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Energy input, output and economic analysis in organic production of mango (*Mangifera indica*) cv. Dashehari

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ABSTRACT

Energy input and cost analysis of any crop production helps in cost effective management of inputs for improving productivity and profitability. Energy input, output and economic analysis was carried out for various components in mango (*Mangifera indica* L.) production system. Irrigation consumed the least energy (63 MJ) and diesel oil ranked first (3 040.74 MJ) in energy consumption. Maximum input energy was consumed (8 121.49 MJ) with application of 50 kg vermicompost + 250 g *Azospirillum* + PSB culture/tree + vermiwash spray compared to 6 232.24 MJ with application of 50 kg FYM/tree. Total production cost per hectare was maximum ₹ 26 989 with 50 kg vermicompost + 250 g *Azotobacter* + PSB culture/tree and minimum (₹ 19 349) with application of 50 kg FYM/tree. Maximum net return (₹ 61 741/ha) was recorded with 50 kg vermicompost + 250 g *Azospirillum* + PSB culture/tree and benefit cost ratio (3.74) was with application of 50 kg vermicompost/tree. The total investment in term of energy was increased with 50 kg vermicompost + 250 g *Azospirillum* + PSB culture/tree over application of 50 kg FYM/tree but production cost also decreased by 28.89% and net return was improved by 138.8% with application of 50 kg vermicompost + 250 g *Azospirillum* + PSB culture/tree.

Key words: *Azospirillum*, BC ratio, Energy input, Energy intensive, Energy output-input ratio, Net return

High cost agrochemicals based mango (*Mangifera indica* L.) production is not sustainable because of loss of soil productivity, surface and ground water pollution, shortages of non-renewable resources and low farm income from high production costs. The mango production strategy in India for future should be focused on reduced external inputs use and higher output without any adverse effect on environment. Emphasis should be given to protect environment from economic exploitation under overuse of agrochemicals (Ayala and Prakasa Rao 2002).

According to a conservative estimation, around 600-700 million tonnes of agricultural wastes (including 272 million tonnes of crop residues) are available in India every year, but most of it remains unutilized. This huge quantity of wastes can be converted into nutrient rich composts for soil fertility restoration (Suthar 2008b). In India, crop waste is often burned. Punjab burns 12 million tonnes of crops residues per year and looses 70 crores and produces 23 million tonnes of CO_2 (Hameeda *et al*. 2006). Straw left on the soil surface supplies small quantities of phosphorus, potassium, and other nutrients present for subsequent crop. Due to high C: N ratio of straw, the mineralizing organisms may reduce the available soil nitrogen.

Mango like other horticultural crops has become increasingly dependent upon energy resources such as electricity, fossil fuels, pesticides and fertilizers, largely due to relatively low energy prices. Efficient use of energies helps to achieve optimum production and productivity and contributes to economy, profitability and competitiveness of sustainability to rural livelihoods (Singh *et al*. 2002). The output energy is obtained in the form of fruit. Agricultural practices in many developing countries continue to be based, to a large extent, on animal and human energy. Mechanical and electrical energy are not easily available to the growers, hence the potential gains in agricultural productivity through the deployment of modern energy services are not being realized (FAO 2000). Mango is grown throughout the tropical and subtropical regions of the world as fruit crop with high energy inputs (due to occurrence of pests and diseases). A lot of research works have been done on input-output analysis of energy and economic analysis in the production of leading fruit crops like apple, citrus and grapes etc. However the information on such aspects is lacking in mango cv. Dashehari. Therefore, an effort was made to compute data on energy use pattern, energy input, out put ratio and economic analysis of mango production to help the growers

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for cost effective management of inputs to improve production and profit.

MATERIALS AND METHODS

A field experiment is laid out in randomized block design with 3 replications on 34 years old trees of mango cv. Dashehari during 2011-2012 at Central Institute for Subtropical Horticulture, Lucknow, India. Two year data (2011 and 2012) from seven treatments, viz 50 kg FYM/ tree (T1), 50 kg FYM + 250 g *Azospirillum* + PSB culture/ tree (T2), 50 kg FYM + 250 g *Azotobacter* + PSB culture/ tree (T3), 50 kg vermicompost/tree (T4); 50 kg vermicompost + 250 g *Azospirillum* + PSB culture/tree (T5), 50 kg vermicompost + 250 g *Azotobacter* + PSB culture/tree (T6) and 50 kg vermicompost + 250 g *Azospirillum* + PSB culture/tree + vermiwash spray (T7) were taken for the estimation of energy. The estimation of energy inputs was based on the schedule (time required for each operation), number of manpower, machinery and inputs used such as manures, biofertilizers and bio-pesticides (Tsatsarelis 1993) (Table.2). Energy equivalent of the inputs used in the mango production is given in Table 1. Variation in energy equivalents were used to express the input of energy associated with the production process in terms of primary energy input (Rathke and Diepenbrock 2006). Energy used in cultural operations, viz tillage, irrigation, manure and biofertilizer application, spraying, harvesting, transportation etc. in mango is presented in Table 1.

