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Analysis Of Energy Use In Rice Production, Post-Production And Cooking, Laguna Philippines

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Abstract
This Study Was Conducted To Determine The Energy Cost Producing, Postproduction And Cooking Of Rice At The Maitim, Bay, And Laguna In 2015. Two Land Owners And Two Rice Millers Were Interviewed. The Calculation Of Energy Cost Estimates Of Producing Of Rice, Postproduction And Cooking Of Rice In Concluded Labour, Machinery, Fuel, Building, Concrete Floor And Material Inputs. The Results Showed That Total Energy Input Estimates Of Producing Of Rice Was 3447.50Mcal/Ha Consequently Of The Material Inputs 2189.95Mcal/Ha (63.52 %), Fuel 906.01Mcal Ha^{-1} (26.28%), Labour 221.89Mcal Ha^{-1} (6.43%) And Machinery 129.69Mcal Ha^{-1} (3.76%). The Material Inputs Particularly N Fertilizer Had The Highest Energy Bill At Maitim, Bay, Laguna, Philippine. The Highest Energy Cost Estimates Of Postproduction Rice Were In Transportation 32.69Mcal Ton^{-1} (45.59%) Included Of Truck 4.15Mcal Ton^{-1} And Fuel 28.54Mcal; And Followed By Diesel Or Power Used In Milling Station 20.66Mcal Ton^{-1} (20.66%); Building 19.63Mcal Ton^{-1} (12.04%); Concrete Floor 5.03Mcal Ton^{-1} (7.02%); Machine 2.42Mcal/Ton (3.38%) And Labour 2.25Mcal/Ton (7.02%). In Term Of Energy, 0.01Mcal/Kg Was Cost In The Cooking Of Rice.
The Energy Efficiency Of Rice Production And Energy Intensity Of Rice Production Were 6.2 And 0.16, Respectively, And Net Energy Gained Was 17963.5Mcal Ha^{-1}. To Produce One Kg Of Rice In Production, Total Energy Input Was 0.57Mcal (0.06LDOE) In Term Of Energy Aspect. Energy Bill Of Producing Of One Kg Rice Was The Highest As Compare With Postproduction, 0.06Mcal/Kg And Cooking Process, 0.01Mcal/Kg.
Keywords: *Energy Cost; Energy Output; Energy Efficiency; Energy Intensity; Rice*

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I. Introduction

Rice is the crucial important crop for Asian country among agricultural field crops production. Rice productivity increase cannot be achieved unless adequate inputs such as energy, improved seeds, fertilizers and irrigation water are available in a timely manner and applied judiciously. Individuals, all these inputs are directly or indirectly dependent on oil. The use of energy is related to human population that requires energy in many activities. With the current increase in world population, energy consumption needs effective planning. That is, the input elements need to be identified in order to use them efficiently methods. Crop yields and food supplies to consumers are directly linked to energy, which means sufficient energy is needed in the right form at the right time for adequate crop production. One way to optimize energy consumption in agriculture is to determine the efficient of methods and techniques used (Kitani, 1999; Safa and Tabatabaeefar, 2002). Crop-yield is directly proportional to the energy input (Srivastava, 1982). Fuel and fertilizers (N and P) account for the largest share (>75%) of all energy expenditures in a mixed cropping system (Hetz, 1992; Ahmad, 1994; Safa and Tabatabaeefar, 2002). Fluck and Baird (1980) hypothesized that the highest partial energy productivity is achieved at the point of minimum mechanization and increasing mechanization increases crop yield at a decreasing rate**.**

Huge amount of energy (also called embedded energy) is used in the manufacture of machines, farm implements, trucks, the mill, buildings and chemical fertilizer. Fertilizers consume the highest amount of energy. The energy equivalent in the manufacture of N is 78.1 MJ kg-1, 17.4 MJ kg-1 for phosphorus (P), and 13.7 MJ kg-1 for potassium (K) (Chamsing et al. 2006). Anhydrous ammonia, urea, and ammonium nitrate constitute energy levels of 12.0, 14.3, and 14.7 Mcal kg-1 N (Pimentel 1980) or as high as 18.5 Mcal fossil energy to produce 1 kg of N. In Brazil, the energy use in fertilizer is about 66.96 MJ tc-1 or 35.27% of the total energy input in agriculture industry (Copersucar 1985). GHG emissions associated with the manufacture, packaging and transport of ammonium nitrate fertiliser were assumed to be 7.11 kg CO2 e per kg N (Anon., 2007). Jan Willem van Groenigen., et.al mentioned that every kg of newly fixed fertilizer N will eventually lead to an emission of 30 to 50 g N_2O-N, either directly from the soil or indirectly after other N deliveries to water resources or the atmosphere. While the yield increase was 10% when it was used in combination with only chemical fertilizers (S.K Rautaray, 2003). Application of 15 t·FYM·ha−1 significantly increased soil organic matter and available water holding capacity and the level of soil total nitrogen from 0.203% to 0.349%. but decreased the soil bulk density, creating a good soil condition for enhanced growth of the rice crop (Tilahun, 2012).

