Madras Agric. J. 92 (1-3) : 84-88 Jan-March 2005
https://doi.org/10.29321/MAJ.10.A00014

Energy input and output relationship in rice based cropping systems

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Abstract: A field experiment was conducted in ICAR Research Complex at Goa, during 1999-2002 to study the energy input-output relationships of different rice based cropping systems with recycled manurial resources in a split-plot design with three replications. Among the cropping systems tried, rice- brinjal system received relatively higher energy input (23,135 MJ ha^{-1}) that too from the non-renewable energy sources (14,909 MJ ha^{-1}). However, the treatment could also yield substantially higher energy output (1,57,269 MJ ha^{-1}). The use of recycled manures particularly paddy straw with mushroom spent substrate accounted for higher energy output although it recorded higher energy input (21,062 MJ ha^{-1}). Rice-brinjal cropping system recorded better energy efficiency with additional input of energy in terms of irrigation which was mainly due to the higher productivity of the cropping system. In contrast, rice-sunnhemp and rice-fallow systems revealed lower energy input but ultimately their energy output was also lower.

Introduction

Farming uses energy intensive technologies for maximizing the productivity. The problems of energy consumption, shortage and environmental pollution have created an urge for processing organics for energy and plant nutrient recovery. Besides this, efficient utilization of renewable energy resources may play a key role in insulating Indian agriculture against any possible oil crisis in the world. The concept of integrated energy production and use management is based on research findings, that farm income is greatly enhanced by increased use of energy produced on the farm (Surendra singh *et al.* 1997).

For practice of integrated energy production and use-management, sources of energy available on the farm are to be used and it should form an integral part of the various activities and products of the farm. The integrated energy production and use management has been shown to be the most viable means of increasing agricultural production. Hence, convincing farmers and researchers to think in this direction is essential.

Keeping these things in view, an attempt was made to assess the energy input-output relationships in a rice based cropping system involving residue recycling from the locally preferred crops suited to the agro-climatic conditions of Goa.

Material and methods

A field experiment was conducted during *kharif-rabi* seasons of 1999-2002 in ICAR Research Complex at Goa. The soil of the experimental site was sandy loam, acidic in reaction, having moderate levels of N (292 kg ha^{-1}), P_2O_5 (37.9 kg ha^{-1}) and K_2O (264 kg ha^{-1}). The experiment was conducted in a split-plot design with three replications. The recycled manurial resources from the rice based cropping systems and allied agro-enterprises of dairy, poultry and mushroom production *viz.* farm yard manure, poultry manure, paddy straw with mushroom spent substrate (in 2:1 ratio) along with a control (no recycled manure) formed the main plot treatments. Rice (variety Jyothi) based cropping systems suited

Table 1. Energy unit conversion equivalents for direct and indirect sources of energy

Sl No.	Components of energy		Unit	Equivalent energy (MJ)
I	INPUTS			
1.	Human labour	Man	Man hour	1.96
	Woman	Woman hour	1.57	
2.	Animals	Bullocks	Pair hour	14.05
3.	Chemical fertilizer	Nitrogen	kg	60.6
		Phosphorus	kg	11.1
		Potassium	kg	6.7
4.	Organic Manures	FYM	kg (dry wt)	0.3
	Poultry manure	kg (dry wt)	0.6	
5.	Chemicals	Superior chemicals	kg	120.0
6.	Seed	All crop seeds	kg (dry wt)	14.7
7.	Feed	Poultry Feed	kg	12.9
8.	Irrigation		ha. cm	143.8
II	OUTPUTS			
1.	Grains Paddy, Cowpea, Groundnut		kg (dry wt)	14.7
2.	Forage grass/straw/stover & haulms		kg (dry wt)	12.5
3.	Sunnhemp stalks		kg (dry wt)	12.5
4.	Brinjal fruits		t (fresh wt)	1.00

Mittal *et al.* (1985)

to the location *viz.* rice-groundnut (variety DH-3-30), rice- cowpea (variety V-118), rice- brinjal (variety local Agassaim), rice-sunnhemp with rice- fallow system as control constituted the sub plot treatments. All the crop residues were incorporated *in situ* after the crop harvest. The recommended dosage of fertilisers were applied both for rice and rice based crops. All the crops were grown under residual moisture except brinjal which was raised under protective irrigation as per the local practice. Practically no rain was received during the crop growth period of rice based crops.

