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Energy input, output and economic analysis in organic production of guava (*Psidium guajava*) cv. Allahabad Safeda

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ABSTRACT

An energy workout for any crop production suggests managing energy inputs and improving energy productivity in crop production. Based on this theory, energy input and out put in organic and conventional production of guava cv. Allahabad Safeda was worked out. Machinery consumed less energy (577.8 MJ) and chemical fertilizers ranked first (10 088 MJ) in energy consumption. Maximum input energy was consumed (13523.41 MJ) in application of recommended doses of chemical fertilizers as compared to (5216.9 MJ) in T3. Output input and energy ratio (9.90) was highest in T3 compared to 3.48 with application of recommended dose of chemical fertilizers. Net return (₹ 126895/ha) and benefit cost ratio (4.26) was computed maximum in T3 compared to ₹ 47,570 and 2.82 in T4.

Key words: BC ratio, Biodynamic, Compost, Cow pat pit, Energy input, Energy ratio, Energy productivity, Net energy

High cost of agrochemical based farming 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 guava production strategy in India for future should be focused on reduced external inputs use and higher output without polluting the environment. Emphasis should be given to protect environment from economic exploitation under overuse of agrochemicals (Ayala and Prakasa Rao 2002).

The poor soil respiration rate and reduced population of natural decomposer fauna from agro ecosystems has questioned the soil sustainability and future food security (Suthar 2008a). Similarly, fast increase in the cost of chemical fertilizers, particularly N, coupled with pollution has focused attention on the use of combined application of nutrients through organic and inorganic sources in horticulture production system. Therefore, nutrient supply in plant system should be economically viable, environment-friendly and socially acceptable without affecting the production. According to a conservative estimation, around 600 to 700 million tonnes of agricultural wastes is produce in India every year, but most of it remains unutilized. This huge quantity of waste can be converted into nutrient rich composts for soil fertility restoration (Suthar 2008b).

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Guava production like other horticultural crops has become increasingly dependent upon energy resources such as electricity, fossil fuels, chemicals 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 produce and wastes. 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). Guava is grown all around the tropical and subtropical regions of the world and in most of the area it is a fruit crop with high energy inputs (due to two to three fruiting cycle in a year). A lot of research work has been done on input – output analysis of energy in the production of leading fruit crops like apple, citrus and grapes etc. However the information is lacking in guava on such aspects. Therefore an effort was made to compute data of a long term research work conducted on guava cv. Allahabad Safeda (2005–2011) on energy use pattern, energy input, out put ratio and economic analysis.

MATERIALS AND METHODS

A field experiment was carried out in randomized block design with three replications on 12 year old plants of guava cv. Allahabad Safeda during 2002–09 at Central Institute for Subtropical Horticulture, Lucknow. Four years data

(2005–009) from seven treatments, viz 30 kg biodynamic compost/ tree (T1), 30 kg biodynamic compost fortified with BD-500 and 100 g cow pat pit /tree (T2), 250 g rhizospheric soil of *Ficus benghalensis* /tree + 5% *Amritpani* + organic mulching (T3), 30 kg FYM /tree + 5 per cent *Panchagavya* (T4); 30 kg vermicompost + 250 g *Azospirillum* culture + 50 g PSB /tree (T5), 30 kg FYM /tree (T6) and 350 g N, 150 g P_2O_5 and 350 g K_2O /tree (T7) were taken for the calculation of energy. Six trees per treatment were allotted for this study. The calculation of energy inputs was based on the schedule (time required for each operation), number of manpower, machinery and inputs used (manure, bio-pesticides, fertilizer, chemicals (Table.2) (Tsatsarelis 1993). Energy consumption in preparation of biodynamic compost, cow pat pit, *amritpani* and *panchagavya* were worked out on the basis of manpower involved and materials used. Energy equivalents of the inputs used in the guava production (Table 2). 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 operation in tillage, hoeing, pruning, irrigation, manure and fertilizer application, spraying, harvesting, transportation etc. in guava was calculated (Table 2).

The working hours of manpower were determined in each activity and added to calculate 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. The mechanical energy was computed on the basis of total energy/fuel consumption (litre/ha) in different cultural operations. The electrical energy was used for electric motor to operate tube well for irrigation in experimental plants.

