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Energy Use Pattern and Economic Analysis of Fluted Pumpkin (*Telfairia occidentalis*) Production in Tillage Methods

Sanusi, B. A. [a], Jekayinfa, S. O. [b], Ibrahim, S. O. [a], Akande, F. B. [b] and Ola, F. A. [b]*

[a] Department of Agricultural and Bio-Environmental Engineering, The Oke-Ogun Polytechnic, Saki, Oyo State, Nigeria.
[b] Department of Agricultural Engineering, Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The study investigates the energy use pattern and economic analysis of fluted pumpkin production in tillage methods (traditional, reduced-conventional and conventional). Human power, machinery, diesel fuel, fertilizers, seed and pesticides energy inputs were used during the cultivation of fluted pumpkin. Input and output energy analysis method was used to estimate the input and output energy in each of the tillage methods during the production of fluted pumpkin. The energy indices of fluted pumpkin production determined were; energy efficiency, energy productivity, specific energy, net energy and energy efficiency index. The economic analysis of fluted pumpkin

**Corresponding author: Email: faola@lautech.edu.ng;*

production in terms of total cost of production, gross monetary return, net monetary return and cost benefit ratio for the three tillage methods used were determined. The total energy required per hectare in traditional, reduced-conventional and conventional tillage methods were 6899.90, 9206.16 and 10176.84 MJ/ha, while the output energy were found to be 8912.48, 12297.8 and 12297.8 MJ/ha, respectively. The energy efficiency, energy productivity and net energy gain of 3.97, 1.50 and 1.20; 0.76, 0.86 and 0.71 MJ/kg; 1.32, 1.20 and 1.40 MJ/ha, respectively were estimated while energy efficiency index were found to be 27, 47 and 20% for traditional, reduced-conventional and conventional tillage methods, respectively. The highest net monetary return and cost benefit ratio of ₦382,000.00k and 3.05 were estimated for reduced-conventional, ₦351, 600.00 k and 2.31 for conventional tillage, while the least values of ₦220, 000.00 k and 2.11 were recorded for traditional tillage method. The result revealed that reduced-conventional tillage was better than both traditional and conventional tillage methods in terms of energy productivity, net energy gain and energy efficiency index. Economically, production of fluted pumpkin under reduced-conventional tillage shows the highest net monetary return and cost benefit ratio compared to the other two tillage methods considered.

Keywords: Energy; fluted pumpkin; tillage; modeling; net energy gain; energy analysis.

1. INTRODUCTION

“Modern agricultural machinery, chemical fertilizers, pesticides and other farm inputs are used extensively in commercial agriculture and thus leading to higher crop yields in the conventional cropping systems. However, commercial agriculture also requires higher energy inputs compared to the organic systems” [1,2]. “Agriculture is both energy consumer and producer” [3]. “Energy is thus increasingly being an important component in production agriculture which must be minimized to enhance profitability” [4,5]. “Therefore, effective and efficient use of energy in agriculture will not only enhance agricultural profitability but will also reduce environmental impacts, prevent damage to natural resources and improve the sustainability of agriculture as an economic production system” [1]. “To meet growing food demand of the increasing population and for export, the productivity of land and labour needs to be increased substantially which would require higher energy inputs and better management of food production systems and this can be achieved through appropriate agricultural mechanization” [6,3]. “Since mechanization is inevitable and it’s associated with an increase in productivity, there is a need to find the most appropriate level of mechanization that minimizes energy consumption, enhance profitability and reduce environmental damage from fossil fuel-related emissions”. [7]

Soil tillage is one of the highest energy and labour consumption in the cultivation of crops and conventional tillage is the mechanical manipulation of the soil with tools and implements for obtaining conditions ideal for seed germination, seedling establishment and growth of crops [8] or modification of the soil structure through mechanization of the system ([9]. “Traditional tillage is the use of crude implements such as cutlass, hoes and other implement for manipulation of the soil surface to create ideal soil conditions for seed germination, reduced-convectional tillage aimed at the reduction in the tillage operations to the minimum necessary for ensuring good seed bed involves the ploughing of experimental land twice before planting whiles conventional tillage involves various energy-intensive tractorized operations during land preparation” [9]. [10] reported that “30% of energy in the field is consumed by tillage and reduce tillage reduces fuel consumption, increases the energy ratio, controls soil erosion, decreases time and energy required for seedbed preparation, while reported that primary tillage practices require 75% of the total energy consumed before seed-time in crop production”.