All the activities involved in making space suitable for human activities, like clearing land for agriculture, modifying the hydrography (irrigation), and establishing distribution infrastructures, as wells as constructing and conditioning (temperature and light) enclosed structures. The relationship between transport and energy is a direct one, but subject to different interpretations since it concerns different transport modes, each having their own performance levels. Land transportation accounts for the great majority of energy consumption. Road transportation alone is consuming on average 85% of the total energy used by the transport sector.

Cooking processes require energy in many ways. In general, variation in energy consumption values depend of several factors, the major factor being: type of energy source used, income level, family size, geographical factors, type of food consumed, cooking habits and type of equipment and utensils used. The cost of energy used for cooking is estimated to around 3% in the case of high-income groups as compared to 12%-15% in low-income groups. Considering the large amount of energy used in the cooking sector there is a urgent need for conservation and efficient utilisation for those reason: energy is very costly and becoming scare, and energy consumption pollutes the environment and disturbs the ecological balance. 7.0-22 MJ is needed to cook one 1 kg of food (R.M. Amarasekara, 1994). Increasing energy consumption of producing, postproduction and cooking of rice not only leading high energy cost per unit, LDOE but also increase emission of GHG, Co_e.

To adequately evaluate producing, postproduction and cooking of rice energy cost and choose alternative minimizing systems, energy used data is needed to collect and analysis all farm inputs applied such as machinery, labour, material, fuel in major crop production systems, especially rice.

Objectives

This study was conducted in order to know the field operating energy involved in a lowland rice production system, rice milling process and rice cooking in Philippine. The specific objectives were:

- To determine the operational energy consumption of field operations involved in the lowland rice production in term of direct and indirect energy sources.
- To identify the “energy hotspots” or high energy consuming aspect or stage of rice production.
- To determine the energy efficiency of the lowland rice production system
- To determine the energy cost of postproduction for rice milling process and rice cooking
- To compute and compare the energy consumption of rice production, post-production and cooking.
- To recommend one on how to reduce the energy bill of rice from farm to plate.

II. Material and Methods

Source of Data

The data were collected from two paddy farmers at Maitim, Bay, Laguna for rice production and two rice mills (small rice mill and big rice mill), by interviewing, using a specially designed questionnaire for one planting season in 2015. These zones are located in the Bay, Laguna Philippines, where rice cultivation and rice milling is the main source of income for farmers/land owner and rice milling owner. The questionnaire included all kinds of inputs e.g., fertilizers, chemicals and power sources, labour and agricultural machinery (power tiller, and thresher) as well as yield of main product, rice grain. In present study the irrigation water was not accounted for computing energy cost estimates. The energy consumption in the lowland rice production system was computed for the following field operations: tillage, planting, controlling, and harvesting while post harvesting including milling up to cooking. In the study area, land preparation such as ploughing, harrowing and levelling was done by small hand tractor. Seed bed preparation and raising seedling, transplanting was mainly depended on the labour forces. Irrigation water for the whole growing season was obtained by the channel irrigation from government support. That is why we did not account for energy cost of irrigation water. To manage and control the pest and disease, any kind of chemical pesticides was not used in the whole growing season because of the no serious pest and disease incidence. However, weed control was also not included any kind of chemical herbicides; it was done by human labours. Harvesting processing was used to labour only for cutting rice and rice grain separating from rice straw was used to small machine. Each agricultural input was divided into direct and indirect energy source. Direct energy sources were the oil energy and while indirect energy sources included the manufacture of tractor and/or other implement/machinery used for the particular operation, labour, seed of high yielding varieties, fertilizers used in the production process. In the postproduction, building, embedded energy of milling machines, transportation, labour and power use of milling rice were accounted for computing of energy cost estimates of postproduction rice. However, the energy gained from the rice husk was not taken into account in calculating of energy. While the only electrical power use was accounted in order to calculate energy cost estimates of cooking rice.

Energy Use Calculations

All the inputs (fuel, fertilizers, seeds, etc) and activities (land preparation, planting material, care and management including growing, fertilizing, harvesting and hauling rice to the store place) were accounted for. The procedures in the energy analysis and the computation for energy coefficient were based on the handbook of Pimentel (1980), and from relevant literatures as cited by Mendoza (2007); Mendoza et al. (2007); Mendoza (2005); Mendoza and Samson (2002). The energy coefficients for estimating the energy use in farm inputs such as oil, machine, labour, fertilizer, material, building, transportation and others are shown in table1.

The energy used (e.g., for fuel) per hectare for a particular field operation was computed by using the formula:

$$Deu = Afe \text{ X } Ev \quad (1)$$

Where: Deu= direct energy use (fuel) for a field operation, Mcal ha^{-1}; Afe = Average of fuel use per working hour, L hr^{-1}; Ev = energy value per litter of fuel Mcal L^{-1} (where 1 L diesel oil = 11.4 Mcal L^{-1}, Pimentel et al. 1980).

