Energetic evaluation and comparison of cucumber production in different cultivation condition for adoptability and suitability in Malwa region of Madhya Pradesh

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ABSTRACT: Cucumber producers are looking for new cultivation practices to harvest best quality with higher yield and for off season cucumber production. So, protected cultivation is an alternative for them, widely selected by most of farmers and especially in Malwa region of Madhya Pradesh. Since, polyhouse production requires huge investment, time, labour and energy input. Therefore, study is needed to assess energy estimation in polyhouse cultivation and their adoptability with suitability for farmers to meet their economical status. The study was conducted to estimate source wise and operation wise energy inputs at different condition of cucumber cultivation in Malwa region of Madhya Pradesh in polyhouse and open field cultivation levels and compare them with the help of different energy indices. The study was carried out in the region by door to door survey and data were collected. Operation wise total energy input for both the system was 28626 and 69234 MJ/ha for open land and polyhouse respectively. Source wise the total energy input for polyhouse was 88085 MJ/ha and for open field it was 48299 MJ/ha. Energy ratio for polyhouse cucumber was 0.41 and for open land it was 0.25. Energy productivity for open land and polyhouse was 0.32 Kg/MJ and 0.52 Kg/MJ respectively. Specific energy for open land and polyhouse was 3.1MJ/Kg and 1.9 MJ/Kg for polyhouse. The results also indicated that in both production systems non- renewable source of energy was used predominantly compare to renewable energy sources. Non-renewable energy input for polyhouse cucumber was 89.8% and 92.5% for open-field cucumber of the total energy. The result indicated that energy wise open field cultivation of cucumber is not efficient due to very low output- input ratio of energy.

Key words: Cucumber, energy input, polyhouse, total energy

Cucumber (*Cucumis sativus* L.) is an important vegetable belongs to most popular members of the Cucurbitaceae family and popularly known as Khira in India. Vegetables production in India has increased to a level of 146,554,000 metric tons from an area of about 84, 95, 000 hectares (Anonymous, 2011). Cucumber is believed to be native to India and evidence indicates that it has been cultivated in western Asia for 3,000 years. Gynoecious cucumber (parthenocarpic varieties) can be grown round the year in Naturally Ventilated Polyhouses (NVP), which produces dark green seedless cylindrical fruits. These fruits are mild in flavor and have a thin, tender skin that does not require peeling. Cucumber is very low calorie vegetable; provide just 15 calories per 100 g. It contains 95% water, which making cucumber an ideal hydrating and cooling food. It is a very good source of potassium, vitamin K and some unique anti-oxidants, which are good for brain, heart and urinary system of human body. The Khira are edible and very much used as salad. Its fruits are also removed human constipation and good for digestion. The fruits are mainly preferred for consumption during summer as a cooling food. They are used as salads and for cooking curries. The tender fruits are preferred for pickling kernels of the seeds are used in confectionary (Chakravarty, 1982) In India, Andhra Pradesh, Karnataka, Telangana and Assam are leading cucumber producing states. India produces 678.0 thousand tonnes of cucumber in 2013-14, in which Madhya Pradesh contributes 32.6 thousand tonnes by an area of 2120 ha.

Protected cultivation practices are gaining momentum in Madhya Pradesh due to combined efforts of Government of India, Madhya Pradesh State Horticulture Mission and Precision Farming Development Centre (PFDC) established at ICAR-Central Institute of Agricultural Engineering, Bhopal. The staff of PFDC provides technical support to the state government in advocating these practices amongst the farming communities. The regular training programmes organized on drip irrigation, plastic mulching technology and covered cultivation by the PFDC helped over 100 farmers of Madhya Pradesh state to establish drip irrigation, plastic mulching, shadenet houses, polyhouses etc for enhancing their income over traditional farming practices. To promote shadenet house and polyhouse technology, farmers were given training at PFDC, Bhopal on protected cultivation techniques during 2013-15 and they started cultivating vegetables (tomato, capsicum, cucumber, broccoli) and flowers (Gerbera and Roses) under shadenet houses/polyhouses. The vegetable growers understood the advantages of offseason cultivation and earned a net profit of Rs 2.0 – 5.0 lakhs in a season depending upon the type of crop from half acre to one acre land *(Source: Central Institute of Agricultural Engineering, Bhopal)*.

