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Energy Use Pattern in Mango Production at Mall – Malihabad Mango Belt of Utter Pradesh

Anil Kumar Verma[1*], A.K.A. Lawrence[2], Ashok Tripathi[3] and Surendra Pal[4]

[1&4]PhD Scholar, [2]Professor Department of Renewable Energy Engineering

[3]Professor Department of Farm Machinery and Power Enfineering

Vaugh Institute of Agricultural Engineering and Technology, Sam Higginbottom University of Agriculture, Technology & Sciences (formerly Allahabad Agriculture Institute), Allahabad (U.P)

*Corresponding Author E-mail: lkoanil@gmail.com

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ABSTRACT

The paper examines the energy use pattern in mango production at the Mall – Malihabad mango belt of Utter Pradesh, which is famous Deshehari mango growing area in India. Data were collected from 50 mango orchards by using a face-to-face survey, after selected the farmers using multi-stage stratified random sampling approach. The results revealed that the energy consumption ranged from 7870 to 9535 MJha^{-1} with an average of 8845 MJha^{-1}. The standard deviation of energy consumption was calculated as 481 MJha^{-1}. The chemical energy inputs 30.77%, mainly in pesticides, has the largest share in the total energy consumption followed by diesel fuel (25.84%). The results also revealed that the total non-renewable energy inputs were 83.51% of the total energy consumption. The direct and indirect form of energy was used 49.67 and 50.33 percent, respectively. The productivity in marginal orchard size was low and increase with increase in orchard size up to medium size orchards (4.4 ha) then almost constant, and its ranged 8700 to 19150 kg/ha with an average of 12304.22 kg/ha. The standard deviation of productivity was calculated as 3787.87. The energy ratio, energy productivity, and net energy yield for mango was estimated to be 3.05, 1.33 kgMJ^{-1}and 18162.75 MJ ha^{-1}, respectively.

Key words: *Mango, energy analysis, energy productivity, energy intensiveness, INR (Indian Rupee), MJ (mega joule).*

INTRODUCTION

The total commercial energy input in Indian agriculture has increased from 15.2 MOTE (636.39 × 10^{9} Mega Joules) in 2005 - 06 to 25.1 (1050.88 × 109 Mega Joules) in 2015-16 this is in increasing trend. Energy use demand in agriculture has developed due to increasing population, limited arable land and improvement of living standard. These factors developed in increasing demand of energy to maximize production and use of machinery and chemicals (fertilizers and plant protection). Horticulture crop production, like agriculture, has become dependent on energy resources such as chemicals, electricity, fossil fuels, and fertilizers.

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Energy requirements in horticulture can be divided into direct (Human labor, fossil fuels, Electricity, Water) and indirect energy (Machinery, Fertilizers, Chemicals, FYM). For agricultural sustainability to rural livelihoods, efficient use of these energies is required to achieve increased productivity profitability and competitiveness.

Mango (*Mangifera indica*) is an Important fruit crop in most continents, particularly in Asia, Central, and South America and Africa. At present, 100 countries grow mango over an area 4649 thousand ha and produce about 42 mt (million tons), the major share was contributed by India (42%).

Mango productivity has been found to be positively correlated with energy inputs[24]. Increasing production cost and depilating energy resources are compelling us to enhance mango production per unit area with minimum input cost and energy. It has been observed that the average yield of the mango can be increased through the proper adoption of recommended cultural practices.

Many researchers conducted energy studies on crop like apricot, grape, raspberry, orange, lemon, plum, pear and apple, citrus, pistachio nut and sultana grape. However, the authors have not come across publications analyzing energy input and output in mango production. Mango production system needs to be analyzed for energy consumption to optimize and establish efficient energy input uses at different farm size.

MATERIAL AND METHODS

Data were collected on seven farm inputs (human labour, machinery, fuel, electricity, fertilizers, pesticides and water) involving in five field operations (tillage, fertilizer application, spraying, harvesting and irrigation) from 50 farmers of different categories (marginal, small, and medium) for the mango production year 2015-2016 from the orchards located in different villages of Lucknow district of Utter Pradesh by using a face to face questionnaire. The simple multi-stage stratified random sampling method was used to determine survey volume[10].

