour, draught animals or engine-driven machinery. Mechanisation is a key input in any farming system applying tools, implements and machinery to improve the productivity of farm labour and land. Based on the power source, the technological levels of mechanisation have been broadly classified as hand-tool technology, draught animal technology and mechanical power technology.

The bulk of direct energy inputs in smallholder production is provided by human and draught animal power (DAP). Agriculture in developing countries relies heavily on the physical capability of farmers, with often limited output, depending on the physical energy available. A fit person consumes around 250-300 W in terms of energy, depending on climate and with a rest of 10-30 minutes/hour. The efficiency of energy conversion is only 25 per cent, with a maximum power output of 75 W.

Methodology

Computation of parameters

Energy analysis is 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 Direct Energy: (MJ/ha)

1. Direct Energy of Labour = No. of labours * Working hours * Energy Equivalent.
2. Direct Energy of Fuel = Fuel Consumption * Operational time * Energy Equivalent.
3. Direct Energy of Electricity = Units Consumed * Energy Equivalent.

(Unit Consumed= Pump Power * 0.746 * Pump Efficiency * Operational Time)

For Indirect Energy: (MJ/ha)

1. Indirect Energy = $\frac{Weight}{Life}$ * Energy Equivalent * Operational Time (Tractor, Machinery).
2. Indirect Energy = Weight of seed * Energy Equivalent (Seed)ice.
3. Indirect Energy = Amount used * Energy Equivalent (Fertilizers, Herbicides).

Table 1: Energy conversion coefficients for direct energy input

Sr. No.	Energy Equivalents	Values
1.	Man	1.96 MJ/h
2.	Tractor	68.4 MJ/kg
3.	Machinery	62.7 MJ/kg
4.	Seed	14.7 MJ/kg
5.	N	60.6 MJ/kg
6.	P	11.11 MJ/kg
7.	K	6.7 MJ/kg
8.	Electricity	11.93 MJ/KWH
9.	Petrol, Diesel	48.8, 56.31 MJ/L
10.	Herbicides and Pesticides	120 MJ/kg

1. Field preparation

Field should be ploughed using mould board plough and tilled using cultivator 3-4 times to eliminate debris and soil clods. Organic manure equivalent to 75 kg N/ha (FYM 15 t/ha or poultry manure 7.5 t/ha or vermicompost 7.5 t/ha should be incorporated at the time of last ploughing and beds of appropriate size should be prepared after levelling. Mostly, flat beds of 1.5-2.0 m width and 4-6 m length are formed. But, for *kharif* or rainy season, flat beds should be avoided to prevent water logging. For this season, broad bed furrows (BBF) of 15 cm height and 120 cm top width with 45 cm furrow are formed, which are suitable for drip and sprinkler irrigations.

A. Primary tillage operation

Ploughing: Ploughing is opening the upper crust of the soil, breaking the clods and making the soil suitable for sowing seeds. The main implement used for primary tillage is a plough.

Mould board plough

Mouldboard plough is one of the oldest of all agricultural implements and is generally considered to be the important tillage implement. Ploughing accounts for more traction energy than any other field operation. Mouldboard ploughs are available for animals, power tiller and tractor operation. While working, a mouldboard plough does four jobs namely

A) Cutting the furrow slice.
B) Lifting the furrow slice.
C) Inverting the furrow slice.
D) Pulverizing the furrow slice.

Fig 1: MB Plough

Disc plough

A action of a disc plough is similar to the mouldboard plough. Disc plough cuts, turns and in some cases breaks furrow slices by means of separately mounted large steel concave discs. A disc plough is designed with a view to reduce friction by making a rolling plough bottom instead of sliding plough bottom as in the case of mouldboard plough. A disc plough works well in the conditions where mouldboard plough does not work satisfactorily.