The total energy for rice production system was calculated from the total material input energy plus their required operational energies in terms of renewable and non-renewable sources by each component in the system using equivalents of energy as per Mittal *et al.* (1985) and the same is presented in Table 1. The amount of output energy was calculated from the yield and biomass residues. Energy efficiency was worked out taking into account the input and output energy for each treatment adopting the method given by Dazhong and Pimental (1984) as

$$\text{Energy efficiency} = \frac{\text{Energy output (MJ ha}^{-1})}{\text{Energy input (MJ ha}^{-1})}$$

Specific energy of the system was calculated in terms of energy required to produce a kg of rice grain equivalent and expressed as MJ kg^{-1}

$$\text{Specific energy} = \frac{\text{Energy input (MJ ha}^{-1})}{\text{Rice grain equivalent yield (kg ha}^{-1})}$$

Results and Discussion

Energy input

The details of energy input for different cropping systems and recycled manures are presented in Table 2.

Table 2. Energy input in rice based cropping systems.

Treatment		Energy input (MJ ha-1)		Total energy (MJ ha-1)
		Renewable	Non-renewable	
M_0	CS_0	3492	5768	9260
	CS_1	6536	8343	14879
	CS_2	4559	8036	12595
	CS_3	5923	14909	20832
	CS_4	4473	5768	10241
	Mean	4997	8565	13561
M_1	CS_0	4992	5768	10760
	CS_1	8036	8343	16379
	CS_2	6059	8036	14095
	CS_3	7423	14909	22332
	CS_4	5973	5768	11741
	Mean	6497	8565	15061
M_2	CS_0	3702	5768	9470
	CS_1	6746	8343	15089
	CS_2	4769	8036	12805
	CS_3	6133	14909	21042
	CS_4	4683	5768	10451
	Mean	5207	8565	13771
M_3	CS_0	10992	5768	16760
	CS_1	14036	8343	22379
	CS_2	12059	8036	20095
	CS_3	13423	14909	28332
	CS_4	11973	5678	17741
	Mean	12497	8547	21067

M_0 - No recycled manure + Recommended NPK
M_1 - Recycled FYM + Recommended NPK
M_2 - Recycled poultry manure + Recommended NPK
M_3 - Recycled paddy straw + Recycled mushroom spent substrate+ Recommended NPK

CS_0 - Rice-Fallow
CS_1 - Rice -Groundnut
CS_2 - Rice - Cowpea
CS_3 - Rice - Brinjal
CS_4 - Rice -Sunnhemp

The use of recycled manures particularly paddy straw with mushroom spent substrate (M_3) accounted for higher (21,062 MJ ha^{-1}) energy input. However, the increased energy was from renewable sources (12,497 MJ ha^{-1}), as paddy straw along with mushroom spent substrate was available within the system. The non-renewable energy input was nearly constant (8,565 MJ ha^{-1}) with all the recycled manurial treatments due to application of recommended fertilizers.

Table 3. Energy output in rice based cropping systems

Treatment		Energy input (MJ ha-1)		Total energy (MJ ha-1)
		Renewable	Non-renewable	
M_0	CS_0	76226	8.23	2.20
	CS_1	91056	6.12	2.58
	CS_2	93823	7.45	1.69
	CS_3	144989	6.96	1.86
	CS_4	91345	8.92	2.17
	Mean	99488	7.54	2.10
M_1	CS_0	77697	7.22	2.58
	CS_1	95452	5.83	2.44
	CS_2	98411	6.77	1.86
	CS_3	149710	6.70	2.09
	CS_4	91684	7.81	2.51
	Mean	102591	6.87	2.30
M_2	CS_0	77303	8.16	2.27
	CS_1	95523	6.33	2.12
	CS_2	94782	7.40	1.57
	CS_3	147314	7.00	2.10
	CS_4	92185	8.82	2.23
	Mean	101421	7.54	2.06
M_3	CS_0	81500	4.86	3.58
	CS_1	97139	4.34	3.37
	CS_2	106233	5.29	2.69
	CS_3	187063	6.60	2.25
	CS_4	96307	5.43	3.52
	Mean	113648	5.30	3.08