The collected data was maintain in separate excel spared sheet in for tillage, fertilization, plant protection /spraying, irrigation and harvesting. The different inputs and output were converted into energy units by multiplying each with respective conversion factor i.e. energy equivalent[14,2]. Further the data was rearranged (i) By operation and (ii) By source for energy use in mango production. Operation wise and source wise energy budget in MJ ha^{-1}, total energy input, total output energy, energy use efficiency, energy productivity and specific energy in each orchards were computed using equations as explained in equation 1 to 6. The energy consumption in horticultural system is associated with all inputs that part in the production of crop. Inputs were converted into equivalent energy units with suitable conversion factors given

E_t Tillage energy $MJha^{-1}$

$$E_t (MJha^{-1}) = (E_m + E_f + E_h) \times (hr\ ha^{-1}) \qquad \mathbf{-1}$$

Where

E_m –Machine energy $MJhr^{-1}$, E_f - Fuel energy $MJhr^{-1}$, E_h - Human energy $MJhr^{-1}$

$$E_m = \frac{\text{weight of tractor} \times \text{coefficient}}{\text{useful life (hrs)}} + \frac{\text{weight of implement} \times \text{coefficient}}{\text{useful life(hrs)}}$$

E_f = Fuel consumption in liter per hrs × coefficient (MJ $litr^{-1}$)

E_h = Human hr consume in operation × coefficient (MJ hr^{-1})

E_{ir} energy consume in irrigation ($MJha^{-1}$)

$$E_{ir} (MJha^{-1}) = (E_{mp} + E_e + E_l + E_w)\ \text{pump operation}\ (hr\ ha^{-1}) \qquad \mathbf{-2}$$

E_{ir} = energy used in irrigation (MJ hr^{-1})

E_{mp} = (weight of pumping set × coefficient) / useful life (hrs)

E_e= Fuel or electricity consumption in kW per hrs × coefficient (MJ kW^{-1})

E_h = Man hr consume in operation × coefficient (MJ hr^{-1})

Esp = Spraying (plant protection) energy

Esp ($MJha^{-1}$) = ($E_{msp} + E_f + E_h + E_{ch}$) (hr ha^{-1}) **- 3**

Where

Esp = spraying energy

E_{msp} = [(Weight of tractor × coefficient) ∕ useful life (hrs)] + [(weight of sprayer × coefficient) ∕ useful life (hrs)] + [(weight of hose pipe × coefficient) ÷ useful life (hrs)] + [(weight of tanker × coefficient) ∕ useful life (hrs)]

E_f = Fuel consumption in liter per hrs × coefficient (MJ $litr^{-1}$)

E_h = Man hr consume in operation × coefficient (MJ hr^{-1})

E_{ch} = (Rate of application of chemical ml l^{-1}) × coefficient (MJ l^{-1}) ×solution delivered hr^{-1}

FYM and chemical fertilizers energy MJ ha^{-1}

$E_{fert} = E_{fym} + E_{chf} + E_h$ **- 4**

Where

E_{fym} MJ ha^{-1} = Rate kg $tree^{-1}$ × coefficient MJ kg^{-1} × no. of tree per ha

E_{chf} MJ ha^{-1} = Rate kg $tree^{-1}$ × coefficient MJ kg^{-1} × no. of tree per ha

Harvesting energy

$E_{harvest}$ MJ ha^{-1} = (man hrs × coefficient MJ hr^{-1}) **- 5**

The input energy is the sum of all the input energy involved in the mango orchards according to Eq. 6

$$\mathbf{E_{input}=E_{tillage}+E_{Irr.}+E_{FYM}+E_{Ferti.}+E_{pp}+E_{harvest}} \quad \textbf{-6}$$

Output energy

$$E_{out} = [(Y \times P) \times \{(P_C \times E_P) + (C_C \times E_C) + (F_C \times E_F) + (OA_C \times E_{OA})] \div 100 \quad \textbf{-7}$$

Where: Y = yield ($kgha^{-1}$); P = Pulp (%) 70% in case of dashaheri mango; P_C = protein content (g/kg); C_C = Carbohydrate content (g/kg); F_C = fat content (g/kg), OA_C = organic acid content and. E_P (22.5kJ), E_C (15.5kJ), E_F (2 77kJ), E_{OA} (9.5kJ) are the enclosed energy in protein, carbohydrate, fat and organic acid respectively. – (Anonymous, 1998)

Energy indices calculation

Energy Indices [Energy Ratio (ER), Net Energy Gain (NEG) and Energy Productivity (EP) were calculated according the following equations

ER = Energy output ($MJha^{-1}$) ∕ Energy input (MJ ha^{-1}) **- 8**

NEG = Energy output ($MJha^{-1}$) − Energy input (MJ ha^{-1}) **- 9**

EP = Yield ($kgha^{-1}$) ∕ Energy input (MJ ha^{-1}) **-10**

Renewable energy (RE) = Water for irrigation + Human labor + FYM **-11**

Non Renewable energy (NRE) = Machinery + Diesel fuel + Electricity + Fertilizers + Chemicals **- 12**

Direct Energy (DE) = Human labor + Diesel fuel + Electricity + Water for irrigation **-13**

In Direct Energy = Machinery + Fertilizers + Chemicals + FYM **-14**

MS- EXCEL worksheet for further analysis work The individual farmer-wise following information were used.