Fig 2: Disc Plough

Rotary tiller

The rotary cultivator is widely considered to be the most important tool as it provides fine degree of pulverization enabling the necessary rapid and intimate mixing of soil besides reduction in traction demanded by the tractor driving wheels due to the ability of the soil working blades to provide some forward thrust to the cultivating outfit. The functional components include tynes, rotor, transmission system, universal joint, leveling board, shield, depth control arrangement, clutch and three-point linkage connection

Rotary tiller is directly mounted to the tractor with the help of three point linkage. The power is transmitted from the tractor PTO (Power Take Off) shaft to a bevel gear box mounted on the top of the unit, through telescopic shaft and universal joint. From the bevel gear box the drive is further transmitted to a power shaft, chain and sprocket transmission system to the rotor. The tynes are fixed to the rotor and the rotor with tynes revolves in the same direction as the tractor wheels. The number of tynes varies from 28-54. A leveling board is attached to the rear side of the unit for leveling the tilled soil. A depth control lever with depth wheel provided on either side of the unit ensures proper depth control. The cost of the unit varies from Rs.62, 000/- to 1,10,000/-.

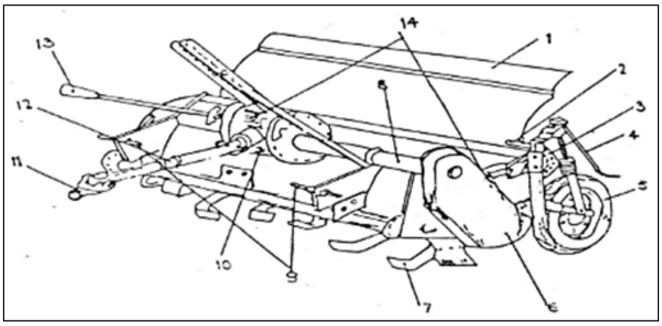

Fig 3: Tractor Operated rotary tiller

1. Protecting cover
2. Lock pin
3. Lock holes
4. Depth control lever
5. Depth wheel
6. Chain sprocket mechanism (oil sealed)
7. Rotor blade (L-type)
8. Power shaft
9. Three point linkage
10. Gear box
11. PTO attachment
12. Telescopic shaft
13. Clutch lever
14. Oil filling plug

B. Secondary tillage operation

Disc harrow

It is a harrow, which performs the harrowing operation by means of a set of rotating discs, each set being mounted on a common shaft. Disc harrow is found very suitable for hard ground with full of stalks and grasses. It cuts the lumps of soil, clods and roots. Discs are mounted on one, two or more axles which may be set at a variable angle to the line of motion. As the harrow is pulled ahead, the discs rotate on the ground.

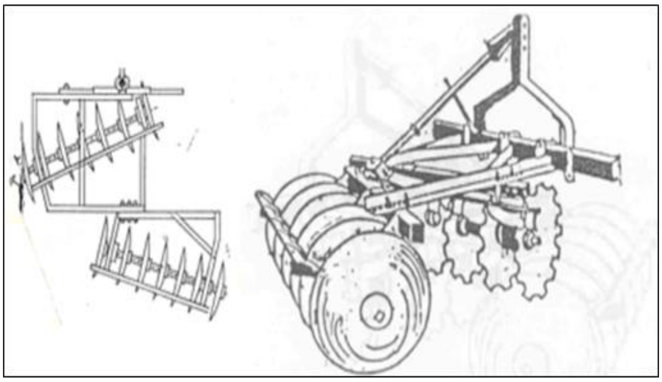

Fig 4: Disc Harrow

Power harrow-tractor drawn

A power harrow tills the soil maintaining the same profile of the field. It pulverizes the upper and lower layer of soil without turning them up side down and thus it forms a good seed bed as well as good soil mulch. It consists of two horizontal cross bars fitted with rigid pegs which reciprocate taking power from the PTO of a tractor. The pegs are spaced 200 mm wide and are staggered with respect to each cross bar. The two bars move in opposite directions and hence the implement is dynamically balanced. The oscillating pegs break the clods and pulverizes the soil to a fine tilth. The width of the operation is 2000 mm. and the field capacity is around 1.5 ha/day.