In Madhya Pradesh, cucumber is produced everywhere, but large amount of cucumber is produced in Jabalpur and its adjoining areas. The cucumber growers are looking for new cultivation practices to harvest best quality cucumber fruits with higher yield and for early/off season cucumber production, and protected cultivation is an alternative for them. Protected cultivation practices can be defined as a cropping technique wherein the environmental elements like temperature, relative humidity etc., just around the plant body is controlled partially or fully as per plant need during their period of growth to maximize the yield and resource saving. The experience of greenhouse production, which emerged in northern Europe, stimulated development in other parts of the world areas including India with various rates and degrees of success. Adaptability of protected cultivation technology depends on local climatic conditions and the socio-economic environment. Agriculture is the most important sector in Indian economy and agriculture is basically an energy conversion industry. The energy requirement in various facets of agriculture varies considerably due to variation in the technology level adopted by the farmers and also because of the diverse agro-climatic conditions (Yadav and Khandelwal, 2013). The energy use pattern for unit production of crop varies under different agro climatic zones. The use of energy in crop production depends on the availability of energy sources in particular region and also on the capacity of the farmers. Agricultural productivity is proportional to energy input in the form of improved seed, fertilizers, chemicals, irrigation and mechanization including management practices (Mittal and Dhawan, 1989). It is therefore, essential to carry out energy analysis of crop production system and to establish optimum energy input at different levels of productivity. The production of agriculture product can only be increase by two methods either by increasing area and cultivation or by increasing productivity. Increase in area is very difficult and day by day it is reducing due to intensive population and increased service area. Greenhouse crop production is one of the most intensive parts of the world agricultural production. It is intensive in the sense of yield and annual production, but also in sense of the energy consumption, investments and costs (Salokhe and Sharma, 2009). It is a very expensive way to produce greenhouse crops and there are many variables to consider before the farmer decides to take this route (Canakci and Akinci, 2006).

MATERIALS AND METHODS

For understanding the energy scenario of horticultural crops under protected cultivation, with energy intensive practices, study was carried out in the Malwa region of Madhya Pradesh. This research attempts to investigate the energy use patterns in polyhouse and open land cucumber production, to determine the flow of energy by different operations and source of energy and output–input ratio and their relationships for establishing rational comparison in both production systems. Therefore, preliminary door to door survey in teamwork was conducted in villages of Malwa plateau to investigate the pattern of energy utilization in open land and protected cultivation system. Different villages of Malwa region where polyhouse are installed in numbers are selected and considered as representative of the specified agro-climatic zones as numbers are limited. The raw data was collected by interviewing all the farmers on an especially designed and pre-tested questionnaire and pro-forma included details of usages of energy sources for all kinds of input and relevant information pertaining to crop production, human labour use, sources of irrigation, numbers of irrigation for region specific crop, quantity of farm inputs, utilization of mechanical power sources, horse power of tractors, diesel engines and electric motors etc. Data were analyzed sharply and separated differently for open land and protected cucumber production.

COMPUTERIZATION AND PROCESSING OF DATA

- Source wise input energy used, MJ/ha
- Operation wise input energy input used , MJ/ha
- Crop yield, Kg/ha
- Energy input through direct sources, MJ/ha

CALCULATIONS OF ENERGY

Energy from Direct Sources:

$$DE = HLH \times 1.96 + BPH \times 10.10 + FC \times 56.31 + EC \times 10.59 \quad (1)$$

Where,
DE = Direct Energy, (MJ)
HLH = Human Labor Hours Used, (h/ha)
BPH = Bullock Pairs Hours Used, (h/ha)
FC = Fuel Consumption, (lit/ha)
EC = Electricity Consumption, (KW-h/ha)
(Source: Research digest on energy requirement in agriculture sector, CAE, PAU, Ludhiana 1985)

Energy from Indirect Sources

IE= (C×WM×HUM×OA)+FYM×0.3+Ch.×120+FER (N×60.0×P×11.1×K×6.7) … (2)

Where,

IE	= Indirect Energy Input from Machinery, (MJ)
C	= Energy Coefficient, (MJ/Kg)
WM	= Weight of Machinery Used per Hour, (Kg)
HUM	= Hours Use of Machinery, (h)
OA	= Operational Area (ha)
FYM	= Farm Yard Manure, (Kg/ha)
Ch.	= Chemical
FER	= Fertilizer

(Source: Research digest on energy requirement in agriculture sector, CAE, PAU, Ludhiana 1985)

INDICES OF ENERGY

The energetic efficiency of the agricultural system can be evaluated by the relation between energy inputs and outputs. The indices of energy use efficiency, energy productivity; specific energy and net energy were calculated using the following equations (Singh *et al.*, 1997).

