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Yield, energy and economic analysis of organic guava (*Psidium guajava*) production under various organic farming treatments

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ABSTRACT

Agrochemicals based horticulture production system is neither sustainable nor eco-friendly. Cost effective organic production of horticultural crops is the need of the day to provide safe food to the consumers. In this regard, a field experiment was carried out in randomized block design with 3 replications on 18 years old trees of guava cv Allahabad Safeda in 2014 and 2015 at ICAR- Central Institute for Subtropical Horticulture, Lucknow, India (26.9044° N, 80.7654° E). Seven organic farming treatments were selected as treatments, viz. T1, T2, T3, T4, T5, T6 and T7 for the study. Results indicated that T3 achieved maximum energy ratio (10.42±0.14), minimum specific energy (221.24±2.60 MJ/T) and maximum energy productivity (4.53±0.06 kg/MJ). Economic analysis of the production also indicated that that T3 achieved minimum input cost (825.87±9.70 ₹/T) and resulted into maximum cost benefit ratio (12.14±0.16). Based on the study it is concluded that T3 was energy efficient and profitable practice among other organic farming practices.

Key words: *Azospirillum*, Cost benefit ratio, Energy efficiency, Input cost, Specific energy, Vermicompost

Agrochemical based horticultural crop production is not sustainable and safe because of loss in soil health, surface and ground water pollution and low income from high production cost (Pimentel *et al.* 2005). Many countries in the world are now looking at ways and means to minimize the use of harmful agro-chemicals in the production system focusing on safe and sustainable food production along with soil health. Increasing awareness about conservation of environment as well as health concerns caused by harmful agro-chemicals has resulted in paradigm shifts in consumers' preference towards safe foods globally with niche markets promoting organic foods (FAO 2010). Crop production can't be sustained with application of N, P and K only (Singh 2008) as it creates nutrients imbalance in the soil. Emphasis should be given to protect environment from pollution with overuse of agrochemicals (Ayala and Rao 2003). Adoption of organic farming practices may be suitable option for cost effective and sustainable production of guava (Ram and Verma 2017). The horticultural crops production strategy should be focused on reduced external inputs use for higher income. Efficient use of energies helps to achieve optimum production and productivity and contributes to more profit per unit area (Singh *et al.* 2002). Seven organic farming treatments adopted and recommended for the farmers were selected for this study. Objective of doing this study was to compare different prevalent organic farming treatments for energy and economic efficiency of guava production.

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MATERIALS AND METHODS

Experiment was conducted at the ICAR-Central Institute for Subtropical Horticulture, Lucknow, Uttar Pradesh, India which is situated at the 26.9044° N, 80.7654° E. The experimental soil was coarse sandy loam, hyperthermic, typic ustrochrepts class with pH 7.72 and electrical conductivity ranging from 0.11-0.17dS/m. Initial composite soil samples analysis for nutrients showed that rhizospheric soil of experimental guava experimental trees soil contained 0.435 % organic carbon, 28.2 ppm N, 15.4 ppm P, 75.55 ppm K, 5.4 ppm Zn, 1.34 ppm Cu, 5.4 ppm Mn, Walkley and Black, (1934), Olsen *et al.* (1954), Watanabe and Olsen (1965), Lindsay and Norvell (1978) and Jackson (1967). Experiment was carried out in randomized block design with 3 replications on 18 years old trees of guava cv. Allahabad Safeda in 2014 and 2015. Two plants/unit of treatment were (6 trees/replication) selected for experimentation. Different organic farming treatments were applied in experimental trees in form of treatments as under: T1. 30 kg FYM / tree; T2. 30 kg FYM + 250 g *Azospirillum* + phosphorus solubilizing bacteria culture /tree; T3. 30 kg FYM + 250 g *Azotobacter* + phosphorus solubilizing bacteria culture/ tree; 4. 30 kg vermicompost/ tree; T5. 30 kg vermicompost + 250 g *Azospirillum* + phosphorus solubilizing bacteria culture/ tree; T6. 30 kg vermicompost + 250 g *Azotobacter* + phosphorus solubilizing bacteria culture /tree; T7. 30 kg vermicompost + 250 g *Azospirillum* + phosphorus solublizing bacteria /tree + two vermiwash spray.

