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Energetics and economics of apple production in district Shopian of Kashmir region: A case study

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Abstract
Study was carried out to examine the energy requirement and cost economics of apple (*Malus* × *domestica* Borkh.) production in the Shopian district of Kashmir province of erstwhile state of J&K. The main objective of the study was to examine the energy use patterns and input-output analysis of apple production being cultivated on an area of about 61,316.84 MJha^{-1}. The information for apple production were collected from sixty different apple farms located in different villages of district Shopian by using face-to-face survey method The study revealed that apple production consumed a total energy of 61,316.84 MJ ha^{-1} contributed mainly by chemical fertilizers (nitrogen), with an energy input of 71.46%, followed by spraying (19.9%). Further, energy input output ratio for apple was estimated to be 1.38. The non-renewable form of energy contributed 93% of the total energy input used in apple production whereas the continuation by for the renewable form was only 7%. The cost benefit ratio of apple was found to be 2.71.

Keywords: apple, energetics, cost economics, renewable, non renewable

1. Introduction

Apple (*Malus* × *domestica* Borkh) is one of the most important fruits in the world. Apples grow readily throughout temperate climate zones. However, commercial apple production is increasingly concentrated in countries and in growing districts that have a strong comparative advantage in apple production. Apple as a dominant fruit of Kashmir valley represents 98% of the total fruit production in the region. The chief varieties of apple are found in Jammu and Kashmir. The erstwhile state of Jammu and Kashmir produces about 1.87 million metric tonnes of apple from an area of 0.16 million hectares with 98.55 percent of apple production from the erstwhile Kashmir valley at 1.51 million metric tonnes from an area of 0.14 million hectares. The leading apple producing districts in the valley are Baramulla, Shopian, Kulgam and Anantnag producing about 0.40, 0.27, 0.22 and 0.21 million metric tonnes of apple respectively from an area of 0.025, 0.021, 0.018 and 0.018 million hectares correspondingly (DES, 2019) [5]. The agriculture sector, like other sectors, has become increasingly dependent on energy resources like manual, electricity, fuels, natural gas and coke. Continuous demand for enhanced food production has resulted in intensive use of, chemical fertilizers, insecticides, fungicides, agricultural machinery and other natural resources. However, intensive use of energy threatens public health and environment (Dalgaard *et al.*,2001) [3] and is partly responsible for the deterioration of world peace and development (Demirbas, 2006; Grennan, 2006) [4]. Energy requirements in agriculture and allied activities are divided into two groups: direct and in-direct. Direct energy is required to perform various tasks related to crop production processes such as land preparation, irrigation, intercultural operation, threshing, harvesting and transportation of agricultural inputs and farm production (Singh, 2000) [2]. Indirect energy consists of the energy used in the manufacture, packaging and transport of fertilizers, pesticides and farm machinery (CAEEDAC 2000; Kennedy 2000) [1]. An input-output energy analysis provides farm planners and policy makers an opportunity to evaluate economic intersection of energy use (Ozkan *et al*., 2004) [12, 13]. Considerable research studies were conducted on energy use in agriculture, however, relatively little information is available on apple production. Therefore, the present study was planned with an aims to determine the energy use pattern, input-output energy use in apple production and to investigate the efficiency of energy consumption. Besides this, to make an economic analysis, and the efficiency of energy consumption.

2. Material and Methods

A total of five villages in the Shopian district were selected randomly and sixty number of apple growing farmers were selected for the purpose of study. A proforma was developed to collect the information from farmers. The information was collected by personal interview of the apple growers.

Table 1: The questionnaire used to collect farmer details

S. No.	Farmer's enquiry details	S. No.	Farmer's enquiry details
1.	Name of farmer	12.	**Manuring** Type Manure per tree Labour required Time taken
2.	Age		
3.	Village		
4.	Area (kanal)		
5.	No. of tress per kanal		
6.	Age of trees	13.	**Hoeing** Type of implement Labour required Time taken
7.	Variety		
8.	**Pruning Operation** Pruning Instrument used Labour required Time required	14.	**Harvesting** Labours required Time taken Produce
9.	**Fertilization** Type of fertilizer Cost of fertilizer Labour required No. of times Time taken	15.	**Sorting and Grading** Labour required Time taken
10.	**Spraying** Type of spray Name of machine used Cost of machine Cost of spray No. of spray Labour required Time taken Fuel used Lubrication used	16.	**Packaging** Wooden paties Cardboard paties Straw used Labour required Time taken
		17.	**Transportation** Type of vehicle No. of paties in one round Distance Cost of transportation Labour required
11.	**Irrigation** Type of irrigation No. of irrigations No. of labours Time required	18.	Selling cost of wooden & cardboard paties
		19.	Selling price of forage in between trees
		20.	Quantity of charcoal
		21.	Selling price of charcoal