Fluted pumpkin (*Telfairia occidentalis*) commonly known as *ugu, iroko* or *apiroko, ubong* and *umeke* among the Igbo, Yoruba, Efik, Urhobo and Edo people of Nigeria, respectively [11] is found in the daily diet of most families in Eastern Nigeria and has equally gained wide acceptance in other parts of the country [12]. “Fluted pumpkin can be grown under a wide range of soil conditions. It however prefers loose, friable soil with ample humus and shade. It grows faster in the warm humid tropics, produces edible leaves in the rainy season and at the beginning of the dry season for a period of 6 -10 months. It can be managed as a short-term perennial crop but mainly grown as annuals especially by West

African traditional farmers" [11] and [13]. "The seed produced by the crop contains oil of specific gravity higher than palm oil and it makes good cooking oil and suitable for margarine production" [14]. [12] reported that "the seed has been successfully used in the production of biodiesel and it can also be used to augment the energy and protein requirements of man, especially among rural dwellers". "Fluted pumpkin is widely used in traditional medicine especially as a hematopoietic agent. The ability of the plant to combat certain diseases may be due to its antioxidant and antimicrobial properties and its minerals (especially Iron), vitamins (especially vitamins A and C) and high protein contents, while the seed is also believed to have lactation-promoting properties and is in high demand by nursing mothers" [14] and [15]. "The rind and pulp of the fruit of fluted pumpkin are used as fodder for livestock such as grass cutters, sheep and goats when compared to most common vegetables because of its high protein content. In addition, fluted pumpkin has been a source of income to many subsistence farmers and is an important component of cross-border trade among Nigeria, Cameroon and the Benin Republic, respectively" [16].

In a study conducted by [17] "on energy use and economic analysis of seedy watermelon production for different irrigation systems in Iran, their results showed that the total energy consumed under high input systems was 25635.94 MJ/ha, whereas under low input was 3129.3 MJ/ha and all of the energy indexes were improved in the reduced irrigation system compared to full condition. The economic analysis indicated that higher return was gained by the full irrigation system due to higher yield compared to the reduced irrigation system". Similarly, [18] conducted "an experiment on energy use patterns and energy input-output analysis of some vegetables, namely; tomato, melon and watermelon, widely grown in the Antalya region, which is one of the most important agricultural centers in Turkey. The average yield of the melon and watermelon vegetables was found to be 35,000 $kgha^{-1}$ with energy ratios of 1.9 and 2.0 and specific energies of 0.98 and 0.97 $MJkg^{-1}$, respectively". Relevant data that would be require to provide a more understanding of the current and potential energy consumption pattern and other environmental inputs which would enable decisions to be made with confidence in the study area are not readily available as the study area selected is an important agricultural zone in Oyo State, Nigeria. Given that there is an identified lack of comprehensive data regarding energy consumption on crop production in Nigeria, particularly with the specified study area, this study aimed at energy balance and economic analysis of fluted pumpkin production under different tillage methods.

2. MATERIALS AND METHODS

2.1 Experimental Procedure

Field study was conducted at the seed unit of the Oyo State Agricultural Development Program (OSADEP), Saki West Local Government Council Area of the Oyo North Senatorial District, Oyo State, Nigeria, West Africa, during raining season's farming from April 2019 to July 2021. "Three different tillage methods; Traditional (tillage with hoeing), Reduced-conventional (ploughing with tractor twice) and Conventional (ploughing twice and harrowing once) tillage methods were used. The experimental farm consisted of three treatments and three replicates which were arranged in a complete randomized block design and each tillage method representing a treatment. The experimental site consisted of three blocks and each block consisted of three plots making a total of 9 plots. The experimental farm was measured 46 x 46 m^2, while each block was measured 46 x 10 m^2 and each plot 10 x 10 m^2 with a space of 4 m in between the two adjacent plots which enabled the tractor to turn conveniently without entering manually tilled plots". [7] Two matured pods of fluted pumpkin were obtained from a cucurbit farmer at Ago-Are in ATISBO Local Government Council Area, Oyo North Senatorial District, Oyo State, Nigeria. The pods were manually broken and the seeds extracted and kept under ambient conditions for two days as recommended [16]. The extracted seeds of the fluted pumpkin were then nursed in polythene for a period of 15 days and later transplanted into experimental plots. The experiment was replicated trice.

