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Energy Use and Economical Analysis for Pea Production

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A study was conducted to determine input–output energy along with the cost economics of Pea (*Pisumsativum* L.) cultivation. Data were collected from two Groups *viz.* Group I (traditional) and Group II (semi mechanized) through a face to face questionnaire. Total direct energy consumption was 3819.66 MJ ha^{-1} for Group I while 5911.18 MJ ha^{-1} for Group II. The specific energy requirement for pea production was 7.54 MJ kg^{-1} and 7.62 MJ kg^{-1}, respectively for Group I and Group II whereas the, net energy required was 6050.19 MJ ha^{-1} and 8209.63 MJ ha^{-1}, respectively. Similarly, the energy output–input ratio was 1.86 and 1.84, respectively for Group I and II with an average energy productivity of 0.13 for both the Groups. Total pea production cost for Group I and II was18270.76 and 20627.06 ^{1} ha^{-1}, respectively with benefit to cost ratio of 1.79 and 2.17, respectively. It is concluded that energy input should be improved for more economic benefit in pea production.

Key words: Pea, Energy analysis, Output–input ratio, Economic analysis

Energy input–output analysis in production and post–production agriculture is very important for developing efficient and sustainable crop production systems. Crop production is highly dependent on yielding varieties, chemicals, fertilizers, mechanization and other energy inputs, which would be further affected by level of technology and agro–climatic zone. Energy input and crop yield vary with farming systems and will ultimately influence on the energy output–input ratio. The increase in energy inputs obviously, increases crop production and productivity. But, increase in fertilizers or other similar inputs per ha may not result in raising yields indefinitely due to biological principle of diminishing returns (Pimentel, 1984). Therefore, studies have been conducted all through the world to estimate the energy requirement in production and post–production agriculture. This energy requirement in agriculture is broadly divided into direct and indirect energy. Direct energy requirement involves land preparation, irrigation, interculture, threshing, harvesting and transportation of agricultural inputs and farm produce. On the contrary, indirect energy are fertilizers, pesticides and farm machinery. Calculating energy input in agricultural production is more difficult in comparison to the industry sector due to more number of factors affecting agricultural production. However, considerable studies have been conducted in different countries on energy use and production in agriculture.

The efficient use of input energy helps to achieve more production, productivity, which also contributes to profitability and competitiveness for agricultural sustainability (Singh *et al.,* 2002). Although, the energy use pattern per unit of production of crops varies with agro climatic zones; the use of energy in crop production depends on the availability of energy sources, in a particular region and the affordability of farmers. Thus, there is a need to carry out energy analysis of crop production system. The appropriate use of input to crop production could originate from several types of energy conservation practices. The reduction, elimination or combination of agricultural inputs will reduce energy input and also may reduce the use of labour and time in crop production (Karale *et al.*, 2008).

Many researchers have studied energy use pattern and estimated its economics for different crop production systems *viz.*, wheat, maize, soybean, (Sartori *et al.*, 2005); tomato Esengun *et al.*, 2007); soybean (Mandal *et al.*, 2002); tomato (Hartirli *et al.*, 2006); green gram (Tripathi *et al.*, 2013) cultivations; chickpea in Vertisols of semi–arid tropics (Patil *et al.*, 2014). Ozkan *et al.*, (2004) studied about greenhouse vegetable production in Turkey. Energy use efficiency and economic analysis of pulses production in Iran was done by Koocheki *et al.*, (2011). Chaudhary *et al.*, (2009) reported that in maize–pea–wheat and rice–pea–wheat–green gram cropping systems the total input energy for vegetable pea was 9477 MJ ha^{-1}. Very few researchers conducted the study for input energy in pea production; but, no one compared animated energy and mechanized energy input and cost analysis. Therefore, present study was undertaken to estimate and compare the energy requirements for pea production in animated and tractor operated farming in selected village of Allahabad district, India

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with respect to technology level, energy input and output along with cost economics.