Fruits were harvested manually and observations on yield/tree were recorded. Experimental data were statistically analysed following the analysis of variance method (Panse and Sukhatme 1976).

Computation of energy inputs was based on the scheduled operations (time required for each operation), number of manpower, machinery and organic inputs used (Tsatsarelis 1993). The energy of different organic inputs like farmyard manure, vermicompost, vermiwash, *Azospirillum*, *Azotobacter*, phosphorus solubilizing bacteria and vermiwash were calculated by energy consumed in the process of production mainly raw materials, manpower used and multiplying their coefficient (Alcorn and Wood 1998). As winter season guava crop in this region requires no irrigation because of moisture buildup of preceding rains. Annual rainfall of the area varies from 550– 600 mm/year. Therefore, energy consumed in irrigation is not included in estimation. Other than this, energy consumption in management of fruit fly and bark eating caterpillar was also not included in the estimation because no incidence of this pest was observed during the study period. Energy consumed and cost of operation in guava production with different cultural operations, viz. tillage, manures and bio-fertilizer application, spraying and harvesting were calculated by using energy equivalents presented in Table 1.

The energy efficiency parameters were determined to evaluate relationship between energy consumption and total output and production per ha. Input output energy, energy efficiency, specific energy and energy productivity were calculated using the formula suggested by Ram and Verma (2015), Singh *et al*. (1997), Mani *et al*. (2017) and Rathke and Diepenbrock (2006).

- Energy input (MJ/ha) = Sum of energy consumed in all operations (MJ /ha)
- Energy output(MJ/ha) = Total production/ha multiplied by calorific value (MJ) of useful product (pulp)
- Energy efficiency (energy ratio) = Output energy (MJ/ ha)/ energy input (MJ/ha)
- Specific energy (MJ/T)= Input energy (MJ/ha)/ Output energy (T/ha)
- Energy productivity (kg/MJ)= Output energy (kg/ha)/ Energy input (MJ/ha)
- Cost of production was calculated by multiplying input unit with their market cost as per market prevailing rates. Benefit cost ratio was worked out keeping sale price of guava (₹ 10/kg) during study period.
- Input cost (₹/T)= Input cost (₹/ha)/ Total production (tonnes/ha)
- Cost benefit ratio = Total production value (₹/ha)/Total production cost (₹/ha).

Human energy was calculated in different operations on the basis of actual labour hrs used in operations and multiplying with coefficient used in literature Mohammadi and Omid (2010) (Table 1). Machine energy was calculated on the basis of its weight and coefficient for energy consumed per kg after considering their useful life (tractor-10000 hr and harrow 3000 hrs) and multiplying with coefficient of agriculture machinery (138 MJ/kg) (Tabatabafeefar *et al*. 2014). Output energy was calculated by multiplying the amount of production and its corresponding energy equivalent which was calculated on the basis of nutritive value, i.e 2.30 MJ/kg of fruit pulp. The energy efficiency parameters were determined to evaluate relationship between energy consumption, total output and production per hectare. Energy indices were calculated using the formula suggested by Mandal (2002), Ram and Verma (2015), Singh *et al*. (1997),

Table 1 Energy estimation of different cultural operations and inputs

Input	Energy equivalent (MJ/unit)	Reference	Cost (₹) **
Human labour (hr)	1.96	Mohammadi and Omid (2010)	25/hr
Manure application		Tewari *et al*. (2014)	
Spraying			
Basin making			
Harvesting			
Agricultural machinery and tractor (Kg) [a]	138	Tabatabafeefar *et al*. (2014)	
Tractor + harrow [b] per hr.	127.97		450/ hr
Tractor + (Sprayer + Tanker)[c] per hr	136.62		350/ hr
Organic inputs			
Farm yard manure (kg)	0.30	Canakci (2014)	0.52
Vermicompost (kg) *	0.61		1.43
Azospirillum (kg)*	5		50
Phosphorus solublizing bacteria (kg) *	5		50
Azotobacter (kg) *	5		50
Vermiwash *	0.2		0.1
Fuel and electricity			
Water for spraying (cubic meter)	0.63	Mandal (2002)	0.1
Output energy (kg)*	2.33*		
Cost of produce @ ₹10/kg			