2.2 Energy Analysis

2.2.1 Energy demand of land preparation in tillage methods

"Land preparation in traditional tillage was carried out manually by using human power with the use of hand tools such as hoes, cutlasses, pick axe and rake. For both reduced-conventional and conventional tillage, the initial land preparation was carried out with a three-bottom disc plough mounted on a New Holland (70866S) tractor model for ploughing operations while harrowing operation was conducted using a disc harrow in conventional tillage. The operating time and the fuel consumed per hectare by the tractor during each operation were recorded and used to compute the energy input. The energy consumed during land preparation in traditional tillage and tractorized operations in both reduced-conventional and conventional tillage's were computed using Equations 1 and 2, respectively" as described by [19].

$$E_P = 3.6(0.075\ NTa) \quad (1)$$

$$E_{lp} = 47.8D + 3.6(0.075\ NTa) \quad (2)$$

Where:

E_p = human Energy consumed in land clearing in reduced tillage (MJ)
E_{lp}= energy consumed in land clearing in reduced-conventional and conventional tillage (MJ)
D = amount of diesel fuel consumed by operation (L)
Ta= useful time spent by a worker per unit operation (min)
N = number of workers involved in the operation.

2.2.2 Energy analysis of other farming operations

All other farming operations such as planting, weeding, fertilizer application, crop protection, fruit gathering, depoding, seed extraction and seed washing in the production of fluted pumpkin under the traditional, reduced-conventional and conventional tillage methods were carried out manually and the energy consumed in each of these operations were computed by using Equation 1 as described by [19].

2.2.3 Energy inputs

The amount of energy consumption from human labour, diesel fuel, machinery, fertilizer, seed and other agrochemical energy inputs were calculated from the multiplication of the quantity of the input energy consumed with their energy equivalent per unit obtained from relevant literature references. The chemical, fertilizer and seed energy inputs were calculated using the expression described in Equations 3, 4 and 5, respectively. The energy equivalents used for calculating input and output energies in the production of fluted pumpkin is presented in Table 1.

$$Chemical\ energy\ input \left(\frac{MJ}{ha}\right) = \frac{Quantity\ (litre) x\ energy\ equivalent}{Applied\ area} \quad (3)$$

$$Fertilizer\ energy\ input \left(\frac{MJ}{ha}\right) = \frac{Fertilizer\ (kg/ha) x\ \%\ NPK}{Cultivated\ area} \quad (4)$$

$$Seed\ energy\ input \left(\frac{MJ}{ha}\right) = \frac{Seed\ (kg/ha) x\ energy\ equivalent}{Cultivated\ area} \quad (5)$$

2.2.4 Energy indices

The energy indices in terms of energy use ratio, energy productivity, specific energy, net energy and percentage energy index in the production of the fluted pumpkin were computed using Equations 6, 7, 8, 9 and 10 [20].

$$ER = \frac{E_O(MJha^{-1})}{E_I(MJha^{-1})} \quad (6)$$

$$EP = \frac{C_Y(kgha^{-1})}{T_{EI}(MJha^{-1})} \quad (7)$$

$$SE = \frac{E_I(MJha^{-1})}{C_O(MJha^{-1})} \quad (8)$$

$$NE = E_O - E_I\ (MJha^{-1}) \quad (9)$$

$$EEI = \frac{E_O - E_I}{E_I} \quad (10)$$

Where: *ER* = energy ratio, $MJha^{-1}$; *EP* = energy productivity, $kgha^{-1}$; *SE* = specific energy, $MJha^{-1}$; *NE* = net energy, $MJha^{-1}$; *EEI* = energy efficiency index, %; E_I = energy input of fuel, seeds, fertilizer, pesticide or farm machinery; MJ/ha and *Eo* = energy output of the harvested crop, MJ/ha.

2.3 Economic Analysis of Fluted Pumpkin Production in Tillage Methods

The economic analysis of fluted pumpkin production under the three different tillage methods were evaluated in terms of the total cost of production, gross and net monetary returns using the method described by [25].