The energy efficiency parameters were determined to evaluate relationship between energy consumption and total output and production per hectare. 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 input - output ratio shows the efficiency of energy input and also marginal

Table 1 Energy estimation of different inputs

Input	Energy equivalent (MJ/unit)
Human labour (hr)	
Manure application	1.96
Spraying	1.96
Cultural practices	1.96
Harvesting	1.96
Transportation	1.96
Machinery (hr)	
Tractor	41.4
Spraying	23.80
Irrigation	2.40
Cultural practices	22.80
Transportation	71.3
Organic inputs and chemical fertilizer (kg)	
Nitrogen (kg)	60.60
Phosphorus (kg)	11.10
Potassium (kg)	6.70
Farm yard manure (kg)	0.30
Biodynamic compost (kg)	0.5
Biodynamic compost with BD -500 (kg)	0.7
Cow pat pit (kg)	0.6
Amritpani (kg)	1
Organic mulch (kg)	0.25
Panchgavya (kg)	3.6
Vermicompost (kg)	0.5
Azospirillum (kg)	10
Phosphorus solubilizing bacteria (kg)	10
Rhizospheric soil of *Ficus benghalensis* (kg)	0.1
Fuel and electricity	
Diesel-oil (liter)	56.31
Electricity (kWh)	11.93
Water for irrigation (m^3)	0.63
Output energy (guava /kg)	2.8386

Table 2 Schedule of cultural operations practiced in guava production

Cultural operations	Time/frequency
Cultivar	Allahabad Safeda
Number of trees (ha)	400
Land preparation	During the month of October and March (using harrow)
Average ploughing frequency	2
Pruning time	May
Number of pruning	1
Time of nutrient application	September -October
Frequency of nutrient application	1
Foliar application	September -October
Number of spraying	2
Basin preparation	September - October
Frequency of basin preparation	1
Harvesting period	1. Starts in November and complete during March (winter season) 2. Starts in August and complete in September (rainy season)

increase in output due to increase in energy input. This ratio is generally higher in lower and higher energy input, which indicates the law of diminishing return (Shrestha 1998). Gross profit, net return and benefit cost ratio was worked out keeping sale price of guava ₹10 /kg. Energy efficiency is a useful tool to measure economic efficiency of crop production.

Energy Ratio = energy out put (MJ/ha)/ energy input (MJ/ha)

Specific energy = energy in put (MJ/ha)/output (MJ/ha)

Energy productivity = output (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 = Guava yield (kg/ha), *Guava price (₹/kg)

Gross profit = Total production value (₹/ha) – Total production costs (₹/ha)

Productivity = guava 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 and inorganic sources used in guava production

The total energy consumed in the form of manpower, machinery, chemical fertilizer and organic manure was 9653.1 MJ in T1, 12104.3 MJ in T2 , 5216.9 MJ in T3, 7427.04 MJ in T4, 10905.6 MJ in T5, 7153.37 MJ in T6 and 13523.41 MJ in T7 (Table 3). Whereas, energy output in the form of yield was recorded as 37673.9 MJ, 38287 MJ, 46973.2 MJ, 360402.2 MJ, 42340.6 MJ, 33154.84 MJ and 47120.76 MJ in the respective treatments. It is clear from the data that energy consumption with recommended dose of chemical fertilizers as compared to treatments consisting organic inputs was maximum. Among various inputs, machinery consumed less energy as compared to manpower, chemical fertilizers, organic inputs and fuel in guava production. Machinery consumed 577.8 MJ energy in all the treatments whereas, chemical fertilizers consumed highest energy, i.e. 10 088 MJ followed by 8 424 MJ in T2 and minimum 3 210 MJ in T3. Manpower was the second lowest energy consuming input and it varied from 1421.98 to 2 370.62 MJ in all the treatments. These results are similar to previous studies done by Funt (1980), Strapatsa *et al.* (2006), Koctuk and Engindeniz (2009) and Pellizzi (1992). Akdemir and Akcaoz (2012) have also reported that chemical fertilizers have consumed maximum energy in apple production. Lower energy in machinery and high energy use in diesel were reported for medium density high yielding apple orchards in eastern US (Funt 1980). In guava no energy input was required for pest and disease management for winter crop because of least incidence. In

Table 3 Energy input and yield output in different treatments

Particular	30 kg biodynamic compost /tree (T1)		30 kg biodynamic compost fortified with BD-500 and 100 g cow pat pit /tree (T2)		250 g rhizospheric soil of *Ficus benghalensis* /tree + 5 per cent *Amritpani* + 30 kg organic mulching (T3)		30 kg FYM /tree + 5% *Panchagavya* (T4)		30 kg vermicompost + 250 g *Azospirillum* culture + 50 g PSB/ tree (T5)		30 kg FYM /tree (T6)		350 g N, 150 g P_2O_5 and 350 g K_2O/tree (T7)	
	Unit	Energy (MJ)	Unit	Energy (MJ)	Unit	Energy (MJ)	Unit	Energy (MJ)	Unit	Energy (MJ)	Unit	Energy (MJ)	Unit	Energy (MJ)
Human labour (h)	1018	1995.28	1040	2036.83	1224.83	2320.31	775.5	1421.98	930.5	1725.78	998.5	1859.06	1209.5	2370.62
Tractor (per hr)		577.8	0	577.8	0	577.8	0	577.8	0	577.8	0	577.8	0	577.8
Chemical fertilizer (kg)		0	0	0	0	0	0	0	0	0	0	0	340	10088
Organic manures	12000	6000	12040	8424	12300	3210	12100	3960	12120	7200	12000	3600	0	0
Diesel-oil (l)	18	1013.58	18	1013.58	18	1013.58	18	1013.58	18	1013.58	18	1013.58	18	1013.58
Total energy input (MJ)		9653.1		12104.3		5216.9		7427.04		10905.6		7135.37		13523.41
Yield (t /ha)	13.272	37673.9	13.488	38287.0	16.548	46973.2	12.824	36402.2	14.916	42340.6	11.872	33154.848	11.680	47120.76