The main cultural operation in apple cultivation involves from planting, irrigating, intercultural operations, fertilization, pruning, till harvesting, sorting and transporting. The apple orchards normally give fruiting after eight years normally and in case of dwarf varieties after two to three years of their cultivation. So, the orchards which were well developed and ready for fruiting were taken into consideration. The major cultivation practices involved in apple cultivation starts from cutting and pruning (in March) followed by fertilization (in March), spraying (March-August), irrigation (March-August), manuring (in August), hoeing (in August), harvesting (September-October), sorting & grading (September-October), packaging (September-October) and transportation (September-October). The major energy inputs in apple production in district Shopian of Kashmir (J&K) comprises mainly of the human labour, machinery, fossil fuel, inorganic fertilizers, manure, pesticides, fungicides, irrigation water etc. The outputs are apple fruits, forage (grass), wood and charcoal. In order to arrive at input and output energy of the apple production, the energy equivalents shown in Table 2 were used for estimation. Based on the energy equivalents of the inputs and outputs, the output-input energy ratio, energy productivity and the benefit-cost ratio were calculated. Energy ratio (energy use efficiency) and energy productivity, benefit-cost ratio were calculated as equations given as (Mandal *et al.* 2002) [11]:

$$\text{Output} - \text{input ratio (ER)} = \frac{\text{Energy output (MJha}^{-1}\text{)}}{\text{Energy input (MJha}^{-1}\text{)}}$$

$$\text{Energy productivity (EP)} = \frac{\text{Total output (kgha}^{-1}\text{)}}{\text{Energy input (MJha}^{-1}\text{)}}$$

$$\text{Benefit cost ratio (BC)} = \frac{\text{Total output cost} - \text{Total input cost}}{\text{Total input cost}}$$

The input energy was further classified into direct and indirect; and renewable and non-renewable forms. The indirect energy consists of seedlings, pesticide, fertilizer, machine and equipment; while the direct energy includes human power and diesel used in the production process. On the other hand, non-renewable energy includes diesel, fungicides, and fertilizers; while renewable energy consists of humans, electricity and manure (Demircan *et al.*, 2006) [4]. The output/input analysis was also applied in economic benefits analysis. The process was similar with energy balance analysis. The economic (or energy) inputs of this system include costs of human labour, chemical fertilizers, packaging, transportation, fixed costs and agricultural machinery. The economic (or energy) outputs of this system include main and secondary yields.

Table 2: Energy equivalents for different inputs and outputs in apple production

Input	Unit	Energy Equivalent (MJ/unit)	Reference/source
Potassuim fertilizer	kg	9.7	Lockeretz, 1980 [10]
Ca and Mg fertilizer	kg	8.8	Pimentel and Pimentel, 1979 [16]
Pesticide	kg	363	Fluck and Baird, 1982
Fungicide	kg	99	Fluck and Baird, 1982
Herbicide	kg	288	Kitani, 1999 [9]
Insecticide	kg	52.7	Agricultural engineering vol 4 by Patrick and Vincent
Fungicide	kg	55.7	Agricultural engineering vol 4 by Patrick and Vincent
Apple	kg	2.4	Jarach, 1985 [8]
Kerosene	L	53.87	Cooley, Le Roy Clark (1873). Elements of Chemistry: for Common and High Schools. Scribner, Armstrong. p. 98.
Charcoal	kg	24	Singh, 2002 [19]

The information collected inputs and that of main products and by-products were utilized to find out benefit-cost ratio, energy productivity, energy ratio, total energy, direct energy, indirect energy, renewable energy, non-renewable energy, total cost of operations and total output cost utilized in apple production.