2.3.1 Total cost of production (TCP)

The total cost of production (TCP) of fluted pumpkin production under traditional, reduced-

Table 1. Energy Equivalent of Inputs in Agricultural Production

Input	Unit	Energy equivalent (MJ/kg)	Reference
Human power	MJ/hr	1.97	[20]
Machinery	Kg	69.83	[21]
Hoeing	Kg	1.53	[21]
Tractor	kg	36.49	[22]
plough	kg	22.30	[20]
cultivator	kg	6.20	[20]
Harrow	kg	42.8	[23]
Diesel fuel	l	53.6	
Chemical Fertilizer			
Nitrogen	Kg	47.10	[8]
Phosphorus	Kg	15.80	[20]
Potassium	Kg	9.28	[21]
Seed Pesticides	Kg	0.8-1.7	[21]
Herbicides	Kg	238	[24]
Fungicides	kg	216	[24]
Insecticides	kg	101.2	[24]

conventional and conventional tillage methods were estimated by the addition of the monetary values of all energy inputs during tillage and other farming operations using Equation 11.

$$TCP = C_{hl} + C_{ma} + C_{df} + C_{fz} + C_{sd} + C_{pe} + C_{mc} \quad (11)$$

Where: C_{hl} = human labour cost, C_{ma} = machinery hiring cost, C_{df} = diesel fuel cost, C_{sd} = seed cost, C_{pe} = pesticides cost and C_{mc} = miscellaneous cost.

2.3.2 Gross monetary returns (GMR)

The current prevailing market price of the energy output (yield) of fluted pumpkin in the study area at the time of harvesting was obtained from the Sango Market, Saki, Oyo State, Nigeria and used for the computation of the gross monetary returns. The GMR was calculated from the multiplication of the energy output of the fluted pumpkin by the market price using Equation 12 [25].

$$GMR = Yield\ (kgha^{-1}) \times Market\ price\ of\ the\ yield\ (₦kg^{-1}) \quad (12)$$

2.3.3 Net monetary returns (NMR)

The net monetary return (NMR) for the estimation of economic efficiency of fluted pumpkin production was calculated as the difference between GMR and TCP using Equation 13 [25].

$$NMR = GMR - TCP \quad (13)$$

2.3.4 Cost-benefit ratio (CBR)

The cost-benefit ratio of fluted pumpkin production was calculated using Equation 14 as described by [5].

$$Cost\ Benefit\ Ratio = \frac{Gross\ monetary\ return}{Total\ cost\ of\ production} \quad (14)$$

3. RESULTS AND DISCUSSION

3.1 Energy Analysis

3.1.1 Energy consumed during land preparation in tillage methods

The average energy demand of land preparation in the traditional, reduced-conventional and conventional tillage methods is presented in Fig. 1. Conventional tillage consumed the highest average energy input of 2666.64 MJ/ha, followed by reduced-conventional tillage with a value of 2076.53 MJ/ha, whiles the least average energy value of 237.43 MJ/ha was expended in traditional tillage during land preparation. [9] reported similar trend in average values of 386.20, 2905.42 and 3460.22 MJ/ha, respectively for zero, medium and high level of mechanization in the production of maize. The higher values of energy input recorded during land preparation for both reduced-conventional and conventional tillage was due to high energy rate from the diesel and machinery energy inputs as compared to human energy input rate which was employed in the traditional tillage method for land preparation. Generally, land preparation under traditional tillage has the merit of low energy input but, the amount of time required and the drudgery suffered by farmers are disproportionately high. Timeliness of operation due to high field capacity (accomplishing larger hectare per hour) with reduced drudgery is the main reason for agricultural mechanization [26].

