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Profitability and Energy Use Pattern in Rice Production Technologies in North Central and North Western Nigeria

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ABSTRACT: Efficient use of energies on crop production helps to achieve increased production and productivity as well as profitability and competitiveness of agricultural sustainability of rural communities. The study examined energy use pattern in rice production under two different technologies in two States of Nigeria. Primary data were generated through structured questionnaire and interview administered to 265 rice farmers comprising 57 semi-mechanized (Group 1) and 208 traditional (Group 2) rice farmers in both States. Results revealed that the semi-mechanized farmer had higher income of ₦370998.2 ($2348.1) per ha compared to ₦307031.1 ($1943.2) per ha from traditional technology. Group 1 farmers produced a total energy output 54842.8 MJ ha^{-1} (3.7 tons) compared to Group 2 farmers with energy output of 46601.9 $MJha^{-1}$ (3.1 tons). Conversely, the energy use efficiency, energy productivity and net energy of traditional system indicate high energy use efficiency compared to that of semi-mechanized system. Findings also showed that non-renewable energy in semi-mechanized (72.1%) was high compared to that of traditional group (32.8%). This could be as a result of high usage of chemical fertilizer, herbicide, diesel and machinery. The result also revealed that rice production was driven by indirect energy in Group 1 (58%) and largely by direct energy in Group 2 (64.2%). Rice farmers are encouraged to shift to semi-mechanized farming for higher output and increase profitability. Semi-mechanized system should adopt more organic agriculture and soil conservation methods such as crop rotation, mixed cropping and inter cropping to maintain soil fertility and to manage pests and diseases.

Keywords:*Rice, net energy, efficiency, net margin*

Introduction

Rice (*Oryza sativa L.*) belongs to the Gramineae family, which is the most important of all cultivated crops world-wide (Pishgar *et al.*, 2011, Cherati *et al.*, 2012). Rice production started in Nigeria in 1500 BC with low-yielding indigenous red grain species *Oryza glaberrima* that was widely grown in the Niger Delta area (Ologbon *et al.*, 2012). Rice is cultivated in virtually all the agro-ecological zones in Nigeria, yet the area allotted for rice farming still appears small (Ajijola *et al.*, 2012; Ibrahim and Ibrahim, 2012; Onu *et al.*, 2015). Furthermore, the shortfall in the supply of rice in Nigeria has been attributed to inefficiency in the use of resources, disincentives from macro-economic environment, continuous rise in per capita consumption brought about by increased population and rapid urbanization and partly to production in the hand of small scale farmers who use traditional technology (Ibrahim and Ibrahim, 2012; Oladimeji and Abdulsalam, 2014).

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In Nigeria and more commonly in most developing countries, the demand for food products has outstripped supply creating a huge deficit (Ajijola, *et al.*, 2012; Onu *et al.*, 2015; Oladimeji, 2017). Although importation of food products was used partially to fill the growing deficits in the past, and presently, its continuation constitutes avoidable drain on the country's scarce foreign earnings, especially during this period of economic recession and dwindling oil prices (Ologbon *et al.*, 2012).