Pea (*Pisumsativum* L.) belongs to the family Leguminoseae well known as Matar. Uttar Pradesh is ranked first in producing peas with 43.6% (1.53 million MT) from an area of 0.16 million ha with productivity of 9.6 t/ha of the total production in the country (Annual action plan, 2013-14). Energy has a key role in economic and social development; but, there exists lack of rural energy development policies in India. 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). Energy *viz.*, mechanical (farm power, human labour, animal draft), chemical (fertilizer, pesticides, herbicides) and electrical are the most valuable inputs in pea production. Sufficient availability of suitable energy sources, its effectiveness and efficiency are the prerequisites for improved pea production.

Materials and Methods

The study was conducted in Allahabad district (25.45°N and 81.84°E) in Uttar Pradesh state, India located at an elevation of 98 m and stands at the confluence of two rivers, the Ganges and Yamuna. The soil type is clay and sandy loam (District profile, ZPD, Kanpur). Data was collected by stratified random sampling method using a face to face questionnaire from two Groups of 55 pea growing farmers. Based on the cultivation practices, farmers were divided into two Groups *viz.*, Group I, using traditional farming system (Bullock operated) and Group II, using semi mechanized farming system (Tractor operated). The average size of the land holding was 0.5 and 2.3 ha for Group I and II farmers, respectively. The sample size was determined using the following formula (Yamane, 1967).

$$n=\frac{\Sigma (N_h S_h)^2}{N^2D^2+\Sigma N_h S_h^2} \qquad (1)$$

Where, n is the required sample size; N is the number of total holdings in the target population; N_h is the number of the population in the h stratification, S_h is the standard deviation in the h stratification, S_h^2 is the variance in the h stratification, D^2 is equal to d^2/z^2; d is the precision, where ($\bar{x} - \bar{X}$) is the permissible error at 5% level of confidence and z is the reliability coefficient (1.96 represents 95% reliability).

Inputs in pea production were human labour, machinery, diesel, seed, chemicals, fertilizers, farmyard manure, water and output was pea (grain). The energy equivalents (Table 1) of different input and output were used to estimate the energy values. The human energy input was calculated by multiplying the number of man–hours (h ha^{-1}) with energy equivalent (Singh and Mittal 1992, Kitani 1999). Other inputs energies like diesel, seed, and fertilizers used in pea production were estimated by multiplying the quantity of the material used in the farms with energy equivalent of each material. Diesel pumps were used to lift the irrigation water. The amount of output energy (MJ ha^{-1}) estimated was by multiplying the pea yield (kg ha^{-1}) with pea energy equivalent (MJ kg^{-1}). The following equations were used to calculate output–input energy ratio, specific energy, energy productivity and net energy.

Output–input energy ratio = Output energy (MJ ha^{-1})/ Input energy (MJ ha^{-1}) (2)

Specific energy = Input energy (MJ ha^{-1})/ Grain yield (Kg ha^{-1}) (3)

Energy productivity= Grain yield (Kg ha^{-1})/ Input energy (MJ ha^{-1}) (4)

Net energy = Output energy (MJ ha^{-1})- Input energy (MJ ha^{-1}) (5)

The economic analysis of pea was done to determine total crop production value, gross return, net return, benefit to cost ratio and productivity by using Eqn. 6-10 (Mohammadi *et al.*, 2008).

Total production value = Yield (kg ha^{-1})* cost (^{1} kg^{-1})(6)

Gross return = Total production value (^{1}ha^{-1}) - Variable production cost (^{1} ha^{-1}) (7)

Net return = Total production value (^{1} ha^{-1}) - Total production cost (^{1} ha^{-1})(8)

Benefit-cost ratio = Total production value (^{1} ha^{-1}) / Total production costs (^{1} ha^{-1}) (9)

Productivity = Pea yield (kg ha^{-1}) / Total production costs (^{1} ha^{-1}) (10)

Results and Discussion

Inputs-output energy analysis

Land preparation was slightly different in traditional farming system (Group I) due to use of bullock as power source than semi mechanized farming system (Group II), which used tractor as power source. It was observed that total input energy requirement was 7023.38 MJ ha^{-1} and 9755.22 MJ ha^{-1} in Group I and II, respectively. The energy requirement and cost of operation in semi mechanized farming system was quite higher than traditional method. In traditional farming system, land preparation input energy was 1382.45 MJ ha^{-1}and in semi mechanized farming system it was 1956.64 MJ ha^{-1}. Similarly, sowing and irrigation operation energy requirement was more in semi mechanized farming system over the traditional farming system (Table 2). In traditional farming system, harvesting operation was carried out by manual labour and transportation was done manually or by bullock cart. In semi mechanized farming system, harvesting operation was carried out by manual labour due to unavailability of appropriate machinery for the harvesting of pea and