Described below are the different formula that were used in calculating the energy used in various energy consuming (direct and indirect) inputs, operations, tools, machineries from production (farm) to post production (plate).

For calculating the energy used in machinery, the formula proposed by Moerschner and Gerowitt (2000) as cited by Bockhari-Gevao et al. (2005) was adopted and described as:

$$M\textit{ie} = [Tw \text{ x } (M\textit{ec})] / LS \text{ x } h \quad (2)$$

Where: M*ie* = specific indirect energy for machinery uses for a field operation, in Mcal ha-1; Tw = Total weight of the machine, in kg; M*ec* = Energy coefficient of a specific machinery, in Mcal kg-1; LS = Life span of machinery (10 yr for this estimate; where 1 yr = 6 mo actual field operation**;** 1 d = 8 hr work**;** 6 d wk-1**;** 4 wk mo-1 = 11,520 h for 10 yr LS of the tractor); and h = the number of hours the machine was used per hectare for a particular operation.

Table 1. The coefficients used in the estimation of energy.

ITEM	Coefficient (Mcal/Unit)	Source
Seeds	3.51	Ozkan et. Al, 2004
Urea (46-0-0) (Kg)	14.3	Pimentel 1980 p24
N (Kg)	24.54 Mcal/kg	Pimentel 1980 p24
P(Kg)	(0.07 GJ/kg)	Pimentel 1980 p24
Labor (MD)	2.3	Ozkan 2004 as cited by Ali p6
Diesel (l)	0.47	Pimentel 1980 p15
Lubrication	11.414	Pimentel 1980 p15
Machines (Field Production) (Kg)	17.121	Brazilian Energy Balance 2004 as cited by Egle
Farm Yard Manure (Kg)	1.279	Alipour A. et. Al, 2012
Machine of rice mill	0.0072	Pimentel 1980 p10
Buildings (ft^2	15	Pimental 1980 p13
Machinery (Kg)	38	Pimentel 1980
Harrow (Kg)	18	Pimentel 1980
Leveler (Kg)	15	Pimentel 1980
Cleaning fan machine (Kg)	15	Pimental 1980

Energy use for building was computed by using the following equation;

$$B\textit{ie} = (A\textit{b} \text{ x } B\textit{ec}) / LS \text{ x } A\textit{mil} \quad (3)$$

Where: Bie = specific indirect energy for building use for one tonne of rice milling, in Kcal T^{-1}; Ab = Total area of the building, in ft^2; Bec = Energy coefficient of a building, in Kcal ft^2; LS = Life span of building (10 years is expected life span of building for this analysis); Amil = amount of milled rice per year, in (tonne per year, T Yr^{-1}; it assumed that the amount of milled rice is 200 tonnes per year for big rice mill and 100 tonnes per year for small rice mall.)

For the energy cost for concrete floor, the equation below was used,

$$E_{cf} = (A_{cf} \text{ x } C_{ec}) / LS \text{ x } A_{rd} \quad (4)$$

Where: E_{cf} = energy cost of concrete floor for one tonne of rice drying, in Kcal T^{-1}; A_{cf} = area of concrete floor, in ft^2; C_{ec} = Energy coefficient of cement floor, in Kcal ft^{-2}; LS = Life span of concrete floor (we assumed that the life span of concrete floor is 50 years); A_{rd} = Amount of rice dried per year, in Tonne per year, T yr^{-1}, we assumed that the 300 tonne of rice in a year is dried by using the concrete floor).

Energy cost of transportation for one tone of rice by using truck, train, rail is computed by the following equation according to David Pimentel;

$$E_T = T_{ec} \text{ x } T_w \text{ x } D \quad (5)$$

Where: E_T = Energy cost of transportation rice, in Kcal Kg^{-1}; T_w = Total weight of rice transported (kg); and T_{ec} = energy coefficient of specific transportation, in Kcal/kg/km; D= distance in Km. The energy coefficient of specific transportation (kcal/kg/km): Water way = 0.08kcal; Rail = 0.12; Truck = 0.12; Air =6.63.

The energy of labour input for each operation in rice production and post-production was estimated using the formula:

$$Lei = M \times Lef \qquad (6)$$

Where: Lei = Labour energy, in Mcal ha-1; M = Number of working hours per operation, in h ha-1; and Lef = labour energy factor, in Mcal hr-1, 1 man-day work = 8 hr as used in the calculations.

The indirect energy per unit area for production inputs (Pei) such as fertilizers and other materials were calculated using the formula:

$$Pei = A \times Ec \qquad (7)$$

Where: Pei = indirect energy input, in Mcal ha-1, A = amount applied, in kg ha-1; and Ec = energy coefficient of the material used, in Mcal kg–1.