Fig 5: Power Harrow

Clod crusher

It is used to finish preparing the seed bed by thoroughly pulverizing and firming the loose soil so that there will not be any large air space or pockets. It presses the upper soil down against the sub soil, making a continuous seedbed in which moisture is conserved and given to the roots of the plants as it is needed.

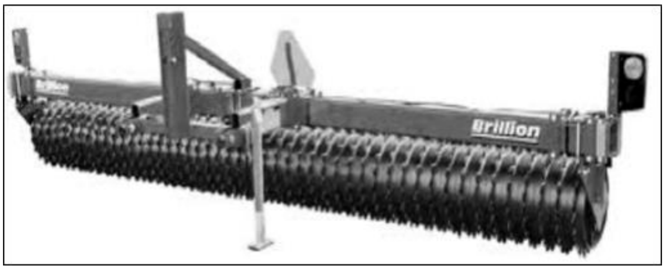

Fig 6: Clod Crusher

Energy required for field preparation

Table 2: Considerations

Implement used	1 MB Plough + 2 harrow/cultivator
Implement I weight (wt), kg	320
Implement I operational time, h/ha	5.70
Fuel Consumption, l/h	3.89
Fuel Consumption, l/ha	22.17
Implement II weight	180
Implement II operational time, h/ha	3.30
Fuel Consumption, l/h	3.72
Fuel Consumption, l/ha	12.28
Total tractor time, h/ha	9
1 man equivalent, MJ/h	1.96
Tractor weight, kg	1800
Useful life of tractor, h	10000
Useful life of implement I, h	3000
Useful life of implement II, h	3000
Human, h	9
Tractor energy equivalent, MJ/kg	68.5
Machine energy equivalent, MJ/kg	62.7
Total fuel consumption, l/ha	34.45
Fuel energy equivalent, MJ/l	56.31

a) Direct energy

1. Direct fuel energy, MJ/ha = Total fuel consumption, l/ha * Fuel energy equivalent, MJ/l
= 34.45 * 56.31
= 1939.8 MJ/ha

2. Direct labour energy, MJ/ha = No. of labours * Working hours * Energy Equivalent
= 1*9*1.96
= 17.64MJ/ha

Total Direct energy = 1939.8 + 17.64
= 1957.44 MJ/ha

b) Indirect energy

1. Tractor indirect Energy = $\frac{Weight}{Life}$ * Energy Equivalent * Operational Time
= $\frac{1800}{10,000}$ *68.4*9
= 110.9 MJ/ha

2. Machine Indirect Energy (MB plough) = $\frac{Weight}{Life}$ * Energy Equivalent * Operational Time
= $\frac{320}{3,000}$ * 62.70* 5.70
= 38.12 MJ/ha

3. Machine Indirect Energy (MB plough) = $\frac{Weight}{Life}$ * Energy Equivalent * Operational Time
= $\frac{180}{3,000}$ * 62.70* 3.30
= 12.41 MJ/ha

Total indirect energy MJ/ha = 110.9+ 38.12+ 12.41
= 161.43 MJ/ha

Total energy in field preparation = Total direct energy + Total indirect energy
= 1957.44 +161.43
= 2118.87 MJ/ha

Total energy in field preparation is 2118.87 MJ/ha.

2. Sowing process

Seed drill

Seed drill is a machine for placing the seeds in a continuous flow in furrows at uniform rate and at controlled depth with or without the arrangement of covering them with soil. Seed drills, fitted with fertilizer dropping attachment, distribute the fertilizer uniformly on the ground. It is called seed cum fertilizer drill. Such a drill has a large seed box which is divided lengthwise into two compartments, one for seed and another for fertilizers. Seed drill may be classified as

1. Bullock drawn.
2. Tractor drawn.

Depending upon the method of metering the seeds, bullock drawn seed drill can be further divided into two groups based on the type of seed dropping as by hand or mechanically. There are a number of bullock drawn implements which are used for sowing seeds in which seeds are dropped by hand. The most popular implement is three lined cultivators with seeding attachment. In different parts of the country it is made in different sizes and shapes.