Table 1. Energy equivalent of inputs and output in agricultural production

Source: Singh and Mittal (*1992*), *Kitani* (*1999*)

Particulars	Unit	Energy equivalent (MJ unit^{-1})
A. Inputs		
1. Human labour	h	
Male		1.96
Female		1.57
2. Animals		
Bullocks		
Large		14.05
Medium		10.10
Small		8.07
3. Machinery	h	62.70
4. Diesel fuel	L	56.31
5. Chemical fertilizers	kg	
Nitrogen(N)		60.60
Phosphate(P_2O_5)		11.1
Potassium(K_2O)		6.7
6. Electricity	kWh	11.93
7. Chemicals	kg	120
8. Water for irrigation	m^3	1.02
9. Seeds (Pea)	kg	14.7
B. Outputs		
1. Pea	kg	14.7

transportation was done by tractor operated trailer. Threshing operation was done by power operated threshers in Group II, while in Group I, 15% of the farmers used power operated thresher and remaining 85% of the farmers used traditional method.

Operation wise inputs used and output gained in production in the surveyed area and their energy equivalents with output energy rates and their equivalents are illustrated in Table 2. Chemical fertilizers consumed the maximum energy *i.e.* 35.11% for Group I and 29.47% for Group II of the total energy inputs during production period with second higher percentage difference. Energy consumed for irrigation by Group I and II was 3.35 and 9.36%, respectively. The reason behind the difference in maximum percentage of irrigation was due to the use of canal by Group I. Further, in Group I, 15% of the farmers used electric motor and diesel pump for water lifting. Whereas, Group II used diesel pump and electric motor only. Group I and II used 1218.83 and 1532.64 MJ ha^{-1} energy for sowing, respectively. Harvesting consumed 987.64 MJ ha^{-1} energy in Group I and 1142.82 MJ ha^{-1} energy in Group II farms. Operation wise energy input ratio, percentage use energy and percentage difference for both the Groups are shown in Table 2.

Table 2. Operation wise energy input and output in pea production

Operation	Energy requirement				Ratio	% difference
	Group I	%	Group II	%		
Inputs, MJ ha^{-1}						
Land preparation	1382.45	19.68	1956.64	20.06	1.42	0.37
Fertilizer application	2465.65	35.11	2874.71	29.47	1.17	5.64
Sowing	1218.83	17.35	1532.64	15.71	1.26	1.64
Irrigation	235.63	3.35	912.73	9.36	3.87	6.00
Harvesting	987.64	14.06	1142.82	11.71	1.16	2.35
Threshing	733.18	10.44	1335.68	13.69	1.82	3.25
Total input energy	7023.38	100	9755.22	100	0	0
Output						
Output, MJ ha^{-1}	13697.901	0	18822.762	0	1.374	0
Pea, kg	931.83	0	1280.46	0	1.374	0

Source wise input energy is presented in Table 3. Direct source wise energy calculated for Group I was 3819.66 MJ ha^{-1} (54.38%) and it was 5911.18 MJ ha^{-1} (60.60%) for Group II. Indirect source wise energy calculated for Group I and II were 3203.72 (45.62%) and 3844.04 MJ ha^{-1} (39.40%), respectively. The input energy used as an indirect source was the lowest from seed in both the Groups. Energy input ratio for Group I and II in direct energy was 1:1.55 and in indirect energy was 1:1.2 with respect to Group I. Human energy use had 14.32% difference among both the Groups. Source wise energy requirement parameters, percentage use energy, ratio and percentage difference are given in Table 3.