[a]Energy equivalent calculated for 35hp tractor weighing 1650 kg and considering 10000 hrs useful life. [b]Energy equivalent calculated for 350 kg harrow with 35hp tractor considering 3000hrs useful life of harrow and fuel consumption. [c]Energy equivalent calculated for 1000 kg (tanker + sprayer) along with 35hp tractor considering 3000 hrs useful life of tanker with sprayer system and fuel consumption. *Calculated by energy consumed in the process of production, mainly raw materials and manpower used. **Cost of manpower and other inputs were taken from prevailing market rates.

Table 2 Schedule of cultural operations practiced during study period

Cultural operation	Time/frequency
Crop	Guava
Cultivar	Allahabad Safeda
Number of trees/ha	400
Land preparation	During the month of October and March (using harrow)
Average ploughing frequency/year	2
Time of treatments application	September
Frequency of treatments application/year	1
Foliar application	September and October
Number of spraying/year	2
Basin preparation/year	September
Frequency of basin preparation/year	1
Harvesting period	Started in November and completed in March

Mani *et al*. (2017) and Rathke and Diepenbrock (2006).

RESULTS AND DISCUSSION

Fruit yield

Mean values of two years statistically analyzed data on yield are presented in table 3 showed that maximum mean yield (28.91±0.30 tonnes/ha) was recorded with T5 and minimum (16.04±0.02 tonnes/ha) in T1 which was 44.52 per cent lower than the yield obtained in T5. Data on yield in T2, T3, T4 T5, T6 and T7 were varied significantly over T1 but variations among the T4, T5 and T7 were non-significant. Maximum production obtained in this study surpassed the India's national yield level (13.71 tonnes/ha) NHB Year Book (2014). Ram and Rajput (1998) and Ram and Pathak (2006) have also reported increase in guava yield with organic amendments.

Energy analysis

Yield data were computed for energy analysis which indicated that maximum mean energy consumption (10354±0 MJ/h) was recorded in T7 and minimum (5122.17 MJ/ha) in T1. Maximum mean out put energy (66497.6±689.57 MJ/ha) was produced in T5 and minimum (36879.74±56.38 MJ/ha) in T1 (Table 3). But energy analysis showed that T3 got ranked over T5 in terms of energy efficiency, specific energy and energy productivity. Maximum mean energy ratio (energy efficiency) (10.42±0.14), minimum mean specific energy (221.24±2.60 MJ/T) and maximum mean energy productivity (4.53±0.06 Kg/MJ) was recorded in T3 which was 46.38 % higher, 31.98 % lower and 46.12% higher than T5, respectively (Table 4). Energy analysis indicated that T3 was most energy efficient practice among all the practices.

Table 3 Production, input and output energy in various organic production practices

Treatment	Production (tonnes/ha)			Input energy (MJ/ha)			Out put energy (MJ/ha)		
	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean
T1	16..02	16.05	16.04±0.02	5122.17	5122.17	5122.17±0.0	36839.87	36919.60	36879.74±56.38
T2	21.90	22.45	22.18±0.39	5624.52	5624.52	5624.52±0	50370.00	51639.60	51004.8±897.74
T3	25.23	25.72	25.48±0.35	5624.52	5624.52	5624.52±0	58036.67	59156.0	58596.34±791.49
T4	26.04	26.33	26.19±0.21	8842.17	8842.17	8842.17±0	59898.13	60554.40	60226.27±464.05
T5	28.70	29.12	28.91±0.30	9344.52	9344.52	9344.52±0	66010.0	66985.20	66497.6±689.57
T6	25.13	25.56	25.35±0.30	9344.52	9344.50	9344.51±0	57806.67	58778.80	58292.74±687.40
T7	27.49	26.58	27.04±0.64	10354.00	10354.00	10354±0	63234.67	61134.0	62184.34±1485.40
CD (P=0.05)	3.48	2.59		00	0.00		7998.46	5948.39	
SEM (m)	1.11	0.83		00	0.00		2567.37	1909.33	