1. Energy ratio $= \dfrac{\text{Energy output (MJ/ha)}}{\text{Energy input (MJ/ha)}}$

2. Specific energy $= \dfrac{\text{Energy input (MJ/ha)}}{\text{Yield kg/ha}}$

3. Energy productivity $= \dfrac{\text{Yield kg/ha}}{\text{Energy input (MJ/ha)}}$

4. Net energy = Energy output (MJ/ha)- Energy input (MJ/ha)

The output-input energy ratio (energy use efficiency) is one of the indices that show the energy efficiency of agriculture system. An increase in the ratio indicates improvement in energy efficiency and vice versa. Changes in efficiency can be both short and long terms, and will often reflect changes in technology, government policies, weather patterns, or farm management practices. The energy values were calculated by transforming data using energy equivalents shown in Table 1. By carefully evaluating the ratios, it is possible to determine trends in the energy efficiency of agricultural production (Unakitan *et al.*, 2010).

Table 1: Energy equivalents of inputs and output in cucumber production (Panesar & Bhatnagar, 1994; Binning, 1983; Singh and Mittal, 1992; Singh, 2002)

Energy sources	MJ
Man	1.96 Hr
Woman	1.57 Hr
Nitrogen	60.60 Kg
Phosphorus	11.10 Kg
Potash	6.70 Kg
Diesel	56.31 L
Electric	10.59 Kw-h
Agricultural machinery	62.7 Kg
Superior chemical	120 Kg
Inferior chemical	10 Kg
Farmyard manure (FYM)	0.3 Kg
CucumberOutput	0.8 Kg

RESULTS AND DISCUSSION

COMPARISON OF OPERATION WISE ENERGY INPUT

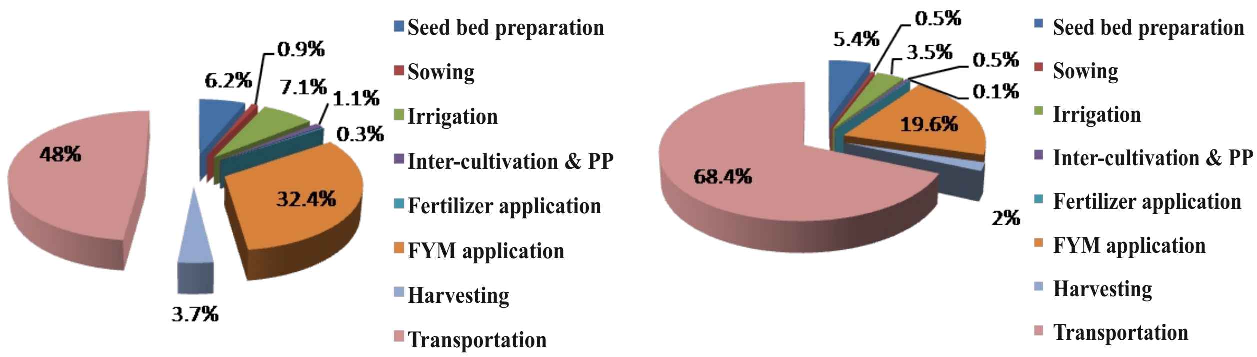
In both systems of cultivation, transportation of yield is the major energy intensive operation followed by FYM application. The average energy input for transportation in open land and polyhouse was 13839 and 47392 MJ/ha respectively. It resulted that three and half times more energy required for transportation of polyhouse production in comparison to open land due to the fact of more yield and much harvesting under polyhouse cultivation, Thus as compared to open land, polyhouse cultivation was supposed to be more energy intensive. The operation wise total energy input for both the system is shown in Table 2 and found to be 28626 and 69234 MJ/ha for open land and polyhouse respectively and also predicted that polyhouse operation wise energy input is approximately 2.5 times more than the open land cultivation of cucumber. Energy consumption in irrigation due to use of drip irrigation system in polyhouse was marked low (only 3.5% of total energy input) as shown in Figure 1 and can be also utilized fertigation purpose for application of soluble fertilizer at the scheduled time during irrigation. It has been also seen that evaporation losses of water is also reduced due to presence of high humidity and diffuse radiation incoming in the polyhouse while open land was subjected with huge water loss and consumes high energy consumption occurred (7.1% of total energy input) due to use of furrow irrigation in the open field cultivation by most of farmers which is less efficient method of irrigation as compare to drip irrigation system used in polyhouse cultivation. The using of non metering electricity for pumping caused careless operation in pumping water that resulted into higher electrical energy consumption. The average energy input for open land irrigation operation was 2041 MJ/ha while for polyhouse was 2449 MJ/ha. In open land average energy used in seed bed preparation, sowing, interculture and plant protection, fertilizer application and harvesting were 1789, 249, 306, 78 and 1058 MJ/ha respectively on other hand for polyhouse, average energy used in seed bed preparation, sowing, interculture and plant protection, fertilizer application and harvesting were 3684, 313, 2449, 360, 58 and 1372 MJ/ha respectively. The operation wise total energy input percentage share basis of energy for different operations has shown in Figure 1.