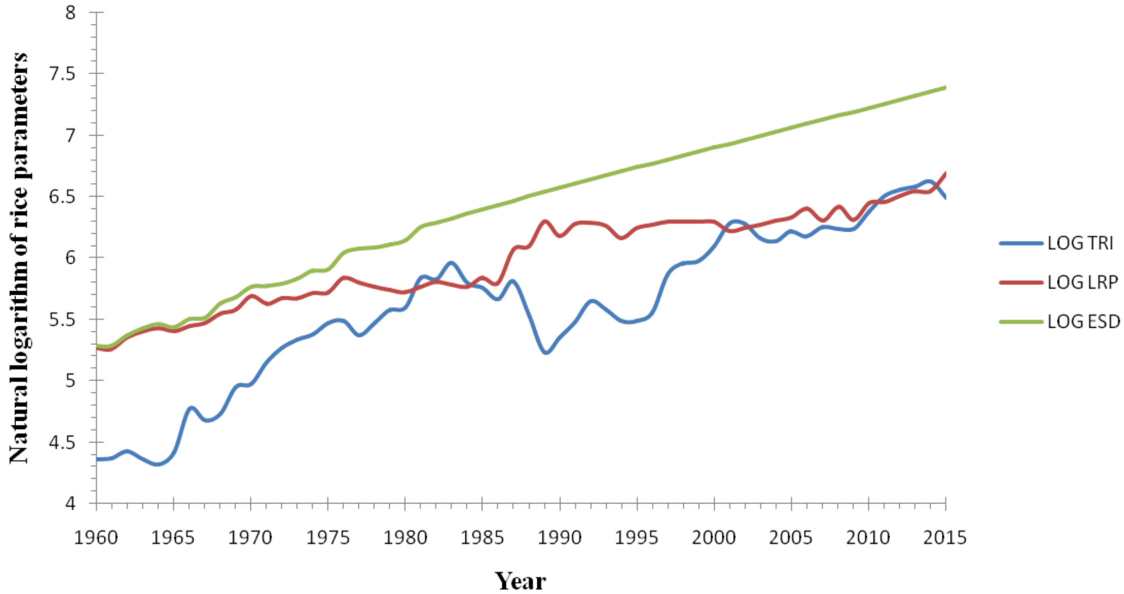

Figure 1 Trend analyses in LRP, TRI and ESD Production in Nigeria (1960 - 2015)
Computation by the author; Data source: CBN/NBS/FDF yearly records (1970-2014)
Source: Oladimeji, 2017

It suffices to note that Nigeria is one of the leading consumers and the largest producers of rice in Africa and simultaneously one of the largest rice importers in the world. Available records from Ajijola *et al.* (2012); FAO (2015); Oladimeji (2017) revealed that the total domestic rice production in Nigeria for 2 decades period (1990-2008) averaged about 3.2 million tons per annum and ranged from 2.5 million tons in 1990 to 4.2 million tons in 2008. But the estimated demand for rice consumption ranged from 3.8 million tons to 14.5 million tons during the same decades with annual average of about 8.0 million tons (Fig. 1). Furthermore, the country's self- sufficiency ratio in rice production ranged from 23.6% in 2007 to 50.17 % in 2014 with an annual average of 45.6% (Ologbon, 2012; FAO, 2015; Oladimeji, 2017). The increase in output of rice over the years in Nigeria was as a result of increase in hectares cultivated as well as increase in yield per hectare. Average yield of rice for both wet and dry season in the country has increased from 1,650 kg/hectare in 2013 to 2,180 kg/hectare in 2014 (World Rice Statistics, 2016; Makama *et al.*, 2017).

Ozkan *et al.* (2004) opined that energy is used in agricultural production in direct and indirect ways. Efficient use of these energies on crop production help to achieve increased production and productivity and help the economy, profitability and competitiveness of agricultural sustainability of rural communities (Singh *et al.,* 2002; Namdari, 2011). Energy analysis can be used as a first step towards identifying crop production process that benefit most from increased efficiency (Mohammadi *et al.,* 2008).

The input energy is also classified into direct and indirect, and renewable and nonrenewable forms energy equivalents for different inputs and outputs in agricultural production. Direct energy is required to perform various tasks related to crop production processes such as land preparation, irrigation, intercultural, threshing, harvesting and transportation of agricultural inputs (diesel fuels) and produce (Pishgar *et al.*, 2011). Direct energy is therefore directly used at farms and on fields and this covered human labor, water and diesel fuel used in the rice production.. Indirect energy, on the other hand, consists of the energy used in the manufacture, packaging and transport of fertilisers, pesticides, seed and farm machinery (Pishgar *et al.,* 2011). This consists of seeds, chemical fertilizer, chemical herbicide and insecticide, and machinery energy. Non-renewable energy is those energy input use in a production process and could not be reuse in the subsequent production and this includes diesel fuel, chemical fertilizer, chemical herbicide and machinery. Renewable energy consists of human labor, water and seed which could be used in the subsequent production activities.

Therefore, it becomes imperative to examine energy use in two different technologies that could enhance both small and large scale farmers to be more efficient in the use of available resources which is a major pivot for a profitable farm enterprise at microeconomic level and increased self-sufficiency and export at macro-level. Furthermore, the subject of energy analysis of rice production in Nigeria has received substantial attention in the literature (Ibrahim and Ibrahim, 2012; Faleye *et al.*, 2013; Oladimeji *et al.*, 2016).However, onlya few estimated energy studies have use in rice production and efficiency in rice production. The objectives of this study were to examine profitability and estimate energy use production for two groups of rice farmers with different level of production technology and machinery ownership status in Kebbi and Kwara States, Nigeria.