Fig 7: Seed Drill

Energy required for sowing

Table 3: Considerations

Implement used	Seed cum fertilizer drill
Implement weight (wt), kg	238
Implement operational time, h/ha	2.12
Fuel Consumption, l/h	3.45
Fuel Consumption, l/ha	7.31
Total tractor time, h/ha	2.12
1 man equivalent, MJ/h	1.96
Tractor wt, kg	1800
Useful life of tractor, h	10000
Useful life of implement I, h	2000
Human, h	2.12
Tractor energy equivalent, MJ/kg	68.4
Machine energy equivalent, MJ/kg	62.70
Total fuel consumption, l/ha	7.31
Fuel energy equivalent, MJ/l	56.31

a) Direct Energy

1. Direct fuel energy, MJ/ha = Total fuel consumption, l/ha * Fuel energy equivalent, MJ/l
= 7.31 * 56.31
= 411.85 MJ/ha

2. Direct labour energy, MJ/ha = No. of labours * Working hours * Energy Equivalent
= 1*2.12*1.96
= 4.16 MJ/ha

Total Direct energy = 411.85 + 4.16
= 416.01 MJ/ha

b) Indirect energy

1. Tractor Indirect Energy = $\frac{Weight}{Life}$ * Energy Equivalent * Operational Time
= $\frac{1800}{10,000}$ * 68.4 * 2.12
= 26.1 MJ/ha

2. Machine Indirect Energy = $\frac{Weight}{Life}$ * Energy Equivalent * Operational Time
= $\frac{238}{2,000}$ * 62.70* 2.12
= 15.82 MJ/ha

3. Seed Indirect Energy = Weight of seed * Energy Equivalent
= 110*14.7
= 1617

Total indirect energy in sowing, MJ/ha = 26.1+ 15.82+ 1617
= 1658.92 MJ/ha

Total energy in sowing = Total direct energy in sowing + Total indirect energy in sowing
= 416.01 +1658
= 2074.01 MJ/ha

Total energy in sowing operation is 2074.01 MJ/ha.

3. Harvesting and threshing process

Tractor operated flail type forage harvester cum chopper

This machine in a single operation can harvest chop and load the chopped fodder in the tractor-trailer attached to the machine. It is operated by a 26.1 kW tractor (Fig. 8). This machine in a single operation can harvest, chop and load the chopped fodder like maize, *bajra*, and oats in the trailer attached to the machine. It consisted of a rotary shaft on which flails are mounted to harvest the crop, auger for conveying the cut crop, cutters for chopping & conveying chopped fodder through outlet into the trailer. After the blades cut the crop, it comes in auger, which conveys it to the chopping mechanism. The chopping mechanism cuts the crop into pieces and chopped material is thrown out with a high speed and is filled into the trailer hitched to the machine. Working capacity of forage harvester is 0.2 ha/h. Weight of the machine is about 670.0 kg.

Fig 8: Harvester

4. Threshing process

Threshing involves beating or rubbing the plant material to detach the seed from its pod or fruit. The detached seed is then winnowed to remove chaff, straw and other light material from the seed. Various types of threshing machines with adjustable cylinder speeds are available for extraction of vegetable seeds. The cylinder clearance, concave mesh size, airflow rate and screen size greatly influence the efficiency of these machines. Every care must be taken to avoid damage to the seed during mechanical threshing, by properly adjusting the speed of the beaters, the width of the gap between the beaters and the concave, the airflow and the sieve sizes.