1. Operation wise energy requirement (MJ/ha).
2. Source wise energy use by farmers (MJ/ha).
3. Crop yield (Kg/ha).
4. Energy input through indirect sources.
5. Energy input through direct sources.
6. Energy input through renewable sources.
7. Energy input through Non renewable sources

RESULTS AND DISCUSSIONS

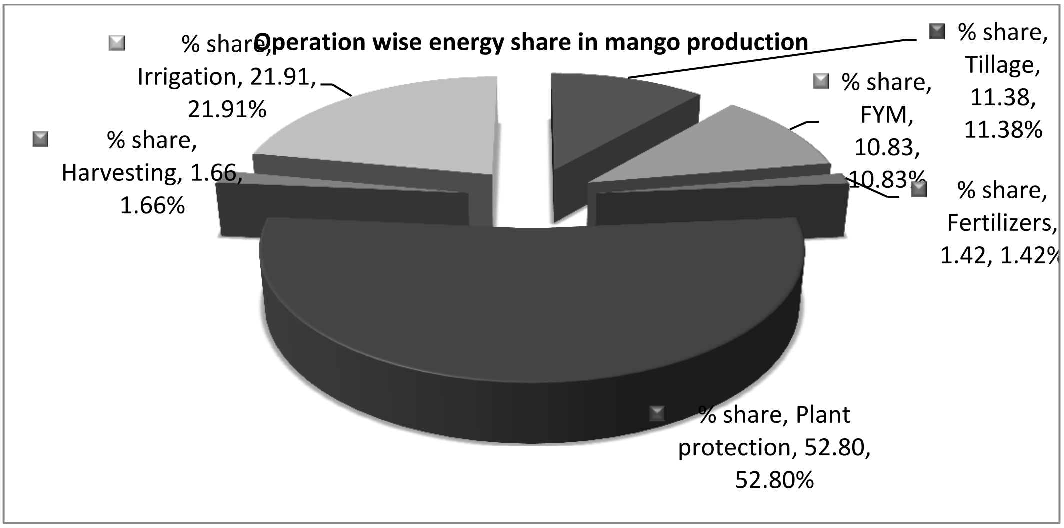
3.1 Operation wise energy use pattern:

Table 3.1 shows that the operation wise energy requirement during 2015-16 varied from 8643.7-8975 MJ/ha with mean value of 8845.6 MJ/ha, there was significant difference in the energy utilization amongst all the category of farmers was observed in performing all the operations for mango production. Table 3.1 indicates that plant protection was the highest energy consuming operation and consumed (4672.54 MJha^{-1}) followed by irrigation (1932.24MJha^{-1}), tillage (1010.0 MJha^{-1}) and FYM (958.04 MJha^{-1}) for mango crop production in 2015-16.

Table 3.1 Operation wise energy use pattern (MJha^{-1}) and energy indices for Mango production

Items	**Marginal**	**Small**	**Medium**	**Wt. avg.**
Tillage MJha^{-1}	1010.61	1016.29	996.4	1010.04
FYM MJha^{-1}	955.71	957.09	967.7	958.04
Fertilizers MJha^{-1}	125.31	125.49	126.88	125.62
Plant protection MJha^{-1}	4661.17	4667.89	4719.64	4672.54
Harvesting MJha^{-1}	142.52	153.53	150.84	147.15
Irrigation MJha^{-1}	2079.71	1723.41	1826.08	1932.24
Input energy MJha^{-1}	8975.03	8643.7	8787.54	8845.63
Production kgha^{-1}	9821.11	11802.86	18115.71	11742.77
Output energy MJha^{-1}	22588.56	27146.57	41666.14	27008.38
Output - input energy ratio	2.52	3.14	4.74	3.05
Energy productivity kgMJ^{-1}	1.094	1.365	2.062	1.328
Net energy gain MJha^{-1}	13613.53	18502.87	32878.6	18162.75

Among the operation wise energy consumption, plant protection operation (52.8 percent) consume maximum energy followed by irrigation 21.91 percent, 11.38 percent in tillage and FYM 10.83 percent all of these operation consume about 97 percent operational energy. (fig.3.1). The maximum energy consumption was found in category I, followed by category III and category II.



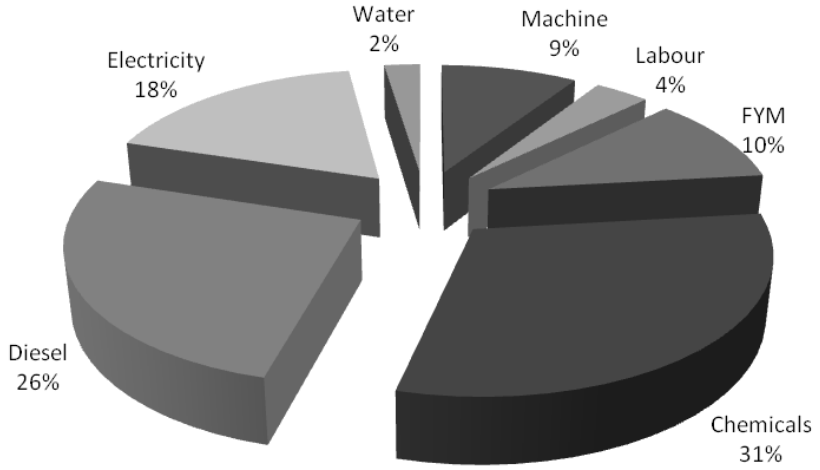
3.2 Source wise energy requirement for mango production