COMPARISON OF SOURCE WISE ENERGY INPUT

Source wise energy requirement for open land and polyhouse cucumber cultivation was represented in Table 3. It is observed that total energy requirement for polyhouse (88085 MJ/ha) is higher than open land (48299 MJ/ha) but it can also be resulted from Table 4 that production is enhanced with increased input energy. Average yield obtained from open land and polyhouse was 15300 and 46000 kg/ha respectively. The source wise percentage share of energy for open land and polyhouse cucumber production was illustrated in Figure 2 and in open land 40.6% of energy came from fuel followed by fertilizer (21.1%) and FYM (18.6%) while in polyhouse, maximum energy was used from fuel (55.8%) followed by fertilizer (12.3%) and human energy (10.1%). There was supposed to be high contribution of fuel energy in both production systems noted due to use of fuel (diesel) for tillage operation, FYM application and transportation of produce. The average fuel energy consumption for open land was 19619 MJ/ha, other side in polyhouse, it increased to 49192 MJ/ha and higher yield obtained in polyhouse cultivation results consumption of more fuel energy, subsequently in transportation. Both type cultivation systems involved mainly humans as energy sources for performing manure spreading and plucking of produce. In open land, average energy use from human was 3603 MJ/ha and it increased to 8927 MJ/ha in polyhouse cultivation.

COMPARISON OF ENERGY INDICES

The different energy indices for open land and polyhouse cucumber production are shown in Table 4. Energy ratio for polyhouse cucumber was recorded 0.41 and for open land, it was 0.25. Energy productivity for open land and polyhouse was estimated 0.32 Kg/MJ and 0.52 Kg/MJ respectively. Specific energy was found 3.1 MJ/Kg for open land where as it was 1.9 MJ/Kg for polyhouse. Output energy obtained from open land cucumber reveled 12240 MJ/ha (15300 Kg/ha) and higher for polyhouse 36800 MJ/ha (46000 Kg/ha) because of higher productivity in polyhouse as compare to open land cucumber practices. The output-input energy ratio of polyhouse is recorded higher in comparison to open land system and supposed to better energy utilization under polyhouse system for cucumber production. Higher energy productivity in polyhouse cultivation indicated that the use of input energy for producing cucumber is more efficient (approx one and half times) than open land practices. The study results showed that the total energy input used both for polyhouse and open field cucumber

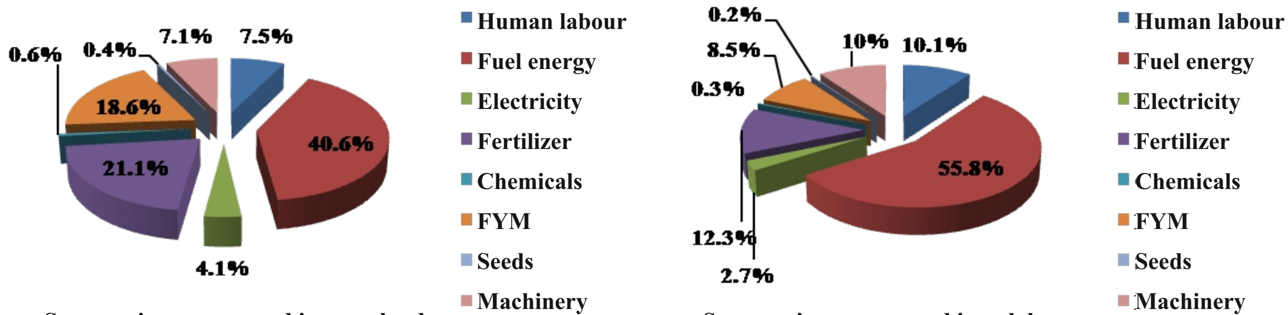


Operation wise energy used in open land **Operation wise energy used in polyhouse**