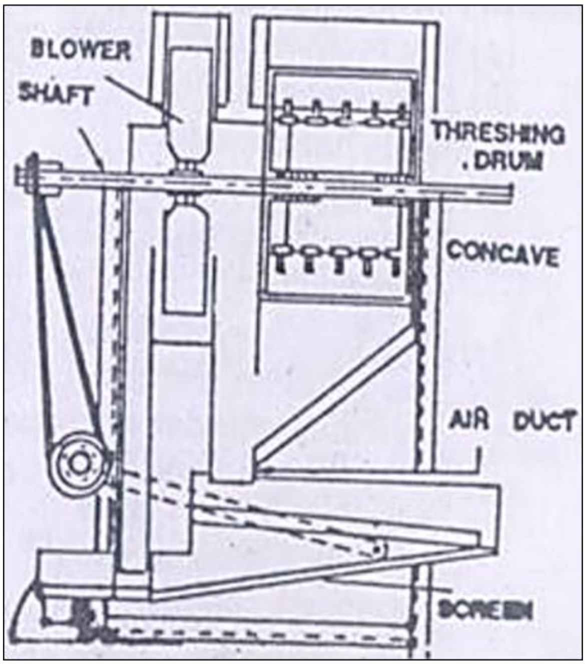

Fig 9: Thresher

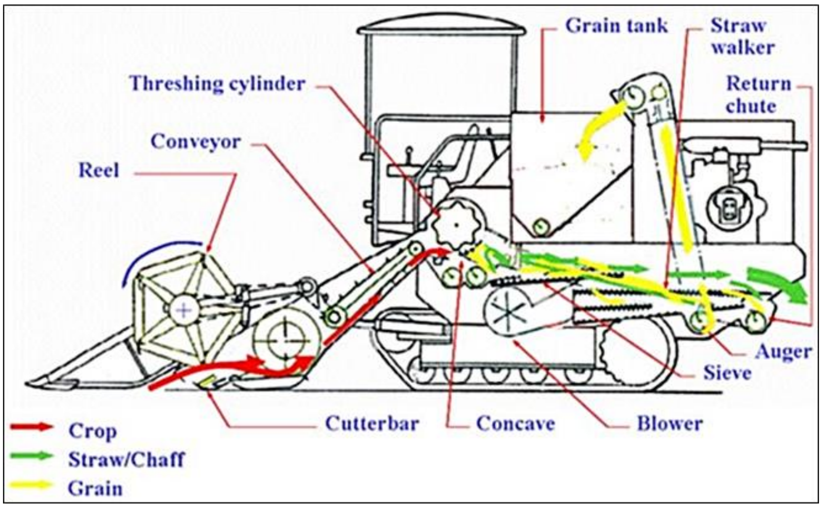

Fig 10: Combine Harvester

Energy required for harvesting and threshing

Table 4: Considerations

Implement used	Combine
Implement I weight (wt), kg	7400
Implement I operational time, h/ha	1.25
Fuel Consumption, l/h	8.00
Fuel Consumption, l/ha	10
Combine time, h/ha	1.25
1 man equivalent, MJ/h	1.96
Useful life of implement I, h	3000
Human, h	250
Machine energy equivalent, MJ/kg	68.5
Total fuel consumption, l/ha	10
Fuel energy equivalent, MJ/l	57.31
Direct fuel energy, MJ/ha	573.10
Direct labour energy, MJ/ha	4.93
Direct electrical energy MJ/ha	1
Total Direct Energy in harvesting, MJ/ha	579.03
Indirect machine energy MJ/ha	211.21
Total energy in harvesting MJ/ha	791.23

a) Direct energy

1. Direct fuel energy, MJ/ha = Total fuel consumption, l/ha * Fuel energy equivalent, MJ/l
= 10 * 57.31
= 573.10 MJ/ha

2. Direct labour energy, MJ/ha = No. of labours * Working hours * Energy Equivalent
= 2*1.25 *1.96
= 4.9 MJ/ha

Total Direct energy = 573.10 + 4.9
= 578 MJ/ha

b) Indirect energy

Machine Indirect Energy = $\frac{Weight}{Life}$ * Energy Equivalent * Operational Time
= $\frac{7400}{3,000}$ * 68.50* 1.25

Total indirect energy in MJ/ha = 211.20

Total energy in harvesting and threshing = Total direct energy + Total indirect energy
= 578.10 +211.20
= 789.3 MJ/ha

Total energy in harvesting and threshing is 789.3 MJ/ha.

Result and Discussion

1. Mode of energy used operations

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. Human labour scarcity became highest at time of harvesting and sowing as they are time sensitive operations. On the other hand, in last two decades the number of draught animals has decreased very rapidly due to shortage of grazing fields and problem of maintaining them which resulted in shortage of draught animal. However, the availability of tractor-mounted machines might be another cause of ever decreasing population of draught animal. 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.