The energy input from various sources of energy is presented in table 3.2 and percent share in Fig 3.2 The data revealed that chemicals was the highest energy consumer in mango production (30.44 – 31.69 %) fowled by fuel (25.63 – 26.55%) and electricity (15.51 – 18.51%). Most of the chemical energy consumes in fungicide, insecticide and pesticide spraying. Fuel (diesel) energy consumed in tractor for spraying and tillage operation, electrical energy mainly consume in running irrigation pumps. Machine energy which includes machine depreciation mainly consumes in tillage, plant protection and irrigation machinery as 9.07 – 9.12% of total energy consumption in mango orchards. Hence, the percentage contribution of chemical energy was highest for mango production.

Table 3.2 Source wise energy use pattern ($MJha^{-1}$) for Mango production

Items	**Marginal**	**Small**	**Medium**	**Wt. avg.**
Machine energy $MJha^{-1}$	820.02	786.75	798.79	806.64
Human energy $MJha^{-1}$	315.97	337.56	319.20	322.96
FYM energy $MJha^{-1}$	921.93	924.27	929.38	923.82
Fuel energy $MJha^{-1}$	2287.25	2280.08	2289.72	2285.49
Chemical energy $MJha^{-1}$	2715.88	2722.91	2737.62	2721.47
Electricity energy $MJha^{-1}$	1688.47	1401.34	1508.89	1573.59
Water energy $MJha^{-1}$	225.54	190.79	203.94	211.66
Input energy $MJha^{-1}$	8975.05	8643.70	8787.53	8845.65

Fig. 3.2 Source wise energy distribution in mango production



3.3. Energy consumption as per modes of energy in mango production

Calculation of energy consumption in mango production as per energy classification, according to direct, indirect, renewable and non-renewable energy forms are presented in Table 3.3 It is evident that, the ratios of direct and indirect energy modes are almost the same; but the ratios of renewable and non-renewable energy forms are fairly different from each other (Fig. 3). The percent share of non-renewable energy is very high (83.51%), indicating that Mango production in the region depends mainly on chemicals and fossil fuels. Several researchers have founded the ratio of DE higher than that of IDE, and the rate of NRE much greater than that of RE in production of different agricultural crops.

Table 3.3 Energy distribution as per modes of energy consumption

Modes of Energy	Energy MJ ha^{-1}	Per cent share	Per cent share
Direct energy	**4393.72**		**49.67**
Human	322.96	7.35	
Diesel	2285.50	52.02	
Electricity	1573.60	35.81	
water	211.66	4.82	
In Direct Energy	**4451.93**		**50.33**
Machinery	806.64	18.12	
FYM	923.82	20.75	
Chemicals	2721.46	61.13	
Renewable Energy	**1458.44**		**16.49**
Human	322.96	22.14	
FYM	923.82	63.34	
Water	211.66	14.51	
Non Renewable Energy	**7387.20**		**83.51**
Diesel	2285.50	30.94	
Electricity	1573.60	21.30	
Machinery	806.64	10.92	
Chemicals	2721.46	36.84	
Total	8845.64		

3.4 Energy indices

The energy indices were also calculated in table 3.1, for all the categories of farmers and found that highest energy ratio 4.74, energy productivity 2.06 $kgMJ^{-1}$ and net energy gain 32878.6 in medium category of farmers followed by small and marginal farmers. The average output input energy ratio (3.05), energy productivity (1.33 $kgMJ^{-1}$) and net energy gain 18162.75 $MJha^{-1}$.

CONCLUSION

In this study, energy consumption for input and output energies in mango production was investigated in Mall – Malihabad mango belt of Utter Pradesh. Data were collected from 50 farmers which were selected based on multi-stage stratified random sampling method. Total energy consumption in mango production was 8845.6 $MJha^{-1}$ of which chemicals (plant protection), diesel fuel and electric energy consumption was 31%, 26% and 18%, respectively. Direct and Indirect energy were 49.6% and 50.4% respectively. Output Energy was 27008.4 $MJha^{-1}$. The energy productivity of the area may be enhanced by efficient utilization of energy inputs in case of marginal farmers. The use of Non-renewable energy may be reduced by judicious use of input like chemicals for plant protection and use of the small size of tractors in orchards.

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