3.1.2 Composition of energy consumption by operations in tillage methods in the production of fluted pumpkin

The percentage composition of energy consumption by operations in tillage methods during the production of fluted pumpkins is presented in Fig. 2 (a-c). For traditional tillage, it was observed (Fig. 2a) that land preparation has the highest percentage value of 30.31%, followed by weeding operation with a value of 18.06 % while harvesting, plant protection, fertilizer application and planting operations has the percentage values of 11.96, 10.87, 9.73 and 9.62 %, respectively and the least value of 9.44 % was estimated during staking operation. For the reduced-conventional tillage presented in Fig. 2b,the highest percentage energy composition value of 43.83 % was also observed during land preparation, followed by fertilizer application with a value of 12.00 % while plant protection, harvesting, weeding and planting recorded percentage values of 11.02, 9.14 8.75 and 8.24 %, respectively, while staking operation has the least percentage energy composition value of 7.02 %. Similarly, the percentage composition of energy consumption by operations in conventional tillage during the production of the fluted pumpkin is presented in Fig. 2c with land preparation having the highest percentage value of 51.27 %, fertilizer application has a value of 10.22 %, while the percentage values of 9.3, 8.5, 8.20 and 7.40 % were observed for harvesting, planting, plant protection and staking operations, respectively and the least value of 5.20 % was observed during weeding operation. Generally, it was observed from the results that land preparation had the highest percentage composition of energy consumption for the three tillage methods considered. This result is in agreement with the finding of [9] who reported energy consumption compositions of 58 % for land preparation, 36 % for ridging, 3 % for weeding, 2 % for fertilizer application and 1 % for planting operations during the modeling of energy demand of tillage methods in the production of maize and also corroborated with the findings of [19]. [27] in a similar study, reported the highest percentage of energy consumption value of 47 % for land preparation, 20 % for fertilizer application and plant protection, weeding, planting and harvesting operations recorded percentage values of 10.0, 8.0, 7.0 and 5.0 %, respectively while the least percentage value of 3 % was recorded during thinning operation.

3.1.3 Anthropogenic energy input ratios in tillage methods in the production of fluted pumpkin

The anthropogenic energy input ratio of fluted pumpkin production under the three tillage methods is presented in Fig. 3. It was observed from the figure that the highest average human power energy input of 823.2 MJ/ha was observed under traditional tillage,

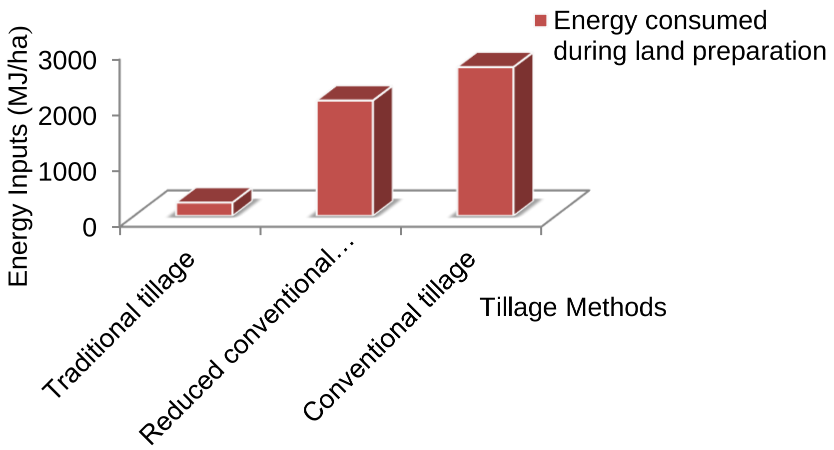
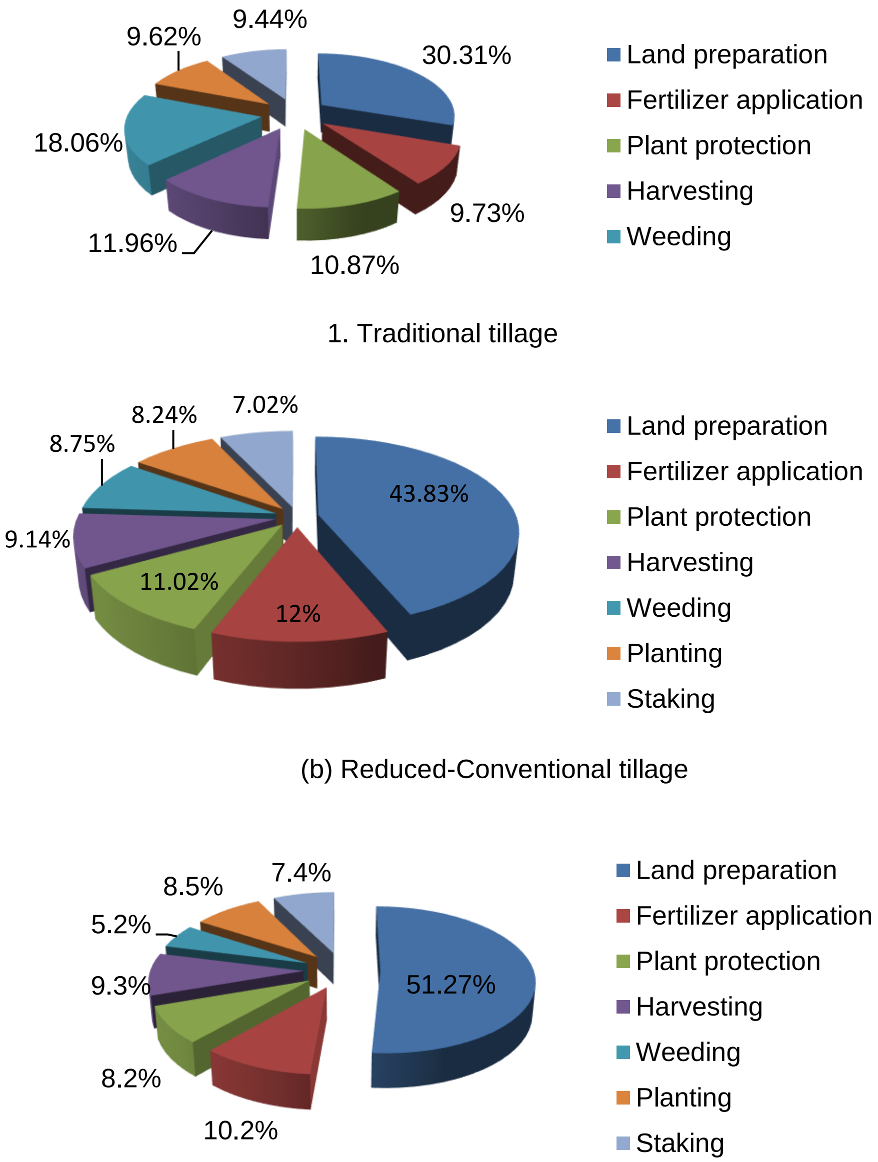