The energy use (Mcal kg-1) in the manufacture of the different fertilizer sources (Pimentel 1980), was converted into L diesel oil equivalent (LDOE): N = 2.0470, P = 0.3109, K = 0.2047, (1 GJ = 179.606 Mcal, 1 L oil = 0.0386 GJ), LDOE = 11.414 Mcal, LDOE = 38.4 MJ = 38.4 x 106 J.

Total Energy cost of rice production for one hectare was determined from the summation all energy cost from computation of farm inputs. It is expressed in the following equation:

$$E_{TI} = E_{Lab} + E_{Mac} + E_{Fu} + E_{Ml} \qquad (8)$$

Where; E_{TI} = Total energy input, Mcal ha^{-1}; E_{Lab} = Labour Energy, Mcal hr^{-1}; E_{Mac} = Energy cost for machine, Mcal hr^{-1}; E_{Fu} = Energy cost for fuel, Mcal hr^{-1}; and E_{Ml} = Energy cost for material input, Mcal hr^{-1} .

For post-production, the total energy cost for one tonne of rice milling was determined by computing the sum of all energy used in the rice milling process. The following equation used to obtain total energy cost in milling process is shown in below:

$$E_{MR} = E_T + E_{Mac} + E_{Fu} + E_{Ma} + B_{ie} + E_{cf} \qquad (9)$$

Where: E_{MR} = Total energy cost for one tone of rice milling, Mcal T^{-1}; E_{Mac} = Energy cost of transportation, Mcal Kg^{-1} Km^{-1}; E_{Fu} = Energy cost of fuel for rice milling, Mcal T^{-1}; E_{Ma} =Enegry cost of machine, Mcal T^{-1}; B_{ie} = Energy cost of building, Mcal T^{-1}; and E_{cf} = energy cost of concrete floor, Mcal T^{-1}.

According to Tribeni Das.et.al (2015), the energy cost of cooking for one kg of milled rice is 1034.86 Kcal. The milling recovery of the study area was 50%. Thus, energy cost of cooking for one kg of un-milled rice is 517.43 Kcal. The convection of energy cost from Kcal to litter diesel oil equivalent, LDOE (1 LDOE = 114000 Kcal).

The energy cost of rice production for one Kg, (E_{cr}) was obtained from the total energy input is denoted by (E_{TI}) in (kcal/ ha) is divided by total grain yield denoted by G in (Kg/ha) and it is shown by the equation by equation below.

$$E_{cr} = E_{TI} \div G \qquad (10)$$

Energy Use Indicators

The energy efficiency (Ee) or energy balance was calculated using the formula:

Energy balance = Energy output/Energy input. Ee greater than 1 means that the production system is gaining energy, otherwise it is losing energy. It is expressed in Ee = rice grain only (without rice straw). The energy from biomass (straw) was not included in the estimates. The other parameters which are indicative of the energy use in rice production were also calculated as: Energy use per hectare = Total Energy input (LDOE ha-1); and Energy use per kg grain = Total Energy input (LDOE ha-1) divided by grain yield in kg ha-1. Energy productivity was measured by grain yield per hectare divided by total energy inputs. Net energy was obtained from (energy output – energy input).