The working hours of manpower were determined in each activity and taken for calculation of total human energy. The total human energy used in each activity was calculated by suitable conversion factors, one man hour = 1.96 MJ/ha (Table 1). The mechanical energy used in experimental plot included tractor and electric tube well was computed on the basis of total energy/fuel consumption (liter/ha) in different cultural operations. The electrical energy was used for electric motor to operate tube well for irrigation in experimental trees.

The energy efficiency parameters were determined to evaluate relationship between energy consumption and total output and production per ha. Energy ratio, specific energy, energy productivity, energy intensiveness and net energy yield were calculated using the formula suggested by Mandal *et al.* (2002), Singh *et al.* (1997), Mani *et al.* (2007) and Rathke *et al.* (2007). Energy output-input ratio shows the efficiency of energy input and also marginal increase of output due to per unit increase in energy input. This ratio is generally higher in lower energy input and lower in higher energy input, which indicates the law of diminishing return applied in energy input (Shrestha 1998). Gross profit, net return and benefit cost ratio was worked out keeping sale price of mango @ ₹ 10/kg. Energy efficiency was used to measure economic efficiency of mango production.

Table 1 Energy level in different inputs and output

Input	Energy equivalent (MJ/unit)
Human labor (h)	
Soil application	1.96
Spraying	1.96
Cultural practices	1.96
Harvesting	1.96
Transportation	1.96
Machinery (h)	
Tractor	41.4
Spraying	23.80
Irrigation	2.40
Cultural practices	22.80
Transportation	71.3
Inputs	
Farm yard manure (kg)	0.30
Vermicompost (kg)	0.5
Azospirillum (kg)	10
PSB (kg)	10
Azotobacter (kg)	10
Vermiwash (l)	0.1
Bio pesticide(l)	0.1
Diesel-oil (l)	56.31
Electricity (kWh)	11.93
Irrigation water (m^3)	0.63
Output	
Fruit	2.3

Table 2 Schedule of cultural operations practiced in mango production

Cultural operations	Time/frequency
Cultivar	Dashehari
Number of trees (ha^{-1})	100
Land preparation	In September-October (harrow)
Average ploughing frequency	2
Time of manure application	September-October
Frequency of manure application	1
Foliar application	September-October
Number of spraying	3
Basin preparation	September-October
Frequency of basin preparation	1
Harvesting period	June

- Energy Ratio = energy out put (MJ/ha)/ energy input (MJ/ha)
- Specific energy = energy in put (MJ/ha)/output (Fruit yield kg/ha)
- Energy productivity = output (Fruit yield kg/ha)/ energy input (MJ/ha)
- Energy intensiveness = energy input (MJ/ha)/cost of production (•/ha)
- Net energy yield = energy output (MJ/ha) - energy input (MJ/ha)

Production value, gross profit, productivity, net return and benefit cost ratio was worked out as per following formula.

- Total production value = Mango yield (kg/ha), Mango price (₹/kg)
- Gross profit = Total production value (₹/ha) – Total production costs (₹/ha)
- Productivity = Mango yield (kg/ha)/Total production costs (₹/ha)
- Net return=Total production value (₹/ha) – Total production cost (₹/ha)
- Benefit/cost ratio=Total production value (₹/ha)/Total production cost (₹/ha)

RESULTS AND DISCUSSION

Estimation of energy inputs in different organic sources used in mango production