Table 4 Energy analysis in various organic production practices

Treatment	Energy efficiency (ratio)			Specific energy (MJ/T)			Energy productivity (kg/MJ)		
	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean
T1	7.12	7.21	7.17±0.06	320.03	319.67	319.85±0.25	3.13	3.14	3.14±0.01
T2	8.95	9.18	9.07±0.16	260.94	251.11	256.03±6.95	3.89	3.99	3.94±0.07
T3	10.32	10.52	10.42±0.14	223.08	219.40	221.24±2.60	4.48	4.57	4.53±0.06
T4	6.77	6.85	6.81±0.06	340.62	336.87	338.75±2.65	2.94	2.98	2.96±0.03
T5	7.06	7.17	7.12±0.08	329.28	321.28	325.28±5.66	3.07	3.12	3.10±0.04
T6	6.19	6.29	6.24±0.07	372.16	366.21	369.19±4.21	2.69	2.74	2.72±0.04
T7	6.11	5.91	6.01±0.14	376.94	390.32	383.63±9.46	2.65	2.57	2.61±0.06
CD (P=0.05)	1.09	0.85		45.12	32.26		0.48	0.37	
SEM (m)	0.35	0.27		14.48	10.36		0.15	0.12	

Table 5 Economic analysis of guava production

Treatments	Input cost (₹/tonnes)			Cost benefit ratio		
	2014	2015	Mean	2014	2015	Mean
T1	997.16	996.05	996.61 ± 0.78	10.03	10.06	10.05 ± 0.02
T2	974.08	937.37	955.73 ± 25.96	10.43	10.69	10.56 ± 0.18
T3	832.73	819.01	825.87 ± 9.70	12.02	12.25	12.14 ± 0.16
T4	1035.48	1024.09	1029.79 ± 8.05	9.69	9.79	9.74 ± 0.07
T5	1124.63	1097.32	1110.98 ± 19.31	8.99	9.13	9.06 ± 0.10
T6	1271.11	1250.78	1260.95 ± 14.38	7.87	8.01	7.94 ± 0.10
T7	1272.08	1317.24	1294.66 ± 31.93	7.87	7.61	7.74 ± 0.18
CD (P=0.05)	155.88	109.98		1.35	1.06	
SEM (m)	50.03	35.30		0.43	0.34	

This result can be supported with work of Akdemir *et al*. (2012) in which they have suggested that energy analysis of any crop production advocates reducing input energy to enhance energy productivity.

Economic analysis

Minimum mean input cost (825.87±9.7 ₹/tonnes) was estimated in T3 which was 25.66 % lower than T5. Maximum mean cost benefit ratio (12.14±0.16) was also calculated in T3 and which was 33.99 % and 14.96 % higher than T5 (9.06±0.10) and T2 (10.56±0.18), respectively. Cost benefit ratio in T3 significantly varied over all practices (Table 5). Economic analysis indicated that T3 is most profitable practice among all the practices. Akdemir *et al*. (2012) have suggested that economic and energy analysis of crop production system may be more comprehensive for the best management strategies. They have worked out maximum cost benefit ratio (1.48) in conventional apple production. Cost benefit ratio (3.74) in organic production of mango cv Dashehari was also worked by Ram and Verma, 2015.

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REFERENCES

AkdemirS, Akcaoz H and Kizilay H. 2012. An analysis of energy use and input costs for apple production in Turkey. *Journal of Food, Agriculture & Environment* **10** (2): 473–9.

Alcorn A and Wood P. 1998. New Zealand Building Materials Embodied Energy Coefficients Database, Volume II-Coefficients. Centre for Building Performance Research, Victoria Unive Rsity of Wellington. *http://www.vuw.ac.nz/cbpr/documents/pdfs/ee-finalreport-vol2.pdf.*

Ayala S and Prakasa Rao E V S. 2003. Perspectives of soil fertility management with a focus on fertilizer use for crop productivity. *Current Science* **82**(7): 797–808.