Fig. 1. Average Energy Consumed during Land Preparation in Tillage

followed by conventional tillage with average value of 446.9 MJ/ha, while the least human power energy input of 421.4 MJ/ha was recorded under reduced-conventional tillage. The highest value of anthropogenic energy input ratio recorded in the traditional tillage treatment compared to both reduced-conventional and conventional tillage methods, was due to the fact that land preparation was manually carried out using human energy. Conventional tillage recorded the highest average machinery energy input of 1152.36 MJ/ha, followed by reduced-conventional tillage with a value of 812.36 MJ/ha, while the least average machinery input of 493.46 MJ/ha was obtained in traditional tillage. Furthermore, conventional tillage has the highest diesel fuel energy input with an average value of 2666.56 MJ/ha, followed by reduced-conventional tillage with an average value of 2076.53 MJ/ha, while zero value of diesel fuel was consumed in traditional tillage. Fig. 3 further revealed that the same quantity of fertilizer, seed and pesticides energy inputs with average values of 3009.91, 283.39 and 2120 MJ/ha, respectively were used on yearly basis in the three tillage methods.



1. Traditional tillage

(b) Reduced-Conventional tillage

(c) Conventional tillage

Fig. 2. Composition of Energy Consumption by Operations in Tillage Methods in the Production of Fluted Pumpkin

3.1.4 Input and Output Energy in the production of fluted pumpkin in tillage Methods

The total input and output energies obtained in the tillage methods during the production of the fluted pumpkin is presented in Fig. 4. Conventional tillage has the highest energy input value of 10176.84 MJ/ha with corresponding energy output value of 10223.8 MJ/ha, followed by reduced-conventional tillage with energy input value of 9206.16 MJ/ha and corresponding energy output value of 10115.23 MJ/ha, while the least input and output energy values of 6899.90 and 8912.93 MJ/ha were recorded under traditional tillage. This result is similar to the findings of [28] on economic analysis and relation between energy inputs and yield of greenhouse cucumber production in Iran with total energy input and output values of 10,973.00 and 10,045.06 MJ/ha, respectively and also comparable with the result of [21] who reported an average energy input of 83,126 MJ/ha during the production of corn silage.

3.1.5 Energy Indices of Fluted Pumpkin Production in Tillage Methods

The energy indices of fluted pumpkin production under the three different tillage methods are presented in Table 2. The highest energy ratio value of 3.79 was observed for traditional tillage, followed by reduced-conventional tillage with a value of 1.5, while the least value of 1.2 was observed for conventional tillage.