METHODOLOGY

The study area

The study was conducted in North-central and North- western Nigeria 40° 00’ N and 75° 09’ W. The two regions fall within the tropical Guinea and Derived Savannah zone of Nigeria which combined to form woodland and tall grass savanna. The mean annual rainfall and temperature ranges from 787 mm to 1500 mm and 29.5 °C-35 °C respectively. Both Kebbi and Kwara States have abundant surface water resources in the form of rivers, such as the Niger, Rima and Ka for irrigation, domestic use, fish and bee farming. The southern guinea savanna zone, which emanated from woodland and tall grass land savanna, where Kwara and Kebbi State belong is one of the four major zones into which Keay (1953) divided the savanna regions of Nigeria. The derived savanna zone extends southwards from the southern guinea zone to the forest zone. The two States were purposefully chosen as the study area for this remarkable factor.

Data collection and Sampling procedure

The study was based on primary sources of the data gathered by field surveys on rice farms in 2013/2014 farming season through questionnaire and interview. For the purpose of this study, a farm that used farm machinery such as tractor, planter, combine harvester, sprayer in most of the farm operations was considered semi-mechanised. On the other hand a farm that uses simple farm tools like hoes, cutlasses was considered as traditional technology or non-mechanised.

A multi-stage random sampling procedure was employed for selecting the representative of rice farmers in north central and north western Nigeria. The first stage involved the random selection of 2 States: Kwara and Kebbi States from the list of the 14 States in the two regions including Abuja Federal Capital Territory. The rice producing LGAs in each State were purposively selected being areas dominated by rice production and, where most of the small rice holders and nearly all mechanised farms were located. These comprises of four LGAs in Kwara State: Ifelodun, Moro, Pategi and Lafiagi and four: Augie, Dandi, Birnin Kebbi and Suru LGAs out of the 20 major rice producing in Kebbi State based on high population of the rice farmers. The second stage involved the random selection of two rice farming villages from each of LGA selected. Finally, with combined efforts of Agricultural Development Project staff, State Ministry of Agriculture, Rice Farming Associations and village heads, a stratified random sampling result in 265 rice farmers comprising 208 traditional and 57 mechanised rice farmers in both States.

It is pertinent to note that the size of each sample from the two States (Kwara and Kebbi) was determined by adopting Neyman method of sample determination (Yamane, 1967) given as

$$n = \frac{\sum N_{cw} S_d}{N_{cw} D^2 + \sum N_{cw} S_d^2} \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots..(1)$$

Where; n is the required sample size; N is the number of holdings in target population; N_{cw} is the number of the population of rice farmers in the North-central and North-western Nigeria, S_d is the standard deviation in the two zones (North Central and North West Nigeria), S^2_d is the variance of in the two zones; d is the precision level, z is the reliability coefficient (1.96 which represents the 95% reliability); $D^2 = d^2/z^2$.

Classification of rice farmers was based on level of farming technology. Semi-mechanised technology consist of farmers who owned or rented machinery such as tractor and imbibed modern management practices such as hybrid seeds, knapsack sprayers and irrigation equipment. Traditional technology farmers was made up of rice farmers that used solely crude implements such as hoes and cutlasses hence refers to as non-owners of machinery or imbibed low level of farming technology (Zangeneh *et al.*, 2010; Namdari, 2011), seldom receive extension contacts and low level of hybrid input usage.

The energy input output analysis used standard energy conversion of previous studies cited by Zangeneh *et al*. (2010); Banaeian and Namdari, (2011); Oladimeji *et al*., 2016 that obtained energy equivalences of unit inputs (Mega Joule) by multiplying inputs with the coefficients of energy equivalent. Table 1 showed standard energy equivalents that were used.