Table 4 Energy consumption and output in guava production in different treatments

	T1	T2	T3	T4	T5	T6	T7
Total energy input (MJ)	9653.1	12104.3	5216.9	7427.03	10905.6	7135.37	13523.41
Total output energy (MJ)	37673.9	38287.0	46973.2	36402.2	42340.6	33154.848	47120.76
Energy output-input ratio	3.90	3.16	9.00	4.90	3.88	4.65	3.48
Specific energy (MJ/kg)	0.73	0.897	0.315	0.579	0.731	0.611	0.815
Energy productivity (kg/ MJ)	1.375	1.114	3.172	1.727	1.368	1.637	1.228
Energy intensiveness (MJ/ ₹)	0.254	0.297	0.133	0.201	0.274	0.209	0.318
Net energy yield (MJ/ha)	28020.8	26182.7	41756.2	28975.2	31434.9	26019.5	33597.3

Table 5 Economic analysis of guava production

Cost items	T1	T2	T3	T4	T5	T6	T7
Total production costs (₹./ha)	37940.68	40667.61	39196.75	36907.85	39771.02	34127.92	42500.8
Yield (kg/ha)	12256	12704	16580	7376	10456	11872	16600
Total production value (₹./ha)	122560	127040	165800	73760	104560	118720	166000
Productivity (kg/₹.)	0.33	0.32	0.43	0.28	0.31	0.37	0.33
Net return (₹./ha)	85731	87164	126895	47570	70573	86334	115794
Benefit cost ratio	3.33	3.19	4.26	2.82	3.08	3.67	3.31

general, energy use in different operations in different crops varies with prevailing climatic conditions.

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

Maximum energy (13 523.41 MJ) use in guava production was worked out in T3 and minimum 5 216.9 MJ in T3 , while, total maximum output energy (47 120.76 MJ) was computed in T7 and minimum (33 154.848 MJ) in T6. In the present study, maximum output and input energy ratio (9.0) was worked out in T3 and minimum 3.16 in T2 (Table 4). Specific energy was observed maximum (0.315 MJ /kg) in T3 and minimum (0.897 MJ/kg) in T2, whereas, energy productivity (3.172 kg/MJ) was recorded maximum in T3 and minimum 1.114 kg /MJ in T2. Energy intensiveness was also worked out in all treatments and 0.133 MJ /Rs was recorded minimum in T3 and maximum 0.318 MJ /Rs in T7. In guava such type of report is still lacking but Akdemir and Akcaoz (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 (41 756.2 MJ/ha) was recorded maximum in T3 and minimum 26 019.5 MJ/ ha in T6.

Economic analysis of guava production

Economic and energy analysis of the production system may be more comprehensive for the best management strategies (Tsatsarelis 1993). The cost and return of present study on guava production is given in Table 5. The results revealed that the cost of production per hectare, production cost (₹ 42 500.8/ha) was recorded maximum T7, and minimum (₹34 127.92) in T6. Maximum production of 16 600 kg/ ha was recorded in T7 and minimum 7 376 kg/ha in T4. However, total production value was recorded maximum (₹166 000/ha) in T7, ₹165 800/ha in T3 and minimum ₹73 760/ha in T4. Maximum productivity 0.43 kg/₹ was worked out in T3 and minimum 0.28 kg/₹ in T4. Maximum net return ₹126 895 /ha was recorded T3 and minimum (₹47 570 /ha) in T4. Maximum benefit cost ratio (4.26) was obtained T3 minimum (2.82) in T4 (Table 5). Similar analysis was also reported by Akdemir and Akcaoz (2012). They have worked out maximum benefit cost ratio (1.48) in conventional apple production .

Input and out put energy analysis in present study indicated the pattern of energy use in guava production. Machinery consumed less energy (577.8 MJ) and recommended dose of fertilizers ranked first (10 088 MJ) in energy consumption. Total minimum input energy (5 216.9 MJ) inT3 was worked out and it was 259.22% less than total input energy consumed (13 523.41 MJ) in T7 for same level of production. Output- input and energy ratio (9.00) was also recorded highest T3 compared to 3.48 T7. Net return (₹126 895/ha) and benefit cost ratio (4.26) was maximum in T3 compared to ₹115 794/ha and 3.31 T7.

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