III. Results and Discussion

Production

The energy cost estimates of producing of rice is showing in Table 2. The total energy cost estimates of producing rice was different between farmer 1 (F1) 3414.50Mcal/ha, and farmer 2 (F2) 3447.5Mcal/ha. The total energy cost of F2 was 65.93Mcal ha^{-1} (4.6LDOE ha^{-1}) higher than the F1 due to the addition 5 tonne Farmyard manure (FYM) used and more labour inputs of care and management, especially, fertilizer application. As a result, the grain yield of two farmers was different that the yield of F2 was higher than F1. The grain yield of F1 was 5400kg ha^{-1} which is equivalent to 18954Mcal/ha whiles the grain yield of F2 was 6800Kg ha^{-1} which is equivalent to 23868Mcal ha^{-1}. For those of reason, organic manure, FYM consumed lower amount on energy than the chemical fertilizers, especially Urea. Using of FYM not only reduced energy cost per unit but also enhanced increase yield per unit. Thus, FYM was one of the importance factors to consider and minimize the dependence on only chemical nitrogen fertilizers and also to minimize energy cost. The results also showed that the average highest energy cost was in material 2189.95Mcal /ha, which accounted for about 63.52 % of the total energy consumption of production 3447.50Mcal /ha and then followed by fuel 906.01 Mcal ha^{-1} (26.28%) (Table 2). The consumption of labour and machinery as terms of energy in rice production was only 211.89Mcal/ha (6.43%) and 129.69Mcal/ha (3.76%). The computation of energy cost in Table 2 showed that there was slightly difference among the labour energy consumption and machinery energy consumption in the rice production. However, there were differences between the material energy consumption and fuel energy consumption. The higher energy cost of material used in the production as a result of the higher application of nitrogen fertilizer, 1430 Mcal/ha (41.48%) and also seed, 438.75 Mcal/ha (12.73%) which show in Table 1 and Pie1. Nitrogen fertilizer application was the highest energy cost of producing rice. By using higher amount of N-fertilizer application will lead to higher energy cost but also increase emission of greenhouse gas. One LDOE is equivalent to 3.63 CO_e. With the increase of LDOE of production Co_e will directly be increased. In the present study show that the higher yield was obtained by using additional FYM which is shown in Table. Thus, organic fertilizer (FYM) was considerable to reduce the dependence on N-fertilizer. Third largest energy cost was the amount of seeds used per hectare. Thus, the number of seed used was one of the most important factors influencing energy costs. The better way to minimize the energy cost and to increase energy efficiency is reducing the dependence of chemical fertilizers, especially, Urea and reducing of the amount of seed uses. The highest energy cost of producing of one kg rice was in the chemical fertilizers used, especially, Urea. The results of this study clearly showed that the rice production in Maitim Bay, Laguna was mainly depended on inorganic fertilizer. This is because the soil fertility is decrease due to the land intensively used to planting every season and farmers was not used to organic fertilizer, especially, FYM. The farmer used large number of seeds which is uncertified seeds; they believe that the more seeds sown lead to higher the yield (Fernandes, 2001). The farmers do not know about alternative to increase of yield by organic farming, like using animal manures to sustain soil nutrition in the long periods and decrease the use of chemical fertilizers and the amount of energy in thus manufacture. The farmers in Bay Laguna believed that more fertilizer is required the rice plants during vegetative stage to promote growth and tiller, which in turn, determines potential number of panicles. Azarpour and Maral (2015) revealed that the fertilizer contributes to spikelet production during early panicle formation stage, and contributes to sink size during the late panicle formation stage. Mendoza (2002) reported that the rice yield in the organic farm was higher and low energy was used than in the conventional farm during sunny and zero typhoon dry season cropping at Infanta Quezon Philippine.

Utilization of the machineries in term of energy was the second highest energy consumption of rice production. Among machineries used in production hand tractor was the highest in energy cost which included of embedded energy, 234.51Mcal ha^{-1} and fuel consumed 539.18Mcal ha^{-1}. Hand tractor

Table 2. Energy cost estimates of producing of rice of two farmers and average

Item	Mcal/ha F1	Mcal/ha F2	LDOE/ ha F1	LDOE/ ha F2	Mcal/ha Average
MACHINES					
Hand tractor	101.51	101.51	8.89	8.89	101.51
Machine	85.50	85.50	7.49	7.49	85.50
Tires	31.50	31.50	2.76	2.76	31.50
Harrow	13.00	13.00	1.14	1.14	13.00
Leveller	3.00	3.00	0.26	0.26	3.00
Thresher Machine	19.78	19.78	1.73	1.73	19.78
Cleaning fan Machine	3.30	3.30	0.29	0.29	3.30
Total	129.69	129.69	11.36	11.36	129.69
Present of Production	3.80%	3.73%	3.80%	3.74%	3.76%
FUEL					
Hand tractor	539.18	539.18	47.24	47.24	539.18
Thresher	252.05	252.05	22.08	22.08	252.05
Cleaning Fan	114.78	114.78	10.06	10.06	114.78
Total	906.01	906.01	79.38	79.38	906.01
Present of Production	27%	26%	27%	26%	26.28%
Farm Inputs -Materials					
Seed	438.75	438.75	38.44	38.44	438.75
Fertilizer N	1430.00	1430.00	125.28	125.28	1430.00
Fertilizer P	148.50	148.50	13.01	13.01	148.50
Rice Cutter	154.70	154.70	13.55	13.55	154.70
FYM	0.00	36.00	0.00	3.15	18.00
Total	2171.95	2207.95	190.29	193.44	2189.95
Present of Production	63.61%	63.44%	63.61%	63.68%	63.52%
LABOUR					

Land Preparation	35.57	35.57	3.12	3.12	35.57
Grass cutting	11.23	11.23	0.98	0.98	11.23
Ploughing	7.49	7.49	0.66	0.66	7.49
Harrowing and levelling	16.85	16.85	1.48	1.48	16.85
Seedling Preparation	5.62	5.62	0.49	0.49	5.62
seedbed Preparation	3.74	3.74	0.33	0.33	3.74
Seedling	1.87	1.87	0.16	0.16	1.87
Transplanting	70.20	70.20	6.15	6.15	70.20
Pulling and Hauling	14.04	14.04	1.23	1.23	14.04
Transplanting	56.12	56.12	4.92	4.92	56.12
Care and Management	14.98	22.40	1.31	1.97	18.69
Irrigation	1.87	1.87	0.16	0.16	1.87
Fertilizer application	7.49	14.98	0.66	1.31	11.23
Weeding	5.62	5.62	0.49	0.49	5.62
Harvesting	80.56	89.90	7.05	7.88	85.23
Cutting	37.44	37.44	3.28	3.28	37.44
Threshing	24.40	33.74	2.13	2.96	29.07
Hauling and Trucking	18.72	18.72	1.64	1.64	18.72
Total	206.92	236.85	18.12	19.61	221.89
Present of Production	6.06%	6.81%	6.06%	6.46%	6.43%
Grain Yield (kg/ha)	5400	6800			6100.00
Mcal/ Kg Grain rice	0.63	0.51			0.57
LDOE/ Kg Grain rice	0.06	0.05			0.06
Mcal/ ha	3414 .57	3480.50			3447.54
LDOE/ ha	299.15	303.79			301.47
F1= Farmer 1 (Lady)	F2=Farmer 2 (Man)				