The energy use efficiency, the energy productivity, the specific energy and net energy gain were calculated based on the energy equivalents in Table 1 as follows:

$$\text{Energy use efficiency} = \frac{\text{Energy output (MJ ha}^{-1})}{\text{Energy input (MJ ha}^{-1})} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

$$\text{Energy productivity} = \frac{\text{Rice output (kg ha}^{-1})}{\text{Energy input (MJ ha}^{-1})} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

$$\text{Specific energy} = \frac{\text{Energy input (MJ ha}^{-1})}{\text{Rice yield (kg ha}^{-1})} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

$$Net\ energy = Energy\ output\ (\text{MJ ha}^{-1})) - Energy\ input(\text{MJ ha}^{-1})\ldots\ldots\ldots.. (5)$$

An input in rice production system was calculated as:

$$\text{Input} = \frac{\text{Total input usage(unit)}}{size\ of\ farmland\ (ha)} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

Table 1: Standard energy equivalents used for estimated inputs and output

Variables	Unit	Energy eq. (MJ)	Sources
1. Inputs			
i Human labour	H	1.96	Cankci *et al*., 2005; Yilmax *et al*., 2005
ii Machinery	H	62.7	Cankci *et al*., 2005; Yilmax *et al*., 2005
iii Diesel fuel	L	56.31	Mohammadi *et al*., 2008; Zangeneh *et al*., 2010
(iv) Nitrogen fertilizer	Kg	66.14	Alam *et al*., 2005; Mohammadi *et al*., 2008
v Farm Yard Manure	Kg	0.30	Cankci *et al*., 2005; Demiran *et al*., 2006
vi Chemicals	L	120.0	Mohammadi *et al*., 2008;
vii H_2O for irrigation	M^3	1.02	Mohammadi *et al*., 2008
viii Rice seed input	Kg	14.7	Singh *et al.*, 2002;
2. Rice output	Kg	14.7	Cankci *et al*., 2005

For the purpose of this study, Net Farm Income (NFI) per ha and Gross Margin per ha were employed to investigate economic analysis of rice production under semi-mechanised and traditional technology respectively. The two models are presented mathematically as:

$$\text{NFI} = \text{GFI} - \text{TVC} - \text{TFC} \quad \ldots\ldots\ldots\ldots\ldots.. \quad (7)$$

$$\text{GM} = \text{GFI - TVC} \quad \ldots\ldots\ldots\ldots\ldots \quad (8)$$

Where: NFI = Net Farm Income (Naira ₦/ha); Gross Farm Income (Naira ₦/ha) = Yield (kg ha^{-1}) X Sale price (Naira ₦/kg); TVC = Total Variable Cost (Naira ₦/ha) and TFC = Total Fixed Cost (Naira ₦/ha).

$$PM(\%) = \frac{\text{net margin}}{\text{grossincome}} * 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (9)$$

$$GR(\%) = \frac{\text{total cost}}{\text{gross return}} * 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (10)$$

$$ROI = \frac{\text{gross income}}{\text{total cost}} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (11)$$

Where: PM= profit margin; GR= gross ratio and ROI= return on investment.

Depreciation values were estimated using a straight line method under the assumption that tractors and irrigation equipment were used for a period of 10 and 5 years respectively before being scrapped without salvage values.

Results and Discussion

Cost structure in rice production technologies

Table 2 depicts cost components used in the two rice production technologies

Table 2: Distribution of total cost components per hectare of rice production

Variables	Semi mechanized (Group 1)		Traditional (Group 2)	
	Value (USDha^{-1})	**%**	**Value (**USDha^{-1})	**%**
Variable cost (₦)				
Seed materials	16.3	1.1	10.4	0.8
Water	189.9	13.3	189.9	15.0
Fertilizer	97.8	6.8	83.9	6.6
Herbicides	32.9	2.3	21.1	1.7
Labour	638.6	44.7	901.6	71.2
energy (fuels)	97.4	6.8	-	-
Repairs	39.3	2.7		
Transport cost	33.7	2.4	28.5	2.2
Total variable cost	**1145.9**	**80.1**	**1235.4**	**97.5**
Land charge/rent	31.6	2.2	31.6	2.5
Machinery depreciation/rent	252.3	17.7	-	
Total Fixed Cost	**284.0**	**19.9**	**31.6**	**2.5**
Total costs	**1429.9**		**1267.0**	

Note: USD denote United State Dollar; exchange rate = ₦158= USD1

Results revealed that total variable cost constituted about 80% and 98% of total cost (TC) per hectare of rice production in semi-mechanised and traditional technologies respectively. In addition, labour cost accounted for about 45% of TC in semi-mechanised and 71% of traditional technology. The finding on cost component is in line with studies of Namdari, (2011); Oladimeji *et al.* (2016) on egusi melon production and Yilmax *et al.* (2011) on watermelon production where labour in semi-mechanised and traditional systems accounted for 17.7% and 67% of TC respectively.