3. Results and Discussions

3.1 Analysis of energy use of apple production in selected villages of district Shopian

The study was conducted on sixty apple orchards in villages of Pinjorah, Sandho Shermal, Mani Hal, Pahano and Reshnagri of Shopian district of Jammu and Kashmir. The operation wise energy utilized in apple cultivation is shown in Table 3. As per the information provided by the apple growers, the flood irrigation was the main source of irrigation given to the orchards. The hoeing/tilling of the field was carried out manually using small tools such as spade, *khurpi*,etc. whereas pruning & cutting was also carried out manually using scissors. The general practice for manuring in all the selected villages under the study of district Shopian was before disturbing the soil and was carried out manually. The use of manure in the field with comparison to the in comparison to the inorganic fertilization was substantial because of the easy availability of manure locally in the villages. The harvesting of the fruit was also carried out manually by hiring labours and similarly packaging, sorting & grading were also accomplished manually. The spraying operation was mechanized and carried out using a Honda GK 300 spray pump by most of the farmers of the selected villages under the research.

Table 3: Energy utilization ($MJha^{-1}$) pattern in selected villages of Shopian district of J&K

Operations	Energy in MJ per hectare
Hoeing	252.37
Cutting and pruning	417.06
Spraying	12250.62
Manuring	429.64
Fertilization	43816.03
Harvesting	1251.40
Irrigation	828.56
Sorting and Grading	2071.15
Total	61316.84

The energy input required for each operation as given in Table 3 shows that the maximum energy of 43,816.03 $MJha^{-1}$ was required in fertilization of the orchards in the selected villages of Shopian district followed by spraying with an energy input of 12,250.62 $MJha^{-1}$. The energy input for sorting & grading, harvesting, irrigation, manuring, cutting & pruning and hoeing was calculated at 2071.15, 1251.40, 828.56, 429.64, 417.06 and 252.37 $MJha^{-1}$ correspondingly. Fertilization (inorganic fertilization) was the most energy consuming operation utilizing about 71.46 percent of the total energy consumed in the apple production as shown in Figure 1. The results of the current study were in accordance with the studies carried out earlier by Gezer *et al*., 2003 [7]; Esengun *et al.*, 2007 [6]; Canakci, 2010 [2]. After fertilization, spraying had the maximum share of total energy utilized in the apple production at 19.98 percent followed by sorting & grading, harvesting, irrigation, manuring, cutting & pruning and hoeing consuming about 3.38, 2.04, 1.35, 0.70, 0.68 and 0.41 percent respectively as shown in Figure 1.

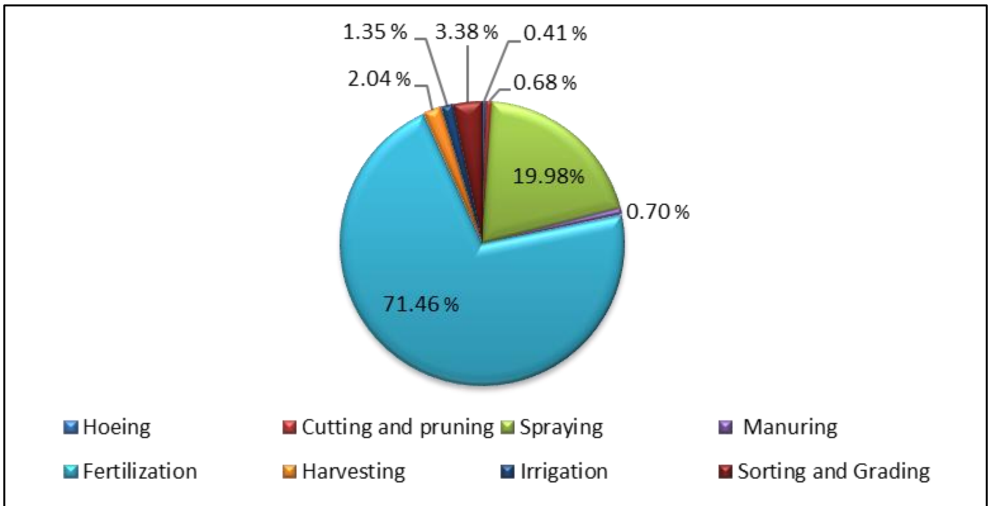

Fig 1: Percentage share of energy utilization pattern in selected villages of Shopian district of J&K

The total energy input was further analysed based upon the nature of sources i.e. direct or indirect and renewable or non-renewable energy sources and is presented in Table 4.