was used in only land preparation during the growing season which consumed 773.69Mcal ha^{-1} 22.44% of total energy cost and then thrasher 271.83Mcal/ha (8%) and cleaning fan 118.08Mcal/ha (3%) which is also included embedded energy of machine and fuel energy consumption. Hand tractor needed more energy than thrasher and cleaning fan. Hand tractor machine had bigger engine and more time was required in preparing the land than thrasher and cleaning fans. The result indicated that land preparation was the second highest energy consumption (Pie 1). By excessive land preparation more than enough or more requirement of land preparation will increase in the energy cost per unit. To reduce energy cost, minimum land preparation such till, ploughing, harrowing, etc. is the best way. Moreover, minimum land preparation promotes to reduce the emission of GHG. Pie 1 and table 2 shows that thresher and cleaning fan was the lowest energy cost of producing of rice. Energy cost of threshing and cleaning was relatively low which is dependent on the amount of rice harvested. For energy cost of labour and other input (FYM, P fertilizer, and Rice cutter) are 221.85Mcal ha^{-1} (7%) and 204.45Mcal ha^{-1} (6%), respectively.

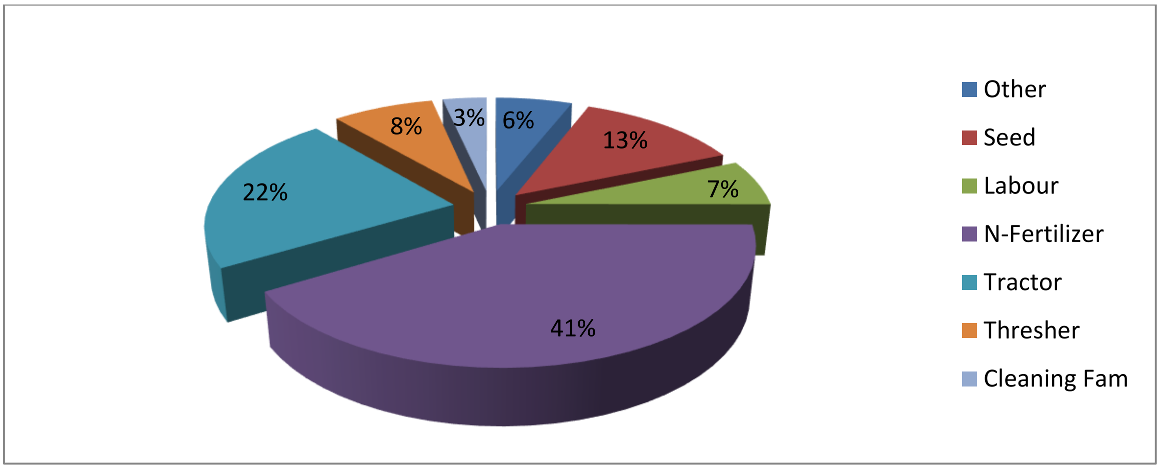

Figure 1. Energy cost estimates of producing of rice

Net energy, Energy efficiency and energy productivity

Table 3 show that the indicator of energy efficiency in lowland rice cultivation of different two farmers. The grain yield of F2 farmer was 1400kg ha^{-1} (26%) higher than the F1 and also the energy efficiency of F2 was 1.31 (23%) higher than the F1. However, the energy cost of F2 was 65Mcal ha^{-1} (1.9%) than the F1 in term of energy aspect. By using additional FYM's energy cost increased only 36Mcal (1.01%) per hectare but yield was increased 26% and energy efficiency was increased 23%. FYM is one of the most important factors to increase energy efficiency and grain yield but also to reduce the dependence on inorganic N fertilizer.