Benefit-Cost analysis in rice production technologies

Table 3 shows the average costs and returns per ha for rice production under semi-mechanised and traditional technologies in the study area.

Table 3: Details average costs and returns per ha of rice production under two different technologies in Nigeria

Variables	Semi-mechanised system			Traditional system		
	₦ha^{-1}	USDha^{-1}	%	₦ha^{-1}	USDha^{-1}	%
Rice price per Kg = ₦160						
Rice Yield(kg/ha)	3730.8			3170.2		
Revenue from (₦):						
A. Gross return	**596928**	**3778.1**		**507232**	**3210.3**	
Variable cost (₦)						
Seed materials	2570.4	16.3	1.4	1650.5	10.4	0.9
Water	30000.0	189.9	16.6	30000.0	189.9	15.4
Fertilizer	15458.7	97.8	8.6	13250.8	83.9	6.8
Herbicides	5205.2	32.9	2.9	3340.7	21.1	1.7
Labour	100904.5	638.6	55.7	142455.3	901.6	73.0
Energy (fuels)	17275.1	109.3	9.5	-	-	-
Repairs	4325.1	27.4	2.4			
Miscellaneous	5320.4	33.7	2.9	4503.6	28.5	2.3
B. Total variable cost	**181059.4**	**1145.9**	**100.0**	**195200.9**	**1235.4**	**100.0**
Fixed cost items						
Land charge/rent	5000.0	31.6	11.1	5000.0	31.6	100
Machinery depreciation/rent	39870.4	252.3	88.9	-	-	-
C. Total Fixed Cost	**44870.4**	**284.0**	**100.0**	**5000.0**	**31.6**	**100**
D. Total costs (B+D)	**225929.8**	**1429.9**		**200200.9**	**1267.0**	
E.Net margin/ha (A-D)	370998.2	2348.1		307031.1	1943.2	
Profit margin (E/A)	0.62			0.61		
Gross ratio (D/A)	0.38			0.39		
ROI (A/E)	1.61			1.65		

Source: Field survey, 2013/2014; *Note: ROI indicate Return on Investment;* Exchange rate = ₦158= USD1

The results concentrate on returns accruing to both farmers under the two different technologies. The net margin shows that rice production was profitable in the two production technologies, although the total expenditure for semi-mechanised system amount to ₦225,929.8 ($1,429.9) per ha while the traditional system was ₦200,200.9 ($1,267.1). Despite this, results revealed that semi-mechanised farmers realized more yield (3.73 tons) and invariably higher income, ₦370,998.2 ($2,348.1) per ha compared to yield of 3.17 tons and profit of ₦307,031.1 ($1,943.2) per ha from traditional technology. Therefore, the net return analysis revealed that semi-mechanised system had a better leverage to increase rice production to attain rice self-sufficiency production in Nigeria.

It suffice to note that traditional rice production technology largely have limitations towards achieving self-sufficiency in rice production viz. drudgery nature, limited size holdings, time consuming and more fatigue. Several studies (Namdari, 2011; Oladimeji and Ajao, 2014) adjudged that the bulk of rice production in Nigeriais by small scale farmers with average size holding of 2-5 ha. This result agrees with the findings of Namdari (2011) and Cherati *et al.* (2011) that reported significant net margin difference between mechanised and traditional technologies in rice production in Iran and Oladimeji and Abdulsalam, (2014), Oladimeji *et al.* (2016) of vegetable and melon production respectively in Nigeria.

Profitability ratios in Table 3 indicated that semi-mechanised system of rice farming had a higher profit margin (0.62) and gross ratio of (0.38) compared to 0.61 and 0.39 respectively in traditional system. The gross ratio is an indicator of the ability of rice farmers to control cost of operation. A less than one ratio is desirable for any for any farm business. The lower the ratio as in semi-mechanised farming (0.38) in this study, the higher the return per Naira invested. A rising ratio shows that variable costs are increasing or that revenue is declining due to falling rice prices. The gross ratio in two rice production technologies was less than 1. According to Gittinger, (1982), enterprises with very high gross ratios in the neighborhood of 90% have difficulty in making adequate returns on investment, due to triple effects of high operating expenses, dwindling rice output, and falling prices; while an abysmally low ratio, say 50%, implied that some costs may have been omitted or grossly underestimated. The return on investment means that for every one naira invested by rice farmer, a profit of either ₦1.60 or ₦1.65 is made in semi-mechanized or traditional system.