Table 4: Contribution of different sources of energy for apple cultivation in selected villages of Shopian district of J&K

S. No.	Parameter	Energy (MJha^{-1})
1.	Direct energy	4820.54
2.	Indirect energy	56496.29
3.	Renewable Energy	4421.62
4.	Non Renewable energy	56895.22

As per the data, the apple cultivation in the selected villages of district Shopian used 56,496.29 MJha^{-1} of indirect energy contributing 92.14 percent (Figure 2) of total energy consumption whereas it used 4,820.54 MJha^{-1} of direct energy sources contributing only 7.86 percent (Figure 2).

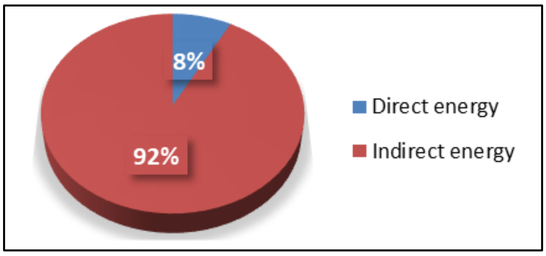

Fig 2: Percentage contribution of direct and indirect sources of energy for apple cultivation in selected villages of Shopian district of J&K

Similarly, the energy consumed from renewable and non-renewable energy sources were 4,421.62 and 56,895.22 MJha^{-1} contributing 7.21 and 92.79 percent (Figure 3) respectively.

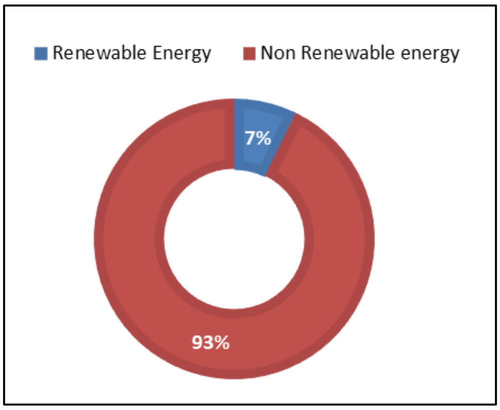

Fig 3: Percentage contribution of renewable and non- renewable sources of energy for apple cultivation in selected villages of Shopian district of J&K

In apple production, the output comprises of apple fruit as main product and wood which is later converted into charcoal as by-product. The average yield in the selected farms was 35.30 tonnes per hectare with an energy equivalent of 84,721.94 MJ per hectare whereas 0.56 tonnes per hectare of charcoal was produced in the selected apple farms having an energy equivalent of 13,607.73 MJ per hectare. Thus the total energy output was 98,329.67 MJha^{-1}.

The output-input energy ratio in energy balances is generally often used as a parameter to describe the energy efficiency in agricultural production. The average output-input energy ratio for the current study in the selected villages of district Shopian was 1.6 as shown in Table 5 which signifies that the various input operations in the apple production in the selected farms were efficient. Furthermore, the data also indicates that the energy productivity of the farms of selected villages taken under the study was equal to 0.575 as shown in Table 5.

Table 5: Energy balance of input and output energies for apple cultivation in selected villages of Shopian district of J&K

Energy input in MJ/ha	Energy output in MJ/ha	Energy ratio ER	Energy productivity
61316.84	98329.67	1.60	0.58

The previous studies carried out on the apple production systems reported the energy ratio in between 1 to 2 (such as 1.57 reported by Page, 2009, 1.18 reported by Pimentel *et al.*, 1983 [17] and 1.11, 1.13 and 1.118 reported by Reganold *et al.*, 2001) [18] and an energy ratio indices of 0.06 (Pimentel *et al.*, 1983) [17], 0.61 (Pimentel, 2006) [15] and 2.34 (Strapatsa *et al.*, 2006) [21]. The direct energy sources used in the farms of the selected village of district Shopian for the study mainly comprised of manual labour and fuel whereas the indirect energy sources were dominated by chemicals and manure. In other words, apple production in the selected farms was highly dependent on both fuel and the production of indirect energy sources. Proper chemicals and manure management might help reduce the indirect energy requirements for pest control and manure. Furthermore, efforts to reduce the direct energy (fuel and labour), could improve the overall energy efficiency of apple production in agricultural production systems. The results indicated that the current energy use pattern among the selected farms of district Shopian are mainly dependent on non-renewable sources of energy.