The data collected from the experimental trees of mango cv. Dashehari for energy input and output analysis (Table 4) revealed that the total energy consumed in terms of manpower, machinery and organic manure was 6232.24 MJ with application of 50 kg FYM/tree, 6833.13 MJ with 50 kg FYM/tree + 250 g each of *Azospirillum* and + PSB culture, 6867.30 MJ in 50 kg FYM/tree + 250 g culture of each *Azotobacter* and PSB, 7329.05 MJ 50 kg vermicompost/tree), 7871.37 MJ in 50 kg vermicompost + 250 g culture of each *Azospirillum* and PSB, 7868.87 MJ in 50 kg vermicompost + 250 g culture each of *Azotobacter* and PSB/tree and 8121.49 MJ in 50 kg vermicompost + 250 g culture each of *Azospirillum* and PSB/tree + vermiwash spray, whereas, energy output per hectare in the form of yield was recorded as 10 396 MJ, 15 566.4 MJ, 20 074.4 MJ, 18 510.1 MJ, 20 414.8 MJ, 20 205.5 MJ and 14 591.2 MJ in the respective treatments. It is clear from the data that energy consumption with 50 kg vermicompost/tree + 250 g cultures each of *Azospirillum* and PSB + vermiwash spray was found maximum (8 121.49 MJ) compared to 6 232.24 MJ minimum with 50 kg FYM/tree. Among various inputs, diesel oil consumed maximum energy (3 040.74 MJ) as compared to irrigation (63 MJ) in all treatments of mango production. Machinery consumed 931.05 MJ energy in various treatments, whereas organic manures consumed (1 500 MJ) energy followed by 397.45 MJ with human labour, 300 MJ with bio pesticides and minimum 63 MJ in irrigation (Table 3). Organic manure and biofertilizers were the second higher energy consuming input and varied from 1 500 to 3 300 MJ in all the treatments. These are similar to earlier reports by Funt (1980), Strapatsa *et al.* (2006), Koctuk and Engindeniz (2009) and Pellizzi (1992). Similar pattern of energy use in machinery and higher energy use for fuel were also reported by Pellizzi (1992) in fruits production. Lower energy in machinery and high energy use in diesel

Table 3 Energy (MJ) consumption in different operations and yield of mango cv. Dashehari

Particular	50 kg FYM/ tree	50 kg FYM + 250 g *Azospirillum* + PSB culture/tree	50 kg FYM + 250 g *Azotobacter* + PSB culture/ tree	50 kg vermicompost/ tree	50 kg vermicompost + 250 g *Azospirillum* + PSB culture/tree	50 kg vermi-compost + 250 g *Azoto-bacter* + PSB culture/tree	50 kg vermi-compost + 250 g *Azospi-rillum* + PSB culture/tree + vermiwash spray
Human labour	397.45	478.73	532.52	494.26	536.58	534.08	486.70
Machinery	931.05	931.05	931.05	931.05	931.05	931.05	931.05
Organic manures	1 500	2 000	2 000	2 500	3 000	3 000	3 300
Diesel-oil	3 040.74	3 040.74	3 040.74	3 040.74	3 040.74	3 040.74	3 040.74
Irrigation	63	63	63	63	63	63	63
Biopesticides	300	300	300	300	300	300	300
Total energy input	6 232.24	6 813.52	6 867.31	7 329.05	7 871.37	7 868.87	8 121.49

Table 4 Energy input consumption, production and cost of production with different treatments in mango cv. Dashehari

Treatment	Total Input energy (MJ/ha)	Input cost (₹)	Total fruit energy (MJ/ha)	Total production (kg/ha)	Farm gate value (₹)	Cost of production (₹/tonne)
50 kg FYM/tree	6 232.24	19 349.38	10 396	4 520	45 200	4 280.84
50 kg FYM + 250 g *Azospirillum* + PSB culture/tree	6 833.13	25 560	15 566.4	6 768	67 680	3 776.59
50 kg FYM + 250 g *Azotobacter* + PSB culture/tree	6 867.30	25 970.19	20 074.4	8 728	87 280	2 975.51
50 kg vermicompost/tree	7 329.05	21511.08	18 510.4	8 048	80 480	2 672.85
50 kg vermicompost + 250 g *Azospirillum* + PSB culture/tree	7 871.37	27 018.93	20 414.8	8 876	88 760	3 044.04
50 kg vermicompost + 250 g *Azotobacter* + PSB culture/tree	7 868.87	26 988.96	20 205.5	8 785	87 850	3 072.16
50 kg vermicompost + 250 g *Azospirillum* + PSB culture/tree+ vermiwash spray	8 121.49	24 020.39	14 591.2	6 344	63 440	3 786.32

were reported for medium density high yielding apple orchards in eastern United States (Funt 1980). In Greece, pest management was recorded as high energy consuming operation for apple production, accounting for 40% of total energy input. Pest management, fertilization and harvesting operations were observed for high energy inputs in apple production in Italy (Strapatsa *et al.* 2006). In general, energy use in different operations in different crops varies with prevailing climatic conditions.