Table 3. Energy efficiency estimates of rice production of two farmers and average				
Item		F1	F2	Average
Yield level (Kg/ha)		5400	6800	6100
1.	Energy input/ha			
	Production (Mcal/ha)	3414.57	3480.50	3447.5
	Production (LDOE/ha)	299.15	303.79	301.47
2.	Energy Output/ha			
	Energy from grain (Mcal/ha)	18954	23868	21411
	Energy from Grain (LDOE/ha)	1660.60	2091.11	1875.9
Energy Efficiency		5.55	6.86	6.20
Energy Intensity		0.18	0.15	0.16
Net Energy Gained (Mcal ha^{-1})		15539	20387.5	17963.25

Average grain yield of two farmers was 6100kg ha^{-1}, equivalent to an energy output 214Mcal/ha. The average energy inputs of two farmers was 3419.19Mcal ha^{-1}, net energy gain of two farmers was 18,991.81Mcal ha^{-1}. The average energy cost of one Kilogram of grain was 1.78 kg/Mcal. The energy efficiency of average was 6.20

Postproduction

Postproduction of rice included of milling process and transportation of rice. Table 4 shows that the different energy cost of one tonne of rice milling in big mill, small rice mill. The energy cost was different due to the differences of power use such as electrical power, diesel oil and also milling efficiency. The energy cost of small rice mill was 81.60Mcal/ tonne while the energy cost of big rice mill was 61.76Mcal/tonne. The energy cost of big rice mill was 19.84Mcal/ton (24%) lesser than the small rice mill. The second highest average energy cost of two milling was the power or diesel used to run the machine which consumed energy 20.66Mcal/ton (28.82%). Using the power in milling process was one of the crucial factors influencing the energy bill. Rice mill is dependent on diesel to run the engine which is higher energy cost than the electrical power used rice mill. The highest energy cost of postproduction was in transporting 32.69Mcal/ton (45.48%) which is included energy cost of truck 4.15Mcal/ton (5.79%) and energy cost of fuel used 28.54Mcal/ton (39.81%) (Table4). But the distance between rice field and rice mill need to transport rice was only. It is obvious that as the distance from the mill to the city where it is consumed increased, the energy used, would partially increase the amount energy used for transport was 1 li oil per 2 Km, as an example, the distance from Bay to Manila is 70 Km (70 li ÷ 2 km/li = 35 li). How the energy requires of the transportation is dependent on the age of the engine. Carley (2015) reported that the high oil consumption depends primarily on the type of vehicle, condition of the vehicle and distance travelled. The distances of field to rice mill about 5 to 10 km is a nearest distances in rice transporting of postproduction. The distances are one of the factor determinants in transportation energy consumption, because the distance can be determined of litters of fuel to use. Carley (2015) reported that the high oil consumption depends primarily on the type of vehicle, condition of the vehicle and distance travelled. The distance of rice transportation is governing directly on oil use which is one of the important factors influencing energy bill of postproduction. With the distance of transportation is too far, the energy bill will be automatically increased but also emission of GHS will be climbed up.

Table 4. Energy cost estimates of milling of rice in two different mill and average									
No	Item	Mcal/Ton		LDOE/ Ton		% of Cost		Mcal/Ton	% of Cost
		Big Mill	Small Mill	Big Mall	Small Mill	Big Mill	Small Mill	Average	
1.	Transportation by truck	4.15	4.15	0.36	0.36	6.72%	5.09%	4.15	5.79%
2.	Fuel of transportation	28.54	28.54	2.50	2.50	46.21%	34.97%	28.54	39.81%
3.	Labour	2.25	2.25	0.20	0.20	3.64%	2.75%	2.25	3.13%
4.	Diesel/ Power in Milling	7.08	34.24	0.62	3.00	11.97	41.97%	20.66	28.82%
5.	Machine	1.50	3.345	0.13	0.29	2.43%	4.10%	2.42	3.38%
6.	Building (sq ft.)	8.18	9.08	0.72	0.80	13.245	11.13%	8.63	12.04%
7.	Concrete Floor	10.07	0	0.88	0.00	16.30%	0.00%	5.03	7.02%
	Total	61.76	81.60	5.41	7.16			71.68	
	Mcal/ 1 Kg rice Milling	0.06	0.08						
	LDOE/ 1 kg rice Milling	0.01	0.01						
*2 cubic ft. of cement floor = 65kg				*Expected life of Big Rice mall Building = 25 Years					
Expected life of cement floor = 50years				*Expected life of Small Rice mall Building = 20 Years					
Expected life small rice mall machine = 10year				**Capacity of Big rice mill = 200 tonnes per year					

Expected life of machine of big rice mall = 10 year	** Capacity of Small rice mill= 100 tonnes/ Year
Assumed Distance Transportation = 5Km	**1 Litter of diesel = 11.1 kWh (N Packer,2011)
	1 Litter of diesel = 8.63 Kcal (Gable, Christine & Gable, Scott, 2015)