Level of Inputs and output usage in rice production technologies

The results of the analysis of input and output in two rice production technologies per ha are presented in Table 4.

Table 4: Inputs and Output in rice production under semi-mechanised and traditional technologies

Inputs/Output (unit)	Quantity per unit area (ha)			
	Semi-mechanised		Traditional	
1. Inputs				
Human labour (h ha^{-1})	Qty/unit (%)	Grand %	Qty/unit (%)	Grand %
Pre planting operations	50.5 (9.6)	7.0	178.2 (20.4)	19.8
pre-nursery and nursery	58.8 (11.1)	8.1	75.3 (8.6)	8.4
Seedling (transplanting)	43.4 (8.2)	6.0	45.9 (5.3)	5.1
Watering	143.0 (27.0)	19.7	114.6 (13.1)	12.7
Chemical fertilizer application	43.5 (8.2)	6.0	39.5 (4.5)	4.4
Farm Yard Manure	10.3 (2.0)	1.4	27.0 (3.1)	3.0
Manual weeding	45.7 (8.6)	6.3	237.2 (27.1)	26.4
herbicides spraying	54.8 (10.4)	7.6	21.9 (2.5)	2.4
Harvesting, threshing & transp.	78.7 (14.9)	10.8	134.4 (15.4)	14.9
Total	528.7 (100)	72.9	874.0 (100)	97.1
Machinery (h ha^{-1})				
Pre planting operations	47.9 (24.3)	6.6	11.5 (43.7)	1.3
herbicides	42.3 (21.5)	5.8	14.8 (56.3)	1.6
Fertilizer application	17.4 (8.8)	2.4	-	-
Harvesting, threshing & transp.	89.5 (45.4)	12.3	-	-
Total	197.1 (100)	27.1	26.3 (100)	2.9
Grand total L ha^{-1}	725.8	100	900.3	
Diesel Fuel (L ha^{-1})				
Land preparation	78 (63.4)		-	
Harvesting, threshing & transp.	45 (36.6)		-	
Total	123 (100)		-	
Inputs				
Seed materials (kg ha^{-1})	35.7		48.9	
N_2 Chemical fertilizer (kg ha^{-1})	185.2		87.2	
Farm Yard Manure (kg ha^{-1})	2590.0		10900.3	
Herbicide chemical (L ha^{-1})	7.4		2.9	
Water (m^3 ha^{-1})	10,000.00		10,000.00	
2. Output				
Rice yield (kg ha^{-1})	3730.8		3170.2	

Source: Field survey, 2013/2014; N_2 denote Nitrogen

Result revealed that semi-mechanised farmers required 528 h ha^{-1} of human labour while traditional system used 874 h ha^{-1} of the same power. The result implies that semi-mechanised rice production system save 346 h ha^{-1} per hectare compared to traditional rice production system. The hours of labour saved in semi-mechanized rice production system can be put in other agricultural production activities such as livestock and aquaculture. The finding is consistent with the studies of Namdari (2011) and Yilmax *et al.* (2011) who found a significant difference in number of hours required between traditional and semi-mechanized technology in watermelon production. However, human labour constituted 72.9% of total hours expended for all operations per ha in semi-mechanised and machinery consumed 27.1%. In traditional technology, human labour accounted for about 97% of total farm operations and machinery power took about 3%. Result further revealed that Group 1 needed a total of 725.8 h ha^{-1} to produce 3.7 tons of rice contrary to Group 2 that used 900.3 h ha^{-1} to produce about 3.1 tons. Several researchers (Mohammadi *et al.*, 2008; Namdari, 2011; Yilmax *et al*., 2005; 2011) reported that human labour is a major input in the two production technologies.