Input-output energy ratio, specific energy and energy intensiveness in mango production

Maximum energy (8 121.49 MJ) use in organic mango production was worked out with application of 50 kg vermicompost + 250 g *Azospirillum* + PSB culture/tree + vermiwash spray and minimum 6 232.24 MJ in 50 kg FYM/tree, while, total maximum output energy (20 414.8 MJ) in 50 kg vermicompost + 250 g *Azospirillum* + PSB culture/tree followed by 20 205.5 MJ 50 kg vermicompost + 250 g *Azotobacter* + PSB culture/tree and minimum (10 396 MJ) was recorded in 50 kg FYM/tree. In the present study, maximum output and input energy ratio (2.92) was worked out in 50 kg FYM + 250 g *Azotobacter* + PSB culture/tree followed by 2.59 in 50 kg vermicompost + 250 g *Azospirillum* + PSB culture/tree and minimum 1.67 in 50 kg FYM/tree (Table. 5). Specific energy was observed maximum (1.38 MJ/kg) in application of 50 kg FYM/tree followed by 1.28 MJ/kg with 50 kg vermicompost + 250 g *Azospirillum* + PSB culture/tree + vermiwash spray and minimum (0.787 MJ/kg) in 50 kg FYM + 250 g *Azotobacter* + PSB culture/tree, whereas energy productivity (1.271 kg/MJ) was recorded maximum in 50 kg FYM + 250 g *Azotobacter* + PSB culture/tree followed by 1.128 kg/MJ in 50 kg vermicompost + 250 g *Azospirillum* + PSB culture/tree and minimum 0.725 kg/MJ in 50 kg FYM/tree. Energy intensiveness was also worked out in all treatments and 0.264 MJ/Rs was recorded minimum in 50 kg FYM + 250 g *Azotobacter* + PSB culture/tree followed by 0.267 MJ/Rs in 50 kg FYM + 250 g *Azospirillum* + PSB culture/tree and maximum 0.338 MJ/Rs in 50 kg vermicompost + 250 g *Azospirillum* + PSB culture/tree + vermiwash spray. Energy output input ratio, specific energy, energy productivity, net energy yield, specific energy and energy intensiveness were found best with 50 kg FYM + 250 g *Azotobacter* + PSB culture/tree followed by 50 kg vermicompost + 250 g *Azospirillum* + PSB culture/tree. In mango such type of report is still lacking but Akdemir *et al*. (2012) have reported energy productivity in apple production as 0.63 kg/MJ and energy intensity as 3.31 MJ. Strapatsa *et al.* (2006) reported energy productivity of 0.42 kg/MJ and energy intensity (2.5 MJ) in apple production. The net energy yield (13 207.1 MJ/ha) was recorded maximum in 50 kg FYM + 250 g *Azotobacter* + PSB culture/tree followed by 12 336.6 MJ/ha in 50 kg vermicompost + 250 g *Azotobacter* + PSB culture/tree and minimum 4163.8 MJ/ha in 50 kg FYM/tree. In an study, the organic crop system was found most energetically efficient considering the relation between the produced energy (by the roots harvest of sweet potato) and the total energy input of the system, followed by the biodynamic and conventional production systems (Raquel Fabbri Ramos and Maristela Simoes do Carmo 2004).

Economic analysis of mango production

Economic and energy analysis of the production system may be more comprehensive for the best management strategies (Tsatsarelis 1993). The cost and net return on mango production is presented in Table 6. The observation showed that the production cost (₹ 27 019/ha) was recorded maximum with application of 50 kg vermicompost + 250 g *Azospirillum* + PSB culture/tree followed by ₹ 26 989/ha in 50 kg vermicompost + 250 g *Azotobacter* + PSB culture/tree and minimum (₹ 19 349/ha) with application of 50 kg FYM/tree. Maximum production of 8 876 kg/ha was recorded with application of 50 kg vermicompost + 250 g *Azospirillum* + PSB culture/tree followed by 8 785 kg/ha with application of 50 kg vermicompost + 250 g *Azotobacter* + PSB culture/tree and minimum 4520 kg/ha in 50 kg FYM/tree. However, total production value was recorded maximum (₹ 88 760/ha) with 50 kg vermicompost + 250 g *Azospirillum* + PSB culture/tree followed by ₹ 87 850/ha in 50 kg vermicompost + 250 g *Azotobacter* + PSB culture/tree and minimum ₹ 45 200/ha in 50 kg FYM/tree. Maximum