Mandal K G, Saha K P, Ghosh P K, Hati K M and Bandyopadhyay K K. 2002. Bioenergy and economic analysis of soybean based crop production systems in Central India. *Biomass and Bioenergy* **23**: 337–45.

Mohammadi A, Omid M. 2010. Economical Analysis and Relation between energy inputs and yield of greenhouse cucumber production in Iran. *Applied Energy* **87**: 191–6.

Murad Canakci. 2010. Energy use pattern and economic analyses of pomegranate cultivation in Turkey. *African Journal of Agricultural Research* **5** (7):491–9.

Panse V G, Sukhatme P V. 1976. *Statistical Methods for Agricultural Works*. ICAR, New Delhi, India.

Pimental D, Hepperly P, Hamson J, Doud, D and Seidel R 2005. Environmental, Energetic and Economic Comparisons of Organic and Conventional Farming Systems. *BioScience* **55** (7): 573–82.

Ram R A and Pathak R K. 2006.Integration of organic farming practices for sustainable production of guava: A case study. *Acta Horticulturae* **735**: 357–63.

Ram R A and Rajput M S. 1998. Effect of organic and bio-fertilizers on growth, yield and fruit quality of guava *cv.* Allahabad Safeda. *International Journal of Mendel* **15**(1-2): 17–8.

Ram R A and Verma A K. 2015. Energy input, output and economic analysis of organic production of mango (*Mangifera indica* L.) cv. Dashehari. *Indian Journal of Agriccultural Sciences* **85**(6): 827–32.

Ram R A and Verma A K. 2017. Energy input, output and economic analysis in organic production of guava (*Psidium guajava*) cv. Allahabad Safeda. *Indian Journal of Agriccultural Sciences* **87**(4): 38–42.

Rathke G W and Diepenbrock W. 2006. Energy balance of winter oilseed rape (*Brassica napus* L.) cropping as related to nitrogen supply and preceding crop. *European Journal of Agronomy* **24**: 35–44.

NHB yearbook 2014. Indian Horticulture database–2014. Ministry of Agriculture, Government of India, p 4.

Singh H, Mishra D, Nahar N M. 2002. Energy use pattern in production agriculture of a typical village in Arial Zone, India-Part I. *Energy Conversion and Management* **43**: 2275–86.

FAO, 2010. Contributing to food security and sustainability in a changing world. Outcomes of an Expert Workshop held by FAO and the Platform on Agro-biodiversity Research from 14–16 April 2010 in Rome, Italy

Singh M K, Pal S K, Thakur R, Verma U N. 1997. Energy input output relationship of cropping systems. *Indian Journal of Agriculture Sciences* **67**(6): 262–4.

Singh MV. 2008. Micronutrient deficiencies in crops and soil in India. B.J. Alloway (Ed). Micronutrient deficiencies in Global Crop Production. Springer Science + Business Media BV.

Tabatabafeefar A, Emamzadeh H M, Ghasemi Varnamkhasti, Rahimizadeh R and Karimi M. 2009. Comparison of energy of tillage systems in wheat production. Comparison of energy of tillage systems in wheat production. *Energy* **34**(1): 41–5.

Tewari R K, Rautaray S K and Srivastava P K. 2014. Energy and cost audit of bullock farming system in buckwheat crop production: A case study. *Journal of progressive Agriculture* **5** (1): 48–51.

Tsatsarelis C A. 1993. Energy inputs and outputs for soft winter wheat production in Greece. *Agriculture, Ecosystems and Environment* **43**: 109–18.

Walkley A and Black C A. 1934. An examination of Degtjareff methods for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science* **37**: 28–9.

Watanabe F S and Olsen S R. 1965. Test of ascorbic acid method for determining phosphorus in water and sodium carbonate extracts of soil. *Proc. Soil Sci. Soc. Am*. **29**: 677–8.

Lindsay W L and Norvell W A. 1978. Development of a DTPA soil test for Zinc, iron, manganese and copper. *Soil Sci. Soc. Am. J.* **42**: 421–48.

Jackson M L. 1967. *Soil Chemical Analysis*. Prentice Hall of India Pvt Ltd, New Delhi.