Energies in Rice Production Technologies

The results of input and output energies in rice production technologies per ha presented in Table 5 revealed that semi-mechanized farms had total energy input of 44959 MJ per ha while traditional had 23666.3 MJ per ha. In semi-mechanized system, machinery and seed material had maximum and minimum energy inputs of 12358.2 MJ and 524.8 MJ representing 27.5% and 1.2% respectively of total energy used per ha. This was expected as machinery was used for pre-planting operations as well as chemical and fertilizer application. The results also revealed that herbicide constitute the minimum energy (1.5 MJ) and water, the maximum energy (10200 MJ) in traditional system in the study area. The findings is in sharp contrast with results of production of egusi melon (Oladimeji *et al.,* 2016) and watermelon, Namdari, 2011) where nitrogen fertilizer and herbicides had higher share and invariably higher energy in the total input of the crop production.

Table 5: Distribution of amounts of inputs and output energies in rice production per hectare

Inputs/Output (unit)	Semi-mechanised		Traditional	
	TEE (MJ $ha^{-1)}$	% of TEE	TEE (MJ ha^{-1})	% of TEE
1. Inputs				
Human labour	1036.3	2.3	1713.0	7.2
Machinery	12358.2	27.5	1649.0	7.0
Diesel Fuel	6926.1	15.4	-	-
Nitrogen Chemical Fertilizer	12249.1	27.2	5767.4	24.4
Farm Yard Manure	777.0	1.7	3270.1	13.8
Herbicide chemical	888.0	2.0	348.0	1.5
Rice seed	524.8	1.2	718.8	3.0
Water	10200.0	22.7	10200.0	43.1
Total energy inputs	44959.0	100.0	23666.3	100.0
2. Output				
Total energy output	54842.8		46601.9	

Source: Field survey, 2013/2014; TEE denote Total Energy Equivalent

Energy Efficiency in Rice Production

The energy productivity of inputs for rice production is presented in Figure 2. The value of energy productivity for the semi-mechanised inputs ranges from 0.31 (Nitrogen fertilizer) to 7.11 (rice seed) compared to energy productivity range from 0.31 (water) to 9.11 (herbicide). The energy use efficiency, energy productivity, specific energy and net energy of rice production in Nigeria are presented in Table 6. The result indicated that the energy use efficiency and energy productivity for semi-mechanised rice production were 1.22 and 0.083 kgMJ^{-1}, while that of traditional system were 1.97 and 0.134 kgMJ^{-1} respectively. The energy productivity implies that 1.22 kg of rice was obtained per unit energy (MJ) in semi-mechanised system which was lower than 1.97 kg per MJ obtained in traditional system. The energy use efficiency ratio of traditional system (1.97) indicates high energy use efficiency compared to the 1.22 of semi-mechanised system. Lower energy usey ratio was observed for semi-mechanised mainly because of the additional energy input of farm yard manure and hybrid seed. The efficient use of energy resources is vital in terms of increasing production, productivity and competitiveness in agriculture as well as sustainability of rural production systems which was in line with *a priori* expectation and result of Yilmaz *et al.* (2005) and Oladimeji *et al.* (2016).