The energy cost of production, post production and cooking process for one kg of rice is shown in Pie 2 and Table 5. The energy cost producing of one kg rice was the highest energy bill 0.57Mcal (89.20%) among producing, postproduction and cooking. The highest cost of energy in production was due the farmer use of high external inputs or the use of large amount of chemical N fertilizer. Reducing the chemical energy input would not only mean reducing the energy use in rice production but would also lead to considerable reduction of CO2 emission. Natural gas comprises 90% of the energy requirement to produce anhydrous ammonia, a basic component of most nitrogenous fertilizers, and there is a correlation in prices of natural gas and anhydrous ammonia and in turn in the prices of nitrogenous fertilizers. As the prices of natural gas increase, it would affect the cost of producing crops including sugarcane. The supplies of fossil fuels are decreasing and their prices are increasing, in turn, the prices of oil-based inputs would increase further (Schnepf 2004). Mendonza (2007), reported that Optimal and low-cost use of local and external resources: making best use of available local resources and, if necessary, efficient use of modest amounts of modern external inputs. Furthermore, agro-ecology: the knowledge base to apply ecological concepts and principles (for example: synergy, biodiversity, nutrient recycling, natural pest management, complementarity and resilience) to the design and management of sustainable agro ecosystems.

Conventional farming, in general, relies mainly on synthetic fertilizer application. The use of chemical fertilizers accounts for 55% of the increase in food production in developing countries (FAO 1998) and 51.4% of the increase in maize yield in China (Wu et al.1998). However, most farmers could not sustain the application of high-priced N fertilizer. Reducing the amount of fertilizer applied without using other nutrient sources would reduce the yield and profitability of the agricultural crop including sugarcane. With using farm yard manure farming, reducing N fertilizer application is possible while maintaining high tonnage yield.

The energy cost estimates of postproduction were the second highest component that was influenced by transportation distance and fuel used to run milling. And then the energy cost of cooking of rice was 0.01Mcal/ha (0.78% of energy cost from farm to plate).

Table 5. Energy cost estimates of rice product, postproduction and cooking

Item	Mcal/kg	Present
Production (Mcal/kg)	0.57	89.20%
Postproduction (Mcal/kg)	0.06	10.02%
Cooking (Mcal/kg)	0.01	0.78%
Total	0.64	100%

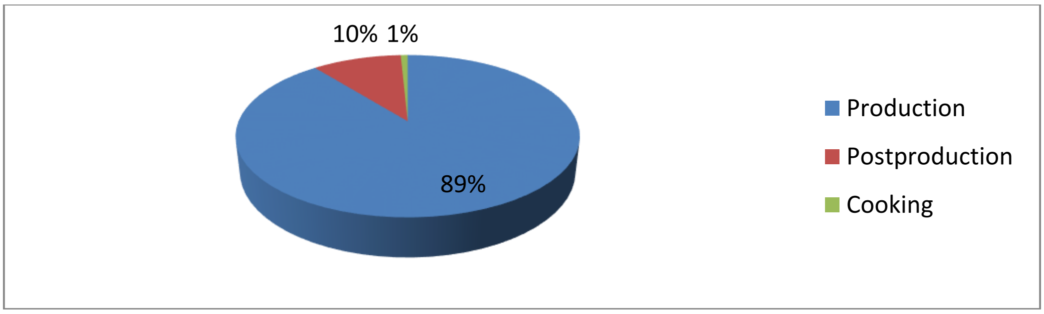

Figure 2. Energy cost sharing producing, postproduction and cooking of rice

IV. Conclusions and Recommendations

Conclusions

Nitrogen fertilizer application was the highest energy cost of producing rice. With using higher amount of N-fertilizer application will lead to higher energy cost but also increase emission of greenhouse gas. By using additional FYM's energy cost increased only 36Mcal (1.01%) per hectare but yield was increased 26% and energy efficiency was increased 23%. FYM is one of the most important factors to increase energy efficiency and grain yield but also to reduce the dependence on inorganic N fertilizer. Among machineries used in production hand tractor was the highest in energy cost which included of embedded energy, 234.51Mcal ha^{-1} and fuel consumed

539.18Mcal ha^{-1}. By excessive land preparation more than enough or more requirement of land preparation will increase in the energy cost per unit. To reduce energy cost, minimum land preparation such till, ploughing, harrowing, etc. is the best way. Moreover, minimum land preparation promotes to reduce the emission of GHG. The highest energy cost of postproduction was in transporting 32.69Mcal/ton (45.48%) which is included energy cost of truck 4.15Mcal/ton (5.79%) and energy cost of fuel used 28.54Mcal/ton (39.81%) (Table4). Using the power in milling process was the second crucial factors influencing the energy bill. Rice mill is dependent on diesel to run the engine which is higher energy cost than the electrical power used rice mill. The distance of rice transportation is governing directly on oil use which is one of the important factors influencing energy bill of postproduction. With the distance of transportation is too far, the energy bill will be automatically increased but also emission of GHS will be climbed up. More research is needed to carry out the best way of efficient transportation.

Recommendation

1) FYM to reduce the dependence of inorganic N fertilizer and to reduce energy bill
2) Excessive land preparation should be avoid to reduce energy bill and emission of GHG
3) Government should support electrical power to mill station
4) More research is need to find out the effective way of transportation

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