Table 3. Source wise energy input and output in pea production

Parameters	Energy requirement				Ratio	% difference
	Group I	%	Group II	%		
Direct energy (MJ ha^{-1})						
Human	2134.92	30.40	1568.25	16.08	0.73	14.32
Bullock	1684.74	23.99	0			23.99
Diesel	0		4342.93	44.52		44.52
Total direct energy	3819.66	54.38	5911.18	60.60	1.55	6.21
Indirect energy(MJ ha^{-1})						
Seed	154.34	2.20	248.76	2.55	1.61	0.35
Fertilizer/chemical	2416.75	34.41	2682.93	27.50	1.11	6.91
Machinery	632.63	9.01	912.35	9.35	1.44	0.34
Total indirect energy	3203.72	45.62	3844.04	39.40	1.20	6.21

The energy input and output, yield, energy use efficiency, specific energy, energy productivity and net energy of pea production in the study area are presented in Table 4. Average yield at farmers' field was recorded as 931.83 kg ha^{-1} and 1280.46 kg ha^{-1} and based on this, the calculated total energy output was 11401.34 and 14329.96 MJ ha^{-1} for Group I and II, respectively. Energy use efficiency (energy ratio) was calculated as 1.86 and 1.84 for Group I and II, respectively.

Table 4. Energy output-input ratio in pea production

Parameters	Unit	Group I	Group II	Ratio
Input energy	(MJ ha^{-1})	7023.38	9755.22	1.39
Output energy	(MJ ha^{-1})	13697.901	18822.762	1.37
Output-input energy ratio		1.95	1.93	0.99
Yield	(kg ha^{-1})	931.83	1280.46	1.37
Specific energy	(MJ kg^{-1})	7.54	7.62	1.01
Energy productivity	(kg MJ^{-1})	0.13	0.13	0.99
Net energy	(MJ ha^{-1})	6674.52	9067.54	1.36

Economic analysis

The results of economic analysis are presented in Table 5. The total production value for Group I and II was 32614.05 and 44816.10 ¹ ha^{-1}, respectively. Fixed cost of production for Group I and II was found 6485.17 ¹ ha^{-1} and 6872.58 ¹ ha^{-1}, respectively. While variable cost of production for Group I and II was 11785 and 13754.48 ¹ ha^{-1}, respectively. The total production cost of pea for Group I and II was 18270.76 ¹ ha^{-1} and 20627.06 ¹ ha^{-1}, respectively. Gross return of 20828.46 ¹ ha^{-1} earned by Group I whereas 31061.62 ¹ ha^{-1} by Group II. The net return in Group II was 14343.29 ¹ ha^{-1}, which was higher than Group I (24189.04 ¹ ha^{-1}).

Table 5. Economic analysis of pea production

Cost and return components	Unit	Group I	Group II	Ratio
Yield	kg ha^{-1}	931.83	1280.46	1.37
Sale price	kg ha^{-1}	35	35	1.00
Total production value	kg ha^{-1}	32614.05	44816.1	1.37
Variable cost of production	kg ha^{-1}	11785.59	13754.48	1.17
Fixed cost of production	kg ha^{-1}	6485.17	6872.58	1.06
Total production cost	kg ha^{-1}	18270.76	20627.06	1.13
Gross return	kg ha^{-1}	20828.46	31061.62	1.49
Net return	kg ha^{-1}	14343.29	24189.04	1.69
Benefit to cost ratio		1.79	2.17	1.22
Productivity	kg ha^{-1}	0.05	0.06	1.22

Energy consumption was the highest for fertilizer application which was 35.11% and 29.47% for traditional and semi mechanized pea cultivation system, respectively. Output–input energy ratio under traditional and semi mechanized pea production systems was 1.86 and 1.84. The operational specific energy requirement in traditional and semi mechanized system was 7.54 and 7.62 MJ q^{-1}. Energy productivity (kg MJ^{-1}) was 0.13 for traditional and semi mechanized. The yield in semi mechanized system is more than traditional system because of more use of energy. Specific energy, output–input energy ratio and energy productivity of traditional and semi mechanized were also calculated and discussed. In an economic analysis of traditional and semi mechanized, the benefit to cost ratio was 1.79 and 2.17, respectively. The net return of semi mechanized was found to be more than traditional. This study shows that semi mechanized farming system is more profitable than traditional farming system. So, traditional farming system should be changed with the semi mechanized farming system in pea production.

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