Table 5 Energy consumption and energy input output relationship in organic production of mango cv. Dashehari

Energy input output relationship	50 kg FYM/ FYM/	50 kg FYM + 250 g *Azospirillum* + PSB culture/tree	50 kg FYM + 250 g *Azotobacter* + PSB culture/tree	50 kg vermicompost/ tree	50 kg vermicompost + 250 g *Azospirillum* + PSB culture/tree	50 kg vermicompost + 250 g *Azotobacter* + PSB culture/tree	50 kg vermicompost + 250 g *Azospirillum* + PSB culture/tree + vermiwash spray
Total energy input (MJ)	6 232.2	6 833.1	6 867.3	7 329.05	7 871.4	7 868.87	8 121.49
Total output energy (MJ)	10 396	15 566.4	20 074.4	18 510.4	20 414.8	20 205.5	14 591.2
Energy output-input ratio	1.67	2.28	2.92	2.53	2.59	2.57	1.80
Specific energy (MJ/kg)	1.38	1.010	0.787	0.911	0.887	0.896	1.280
Energy productivity (kg/MJ)	0.725	0.990	1.271	1.098	1.128	1.116	0.781
Energy intensiveness (MJ/Rs)	0.322	0.267	0.2644	0.341	0.291	0.291	0.338
Net energy yield (MJ/ha)	4 163.8	8 733.3	13 207.1	11 181.4	12 543.4	12 336.6	6 469.7

Table 6 Economic analysis in organic production of mango cv. Dashehari

Particular	50 kg FYM/ tree	50 kg FYM + 250 g *Azospirillum* + PSB culture/tree	50 kg FYM + 250 g *Azotobacter* + PSB culture/tree	50 kg vermicompost/ tree	50 kg vermicompost + 250 g *Azospirillum* + PSB culture/tree	50 kg vermicompost + 250 g *Azotobacter* + PSB culture/tree	50 kg vermicompost + 250 g *Azospirillum* + PSB culture/tree+ vermiwash spray
Total production costs (₹/ha)	19 349.38	25 560	25 970.2	21 511.1	27 019	26 989	24 020.4
Yield (kg/ha)	4 520	6 768	8 728	8 048	8 876	8 785	6 344
Total production value (₹/ha)	45 200	67 680	87 280	80 480	88 760	87 850	63 440
Productivity (kg/₹)	0.234	0.265	0.336	0.374	0.329	0.326	0.264
Net return (₹/ha)	25 851	42 120	61 310	58 969	61 741	60 861	39 420
Benefit cost ratio	2.34	2.65	3.36	3.74	3.28	3.25	2.64

productivity 0.374 kg/Re was worked out in 50 kg vermicompost/tree followed by 0.234 kg/Re in 50 kg FYM/ tree. Maximum net return ₹ 61 471/ha was recorded with 50 kg vermicompost + 250 g *Azospirillum* + PSB culture/tree followed by ₹ 61 310/ha with 50 kg FYM + 250 g *Azotobacter* + PSB culture/tree and minimum (₹ 25 851/ha) in 50 kg FYM/tree. Maximum benefit cost ratio (3.74) was obtained with 50 kg vermicompost/tree followed by 3.36 in 50 kg FYM + 250 g *Azotobacter* + PSB culture/tree and minimum (2.34) in 50 kg FYM/tree (Table 5). Contrary to this Akdemir *et al*. (2012) reported maximum benefit cost ratio (1.48) in conventional apple production.

Input and out put energy analysis in the present study indicated the pattern of energy use in mango production system. Irrigation operation consumed less energy (63 MJ) and application of 50 kg vermicompost + 250 g *Azospirillum* + PSB culture/tree + vermiwash spray ranked first (8 121.49 MJ) in energy consumption. Total minimum input energy (6 232.24 MJ) was recorded with application of 50 kg FYM/tree and it was 23.26 per cent less than that consumed (8 121.49 MJ) with application of 50 kg vermicompost + 250 g *Azospirillum* + PSB culture/tree + vermiwash spray. Output and input energy ratio (2.92) was also recorded highest with 50 kg FYM + 250 g *Azotobacter* + PSB culture/tree as compared to 1.67 with application of 50 kg FYM/tree. Maximum return (₹ 61 741/ha) was realized in 50 kg vermicompost + 250 g *Azospirillum* + PSB culture/ tree while benefit cost ratio (3.74) was highest with 50 kg vermicompost/tree.

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