Figure 1: Operation wise energy used in open land and polyhouse cucumber production

Table 2: Operation wise energy inputs for open land and polyhouse cucumber production

Field operations	Energy used in open land(MJ/ha)	Energy used in polyhouse (MJ/ha)
Seed bed preparation	1789	3684
Sowing	249	313
Irrigation	2041	2449
Inter-cultivation & PP	306	360
Fertilizer application	78	58
FYM application	9266	13606
Harvesting	1058	1372
Transportation	13839	47392
Total	28626	69234



Source wise energy used in open land **Source wise energy used in polyhouse**

Figure 2: Source wise energy used in open land and polyhouse cucumber cultivation

Table 3: Source wise total energy input for open land and polyhouse cucumber cultivation

Input	Open land MJ/ha (Equivalent Energy)	Poly house (Equivalent Energy) MJ/ha
	Direct sources	
Human labour	3603	8927
Fuel energy	19619	49192
Electricity	1963	2354
Total	25185	60473
	Indirect sources	
Fertilizer	10170	10849
Chemicals	300	300
FYM	9000	7500
Seeds	200	200
Machinery	3444	8763
Total	23114	27612
Grand total (Direct+ Indirect Sources)	48299	88085

Table 4: Energy indices for open land and polyhouse cucumber cultivation

Particulars	Open land	Poly house
Direct energy	25186.3 MJ/ha	60474.7 MJ/ha
Renewable energy	3603.85 MJ/ha	8927.8 MJ/ha
Non -renewable energy	44698.05 MJ/ha	79159 MJ/ha
Yield	15300 Kg/ha	46000 Kg/ha
Output energy	12240 MJ/ha	36800 MJ/ha
Energy ratio	0.25	0.41
Energy productivity	0.32 Kg/MJ	0.52 Kg/MJ
Specific energy	3.1 MJ/Kg	1.9 MJ/Kg
Net energy	-36061.9	-51286.8

production was mainly dependent on non-renewable and direct sources of energy forms as tabulated in Table 3. It can be clearly seen from the above table, on an average, the direct form of energy input was 68.6% in polyhouse cucumber and 52.2% in open field cucumber of the total energy input. As same as share of non-renewable energy input for polyhouse cucumber is 89.8 and 92.5 % for open field cucumber of the total energy. For both systems of production, net energy was estimated -36061.9 (open land) and -51286.8 MJ/ha (polyhouse) Since, Net energy is negative (less than zero) Therefore, it can be concluded that in cucumber production, energy is being lost in both systems and requires effective energy management practices. The result also revealed that energy intensiveness of the greenhouse crop production could be considerably improved by adoption of new upgraded greenhouse technologies. It is suggested on the basis of energy estimations that energy efficient greenhouse could be designed and renewable energy sources could be utilized to reduce dependency on uses of conventional energy sources (Chandra and Gupta, 2000).

CONCLUSION

1. The results revealed that operation wise energy consumption was higher in polyhouse system as compared to open land cucumber production. The total operation wise energy input for both the system was 28626 MJ/ha and 69234 MJ/ha for open land and polyhouse respectively Therefore, operation wise energy input is approximately 2.5 times more than the open land cultivation of cucumber.
2. Source wise energy input for polyhouse and open land cucumber production was 88085 and 48299 MJ/ha respectively. Source wise fuel energy was used maximum in both the systems in the operations like tillage, FYM application and transportation of produce. Source wise total energy supplied from fuel was estimated 55.8 and 40.6 % of total energy in polyhouse and open land systems cucumber production.
3. In open land system, operation wise most energy intensive operations were transportation, FYM application and irrigation while for polyhouse transportation, FYM application and seed bed preparation were the most energy intensive operations.
4. The non renewable sources of energy were used in both production systems predominantly as compare to renewable energy sources. Non-renewable energy input for polyhouse cucumber was found 89.8% and 92.5% of the total energy for open field cucumber.

On the basis of energy estimation study, it can be concluded that use of polyhouse for production of cucumber in Malwa region is energy wise efficient as compare to open land cucumber production in view of energy use efficiency and energy productivity, provided with better energy management practices and use of renewable energy sources.

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Received: April 13, 2020
Accepted: May 26, 2020