3.2 Analysis of cost economics of apple production in selected villages of district Shopian

The cost of operation for various operations was calculated and presented in Table 6. The cost of operation for each operation as given in Table 6 shows that the maximum cost of ₹ 1,39,659.13 per hectare was required in packaging operation of apple fruits into different paties in the selected villages of Shopian district followed by spraying with a cost input of ₹ 79,841.15 per hectare. The cost of operation for manuring & fertilization, sorting & grading, harvesting, transportation, cutting & pruning, hoeing and irrigation was evaluated at ₹ 63431.86, 58839.49, 28440.99, 14120.32, 9478.72, 5735.54 and 761.15 per hectare correspondingly. The cost of packaging operation per hectare was the maximum filching about 70 percent of the cost of all the operations in apple production as shown in Figure 4.

Table 6: Energy utilization (MJha^{-1}) pattern in selected villages of Shopian district of J&K

Input (Operations)	Cost of Operation in ₹
Pruning and cutting	9478.72
Manuring and fertilization	63431.86
Hoeing	5735.54
Spraying	79841.15
Irrigation	761.15
Harvesting	28440.99
Sorting and Grading	58839.49
Packaging	139659.13
Transportation	14120.32

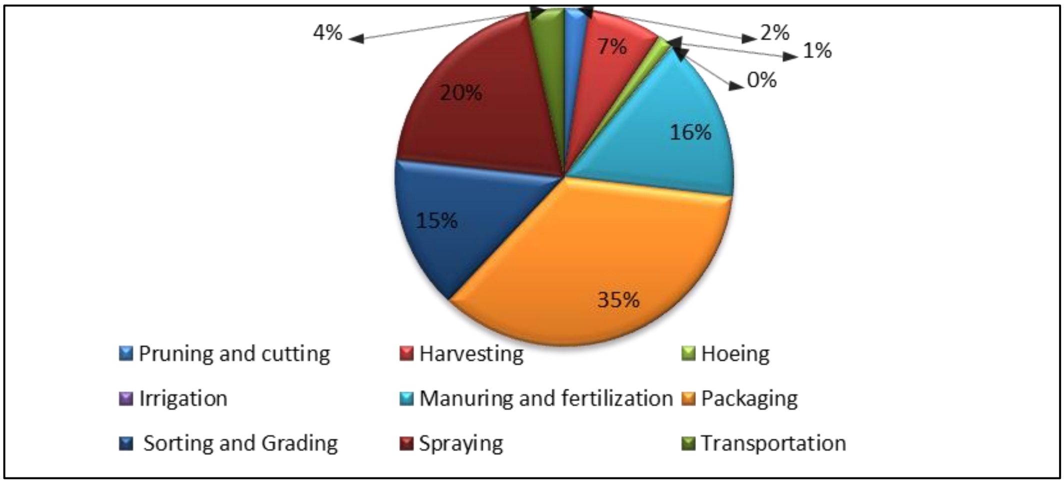

Fig 4: Percentage share of cost of operation for various operations during apple production in selected villages of Shopian district of J&K

The total cost various input operations was calculated as ₹ 4,00,308.35 per hectare whereas, the total value of produce (apple+charcoal) was evaluated as ₹ 14,88,614.63 per hectare. The data showed that apple fruit dominated the output value by contributing 99.52 percent to the total output value whereas charcoal contributed only 0.48 percent of the total output value per hectare. The calculated benefit-cost ratio of apple production for the selected villages of Shopian district was 2.71.

4. Summary and Conclusion

The total input energy in apple production for the selected villages of Shopian district of Kashmir was calculated as 61,316.84 MJ ha^{-1}. Fertilization, spraying and sorting & grading were the major energy inputs with 71.46, 19.98, and 3.38 percent share to the total energy input of various operations in apple production, respectively. About ninety three percent of total energy input in apple production was from non-renewable sources, whereas 7 percent was utilized from renewable sources. Also 92% of total input energy was taken from direct energy sources and the rest is indirect energy sources. Thus, it was concluded that the use of renewable energy sources in the studied farms was low. It shows that apple production in the selected villages of Shopian district needs to improve the efficiency of energy consumption in production and to employ more and more renewable energy sources. The total input cost of various operations carried out in apple production was ₹ 4, 00,308.35 per hectare whereas the total value from produce (apple+charcoal) was ₹ 14, 88,614.63 per hectare. The charcoal constituted about 0.48 percent of the output valve whereas the major share of output value was contributed by the main product i.e. apple fruit, contributing about 99.52 percent of the output valve. Furthermore, the calculated benefit-cost ratio of apple production for the selected villages of Shopian district was 2.71.

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