2. Average usage of different energy sources

Animal energy was found maximum (439.07 MJ/ha) for small farmers and minimum (68.03 MJ/ha) for large farmers in various farm categories. Human energy was found maximum (343.44 MJ/ha) for marginal farmers and minimum (145.83 MJ/ha) for large farmers in various farm categories and for machine energy it was found maximum (4148.65 MJ/ha) for large farmers and minimum (900.40 MJ/ha) for small farmers.

Conclusion

It is seen that crop energy required requirement for production of major crops in was more in traditional farming as compared to the mechanized farming. It means that mechanized farming saves much energy input. Bullocks are the most commonly used animals for farms operations. The bullock use percentage highest in marginal type land holding pattern which reduces gradually though very minutely from the marginal to the large farm category. Bullocks occupy approximately 80% of total draught Animal strength.

The farm implements used are Cultivator, Mouldboard plough, Disc plough, Harrow, Leveller, sprayer, Seed-Drill, Planter, Transplanters, Reaper and Thresher. In all the regions, the farm categories defined these implement and their use of status. Mould board plough, disc plough and other farm implements bear very less percentage in terms of use for the case of marginal farm category. Hence, it can easily be said that farmers with marginal land holding use animal power in comparison to farm implements. While use of threshers are minimal as well as their final product is not much in amount which did not make it efficient to go for such a costly implement.

The energy requirement for different combination of matching implement with farm operations for various regions can be classified according to sources in various operations. Various sources in farm operations are Animal, Human and Machinery which are to be defined on the terms of various operations like Seedbed, Sowing, Irrigation, Intercultural, Plant protection, Harvesting and Threshing. Based on these operations the total is calculated of various farm operations. Animal energy was found maximum (439.07 MJ/ha) for small farmers and minimum (68.03 MJ/ha) for large farmers in various farm categories. Human energy was found maximum (343.44 MJ/ha) for marginal farmers and minimum (145.83 MJ/ha) for large farmers in various farm categories and for machine energy it was found maximum (4148.65 MJ/ha) for large farmers and minimum (900.40 MJ/ha) for small farmers.

References

1. Karale DS, Khambalkar VP, Bhende SM, Sharddha B Amle, Pranali S Wankhede. Energy economic of small farming crop production operations. World Journal of Agricultural Sciences. 2008;4(4):476-482.
2. Khambalkar V, Pohare J, Katkhede S, Bunde D, Dahatonde S. Energy and Economic Evaluation of Farm Operations in Crop Production. Journal of Agricultural Science, 2010, 2(4).
3. Ray A, Kumar A, Rai A, Tripathi S. Farm Mechanization and Energy Consumption for Different Farm Categories of Phaphamau Region. Trends in Biosciences. 2018;11(48):4419-4435.
4. Kalbande SR, More GR. Assessment of Energy Requirement for Cultivation of Kharif and Rabi Sorghum. Karnataka J Agric. Sci. 2008;21(3):416-420.
5. Methew M, Guruswamy T, Desai SR, Veranagouda M, Murthy GRK. Energy requirements of crop production under Dryland agriculture in Karnataka-a case study. Agric. Engng. Today. 1993;17(5-6):90-97.
6. Gupta VK, Prasad R, Dipankar De, Chandra H, Singh RS. Energy requirement in agricultural sector: A linear programming approach, 2001.
7. Schnepf R. Energy Use in Agriculture: Background and Issues. CRS Report for Congress, 2004.
8. Victor VM, Davel AK, Lawrence AKA. Puddling Effects on Energy Parameters under Animal Farming for Mechanized Cultivation of Rice. International Journal of Agriculture, Environment and Biotechnology. 2020;13(4):447-451.
9. Nkakini SO, Vurasi NM. Effect of moisture content, bulk density and Tractor forward speed on energy requirement of disc plough. International Journal of Advanced Research in Engineering and Technology. 2015;6:69-79.