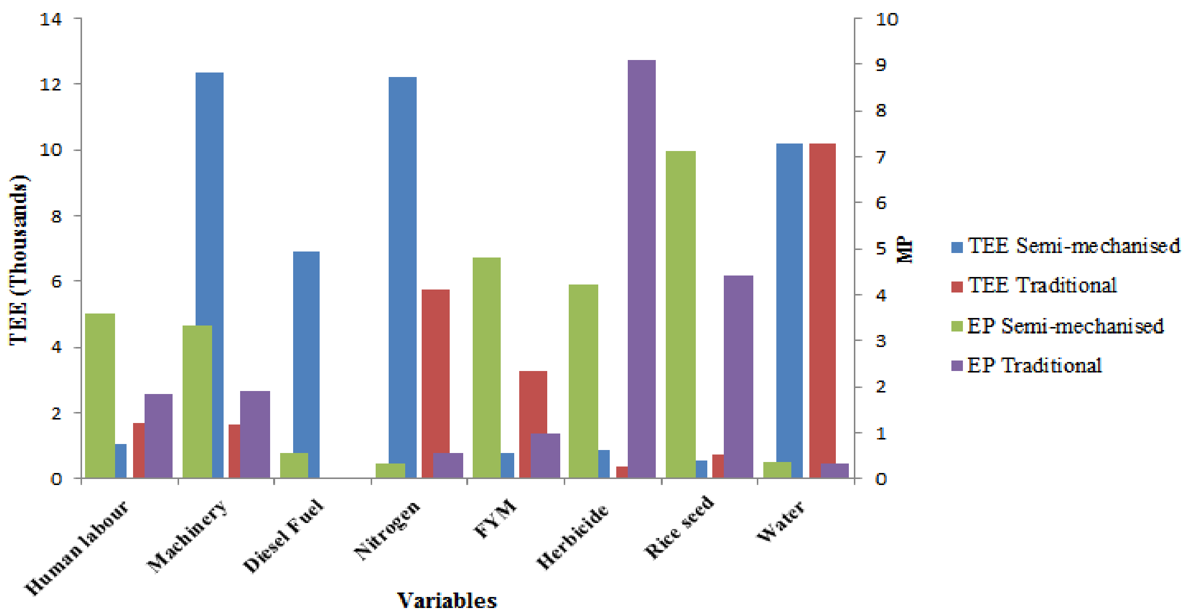

Fig. 2: Energy productivity for various inputs used in two rice production technologies

Table 6 Level of energy input–output efficiency in rice production

Variables	Unit	Semi-mechanised	Traditional
Total energy output	MJ ha^{-1}	54842.8	46601.9
Total energy input	MJ ha^{-1}	44959.0	23666.3
Yield	Kg ha^{-1}	3730.8	3170.2
Energy use efficiency	-	1.22	1.97
Specific energy	MJ kg^{-1}	12.1	7.5
Energy productivity	Kg MJ^{-1}	0.083	0.134
Net energy	MJ ha^{-1}	9883.8	22935.6

Source: Field survey, 2013/2014

Total energy input in rice production to energy types

Table 7 shows that non-renewable energy (NRE) in semi-mechanised rice production system (72.1%) was high compared to that of traditional production system (32.8%). This could be as a result of relatively high usage of chemical fertilizer, herbicide, diesel and machinery. This corroborates the studies of Namdari, (2011) that estimated non-renewable energy in watermelon to be about 79% and 81% in mechanised and non-mechanised technologies respectively. However, result revealed that direct energy (DE) in semi-mechanised sector (42.1%) was also lower than traditional sector (64.2%). Therefore, rice production among semi-mechanised farmers in the study area was driven by indirect energy while traditional production was largely driven by direct energy. The high consumption of chemical fertilizer, herbicides and machinery accounted for high indirect energy in semi-mechanised system lead to increasing total cost of production. On the other hand, labour consumption account for high direct energy in traditional production system.

Figure 7: Distribution of total energy input in rice production to energy types

Form of energy (MJ ha^{-1})	Semi-mechanised Amount of energy	%	Traditional Amount of energy	%
Renewable	12538.1	27.9	15901.9	67.2
Non-renewable	32421.4	72.1	7764.4	32.8
Direct	18939.4	42.1	15183.1	64.2
Indirect	26020.1	57.9	8483.2	35.8

Source: Field survey, 2013/2014; *Note direct energy include: human labour, Farm yard manure, water and diesel fuel; indirect: seeds, chemical fertilizer, herbicides and machinery; renewable: human labour, farm yard manure, water and seed; non-renewable: diesel fuel, chemical fertilizer, herbicide and machinery*

Conclusion and Recommendations

It can be concluded from the study that the two rice production systems are profitable and energy use in both traditional and semi-mechanised rice production systems are efficient as the net energy were positive. Profitability ratios indicated that semi-mechanised rice farming had a better profit margin and gross ratio compared to traditional production system. The net farm income (profit), energy used per ha, energy output per ha and specific energy were higher in semi-mechanized sector than traditional method. However, renewable energy, direct energy, energy productivity and net energy thrived better in traditional method than semi-mechanized unit.

Rice farmers are encouraged to shift to semi-mechanized farming for higher output and increased profitability. Yet, the results of this study also signify that there is need to critically find a way of increasing low energy productivity in both production systems on one hand and increase renewable energy use in semi-mechanize farming on the other hand. Semi-mechanized system should adopt more organic agriculture and soil conservation methods such as crop rotation, mixed cropping and inter cropping to maintain soil fertility, to manage pests and diseases and reduce environmental pollution that emanated from non-renewable inputs. Therefore government policy must promote gradual technology shift to mechanized farming to achieve self-sufficiency in rice production. The study also recommends the introduction of integrated weed management system to reduce the use of herbicide for weed control.

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