M_0 - No recycled manure + Recommended NPK
M_1 - Recycled FYM + Recommended NPK
M_2 - Recycled poultry manure + Recommended NPK
M_3 - Recycled paddy straw + Recycled mushroom spent substrate+ Recommended NPK

CS_0 - Rice-Fallow
CS_1 - Rice -Groundnut
CS_2 - Rice - Cowpea
CS_3 - Rice - Brinjal
CS_4 - Rice -Sunnhemp

Among the cropping systems tried, rice-brinjal system received relatively higher energy input (23,135 MJ ha^{-1}) that too from non-renewable energy sources (14,909 MJ ha^{-1}). The requirement of non-renewable sources of energy for the system was relatively higher than the renewable energy as a result of higher energy involvement with irrigation, which accounted for nearly 60 per cent of the total energy requirement for the crop production as is also reported earlier by Jayanthi (1995). In contrast, rice-cowpea system was moderate in its energy input (14,898 MJ ha^{-1}) without much dependence on non-renewable energy (8,036 MJ ha^{-1}) sources.

Energy output

The mean energy output varjed among the recycled manures and cropping systems and the same is presented in Table 3.

Higher energy output (1,13,648 MJ ha^{-1}) was recorded with recycling of paddy straw and mushroom spent substrate and was followed by recycled FYM (1,00,199 MJ ha^{-1}). Energy output was the lowest when no manure was recycled (99,488 MJ ha^{-1}). Recycling of paddy straw with mushroom spent substrate recorded 14.2 per cent higher energy output over no recycled manure treatment.

Among the cropping systems, rice-brinjal system recorded considerably higher energy output (1,57,269 MJ ha^{-1}) and was followed by rice-cowpea system (97,562 MJ ha^{-1}). Higher productivity of the crops in the sequence both in terms of economic and biomass yield with the application of recycled manures accounted for higher energy output. The lowest energy output (78,182 MJ ha^{-1}) was recorded with rice-fallow system.

Energy efficiency

Energy efficiency gives the energy produced per unit of energy invested. The mean energy efficiency was the highest with recycled poultry manure and when no recycled manure was applied (both 7.54) while recycling of paddy straw with mushroom spent substrate recorded lower energy efficiency (5.30).

Rice-sunnhemp system was more efficient in energy conversion (energy efficiency 7.75) while rice alone was the next best in order (7.12) which was mainly due to the lesser energy input involved in contrast to the energy rich outputs. Rice- groundnut system recorded the least efficiency in terms of energy (5.66). However, rice-brinjal cropping system had better energy efficiency even with additional input of energy in terms of irrigation which was mainly due to the higher productivity of the cropping system.

Specific energy

Specific energy of a cropping system which indicates the energy required to produce a kg of rice grain equivalent, followed a trend similar to that of energy efficiency. The specific energy pooled over years revealed that the energy required to produce a kg of rice grain equivalent yield was the least with recycled poultry manure (2.1 MJ kg^{-1}) and the highest with paddy straw with mushroom spent substrate (3.08 MJ kg^{-1}) among the recycled manures.

Rice-cowpea system was found to be the best with least energy requirement to produce a kg of rice grain equivalent yield (1.95 MJ kg^{-1}). In contrast, cropping rice during *kharif* and fallow during *rabi* season recorded the highest specific energy (2.66 MJ to produce a kg of rice grain) among the cropping systems.

References

Dazhong, W. and Pimental, D. (1984). Energy flow through an organic agro-eco-system in China. *Agricultural Ecosystems Environment*, **11** : 145-160.

Jayanthi, C. (1995). Sustainable component linkage and resource recycling to lowland integrated farming systems. *Ph.D. Thesis*, Tamil Nadu Agricultural University, Coimbatore.

Mittal, U.K., Mittal, J.P. and Dhawan, K.C. (1985). AICRP on energy requirements in agriculture sector. In : *Research Manual on Energy Requirements in Agriculture Sector*, Co-ordinating Cell, Punjab Agricultural University, Ludhiana, pp.20-23.

Surendra Singh, Verma S.R. and Mittal, J.P. (1997). Energy requirements for production of major crops in India, *Agricultural Mechanisation in Asia, Africa and Latin America*, **28:** 13-17.

(Received : September 2003; Revised : January 2005)