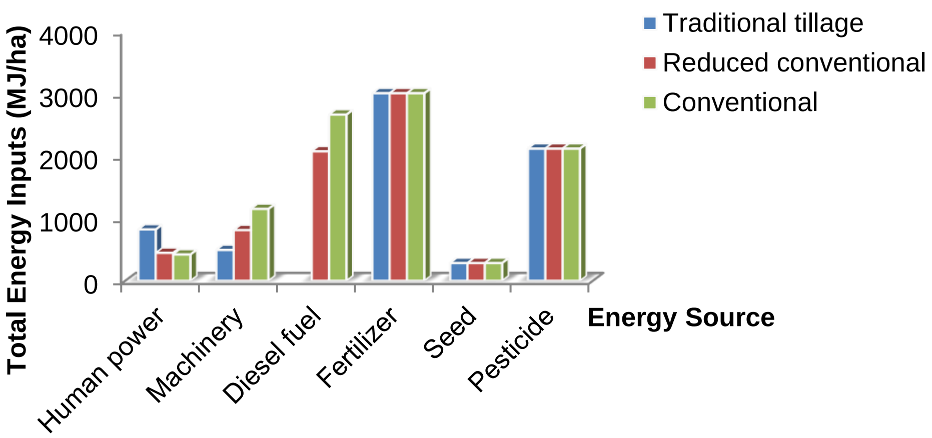


Fig. 3. Anthropogenic Energy Input Ratios in Tillage Methods in Fluted Pumpkin Production

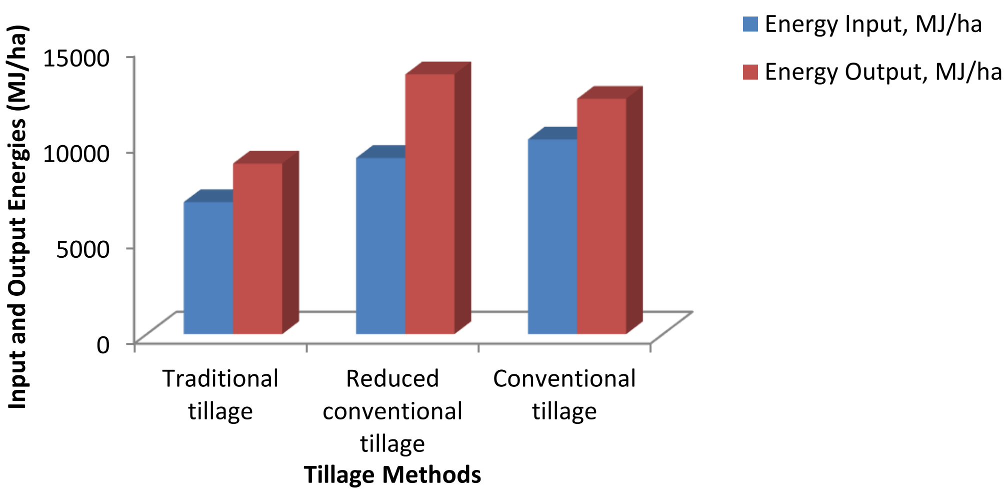


Fig. 4. Input and Output Energy in Tillage Methods in the Production of Fluted Pumpkin

The highest energy productivity value of 0.86 MJ/kg was observed for reduced-conventional tillage. Traditional tillage has a value of 0.76 MJ/kg and the least value of 0.71 MJ/kg of energy productivity was estimated for conventional tillage. The highest specific energy value of 1.40 MJ/ha was observed for conventional tillage, followed by traditional tillage with a value of 1.32 MJ/ha whiles the least value of 1.20 MJ/ha was observed for reduced-conventional tillage. Reduced-conventional tillage has the highest energy gain with a value of 4308.84 MJ/ha, conventional tillage has a value of 2120.96 MJ/ha, whiles the least value of 2013.03 MJ/ha was recorded for traditional tillage. The highest energy efficiency index value of 47% was observed for reduced-conventional tillage, followed by traditional tillage and the least value of 20% of energy efficiency index was estimated for conventional tillage. A number of researchers have reported higher ratio of direct energy than indirect energy and higher rate of non-renewable energy than renewable energy consumption in cropping systems [1], [29] and [30].

3.2 Economic Analysis and Cost-benefit Ratio of the Fluted Pumpkins Production in Tillage Methods

The economic analysis of the fluted pumpkin production in terms of the total cost of production, gross monetary return, net gain and cost-benefit ratio in the different tillage methods are presented in Table 3. The total cost of production and gross monetary returns of ₦208000.00k and ₦198500.00k; ₦156000.00k and ₦481120.00k, and ₦476000.00k and ₦419432.00k were estimated for conventional, reduced-conventional and traditional tillage methods, respectively. The highest net monetary return of ₦320,000.00k was estimated for reduced-conventional tillage, conventional tillage has a sum of ₦273,120.00k whiles the least sum of ₦220,932.00k was realized in traditional tillage. The highest cost-benefit ratio of 3.05 was estimated for reduced-conventional tillage, conventional tillage has a value of 2.31 while the least cost benefit ratio of 2.11 was observed for traditional tillage. Several studies have reported higher ratio of variable cost than fixed cost in cropping systems [19], [31] and [32].

Table 2. Energy Indices of Fluted Pumpkins Production in Tillage Methods

Energy Indices	Tillage Methods		
	Traditional	Reduced-conventional	Conventional
Total Energy Input (MJ/ha)	6899.90	9206.16	10176.84
Yield (kg/ha)	5242.63	7950	7234
Total Energy Output (MJ/ha)	8912.48	13515	12297.8
Energy Ratio	3.97	1.5	1.2
Energy Productivity (MJ/kg)	0.76	0.86	0.71
Specific Energy (MJ/ha)	1.32	1.20	1.40
Net Energy Gain (MJ/ha)	2013.03	4308.84	2120.96
Energy Efficiency Index (%)	29.0	47.0	20.0

Table 3. Economic Analysis and Benefit-Cost Ratio of Fluted Pumpkins in Tillage Methods

Cost and return Components	Unit	Tillage Methods		
		Traditional	**Reduced-conventional**	**Conventional**
Yield	$kgha^{-1}$	5242.90	5950.00	6014.00
Sale price	₦kg^{-1}	80.00	80.00	80.00
Total cost of production	₦ha^{-1}	198500.00	156000.00	208000.00
Gross monetary return	₦ha^{-1}	419432.00	476000.00	481120.00
Net monetary return	₦ha^{-1}	220932.00	382000.00	351600.00
Cost-benefit ratio		2.11	3.05	2.31

4. CONCLUSIONS

This study investigated the energy use pattern and economic analysis of fluted pumpkin (*Telifaira occidential*) production in the traditional, reduced-conventional and conventional tillage methods in Saki West Local Government Council Area, Oyo State, Nigeria. Based on the study, the results obtained can be summarized as follows:

1. Conventional tillage method consumed the highest energy input value of 10176.84 MJ/ha, followed by the reduced-conventional tillage with a value of 9206.16 MJ/ha, whiles the least value of 6899.90 MJ/ha of energy input was observed for traditional tillage method.
2. Reduced-conventional tillage method has the highest output energy value of 13575 MJ/ha, followed by the conventional tillage with a value of 12297.8 MJ/ha whiles the least value of 8912.48 MJ/ha was observed for traditional tillage method.
3. Traditional tillage method has the highest energy ratio value of 3.97, followed by reduced-conventional tillage with a value of 1.5 and the least value of 1.2 was observed for conventional tillage method.
4. Reduced-conventional tillage method has the highest energy productivity value of 0.86 MJ/kg, traditional tillage has a value of 0.76 MJ/kg and the least value of 0.71 MJ/kg was estimated for conventional tillage method.
5. The highest net energy gain value of 4308.84 MJ/ha was observed for reduced-conventional tillage, followed by conventional tillage with a value of 2120.96 MJ/ha and the least value of 2013.93 MJ/ha was recorded for traditional tillage method.
6. Reduced conventional tillage has the highest cost benefit ratio of 3.05, followed by conventional tillage with a value of 2.31, while the least cost benefit ratio of 2.11 was observed for traditional tillage method.

The experiment result showed that reduced-conventional tillage method is more energy saving and economical when compared with both conventional and traditional tillage methods for the production fluted pumpkin and other similar crops in the study area.

5. RECOMMENDATIONS

Energy analysis is fundamental in defining and classifying agricultural production systems in terms of energy consumption pattern, while the management of energy is important in terms of efficient, sustainable and economic use of energy [20]. Therefore, based on the results obtained from this study, an integrated approach in the analysis of the amount of energy input in various operations in the production of pumpkin and other similar crops in the study area is recommended for further study [33].

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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