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Energy Bill on Cassava Production Under Barangay Kandaga, Talipao, Sulu Condition, Philippines

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***Abstract*: The aim of the research is to gather findings on the energy bill of one of the important crop or commodity in the Province, in the Philippines as well as worldwide, it is situated at approximately 5.9930, 121.1035, in the island of Jolo. Elevation at these coordinates is estimated at 143.4 meters or 470.5 feet above mean sea level and 23 kilometers away from the down town of Jolo, Sulu. The information produced could be of great help to the local and national government with the collaboration of the different sectors for possible implementation of agricultural policy that lead to more efficient energy usage. The total energy inputs on cassava production at 2,273.41 Mcal ha^{-1} (199.18 LDOE ha^{-1}). Lowest energy inputs is obtained by harvest and pre-harvest activities with 629.25 Mcal ha-1 (55.13 LDOE ha^{-1}), of this total, DEI, IEI, EEI contributed 93.19%, 6.26%, 0.56%, while the Crop Establishment at 814.51 Mcal ha^{-1} (71.36 LDOE ha^{-1}), the DEI, IEI, EEI contributed 4.65%, 0.54%, 56.51, 38.84%, the pre-land Preparation got the highest energy inputs at 829.65 Mcal ha^{-1} (72.69 LDOE ha^{-1}), of this total, DEI, IEI, EEI contributed 62.15%, 37.46%, 0.40%, Within the whole activity in cassava production, the value for DEI, IEI, EEI ranged from 0.56% - 93.19%, 4.65% - 56.51%, 0.40% - 62.15%, respectively. The harvest and pre-harvest activity obtained the EnROEI of 5.06 Mcal ha^{-1}. The energy hotspot was obtained by the direct energy inputs. Pre-land preparation obtained 62.15% energy share, while hauling and transport activity marked as the energy hotspot among activities with 93.19% energy share. With the energy productivity (EP) of 6.68Mcal ha^{-1}, and obtained the net energy (NE) of 13,136.59Mcal ha^{-1}. The high net energy was attributed by high energy output and low in energy inputs. Among the entire activities on cassava production the crop management obtained no data this was due to no activities implemented on these particular activities such as application of insecticide, fungicide and herbicide.**

***Keywords*: energy inputs, energy hotspot, net energy, total energy inputs.**

1. Introduction

The large source of greenhouse gas (GHG) emissions and has large energy requirements is from Agriculture, such as seed, manure and animate energy, as well as commercial energies, directly and indirectly, in the form of diesel, electricity, fertilizer, plant protection, chemical, irrigation water, machinery etc. Efficient use of these energies helps to achieve increased production, productivity and contributes to the profitability and competitiveness of agricultural sustainability in rural living (Singh et al., 2002). Previous research has shown that organic farming and conservation tillage practices can reduce environmental impacts from agriculture. Our results indicate that organic management consistently had lower energy use than conventional management on an area basis, but not when expressed on a crop yield basis (Hoffman, 2018).

On the other hand, Cassava (*Manihot esculenta*), also called manioc, tapioca or yuca, ranks very high among crops that convert the greatest amount of solar energy into soluble carbohydrates per unit of area. Among the starchy staples, cassava gives a carbohydrate production which is about 40% higher than rice and 25% more than maize, with the result that cassava is the cheapest source of calories for both human nutrition and animal feeding. A typical composition of the cassava root is moisture (70%), starch (24%), fiber (2%), protein (1%) and other substances including minerals (3%).

More than two-thirds of the total production of cassava is used as food for humans, with lesser amounts being used for animal feed (Nwokoro et al. 2002) and industrial purposes. The future demand for fresh cassava may depend on improved storage methods, but the markets for cassava as a substitute for cereal flours in bakery products and as energy source in animal feed rations are likely to expand.

The energy that is being utilized such as input/output relationships in cropping systems vary with crops being grown in sequence, by type of soils, nature of tillage operations for seedbed preparation, nature and amount of chemical fertilizer, plant protection measures, harvesting and threshing operations and, finally, yield levels (Mandal KG et al.,2002). It is realized that crop yields and food supplies are directly linked to energy (Onal I et al., 1986).

Other research findings revealed that diversifying grain cropping systems to include perennials was a more effective

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Table 1
Energy coefficient of various farm inputs and outputs

Particulars	Unit	Energy Equivalent Per Unit		References
		MJ	Mcal	
A.) INPUTS				
Cuttings		3.6	0.86	Demerirean et al, 2006
Long purple Eggplant seed	kg	1.0	0.24	Singh, 2002
AGROCHEMICALS:				
a) Herbicide (gyphosate)	Lit	553.07	132.19	Pimentel, 1980a; Barber, 2004
b) Herbicide (Gen.), ave.	Lit	274	65.5	Saunders et al., 2006; Gundogmus, 2006
c) Insecticide (solid)	kg	315	75.29	Wells, 2001; Saunders et al., 2006
d) Insecticide (liquid), ave.	Lit	281. .32	67.24	Pimentel, 1980a; Gundogmus, 2006
e) Fungicide (solid)	kg	210	50.2	Wells, 2001; Saunders et al., 2006
f) Fungicide (liquid), ave.	Lit	104.1	24.88	Gundogmus, 2006, Pimentel, 1980a
CHEMICAL FERTILIZERS				
a) Nitrogen	kg	102.23	24.43**	Lockeretz, 1980, Rodolfo, 2008, Mendoza, 2014
b) Phosphate (P205), ave.	kg	20.6	4.92	91 Lockeret2, 1980, , Rodolfo, 2008, Mendoza, 2014, Safa et al, 2011
c) Potassium (K20), ave.	kg	16.38	3.91	91 Lockeret2, 1980, Pimentel 1980, Mendoza, 2014, Safa et al, 2011
FUEL				
a) Gasoline	Lit	42.32	10.11	Kitani, 1999
b) Diesel fuel	Lit	56.31	13.46**	Mohammadi et al, 2008, Erdal et al., 2007
LABOR				
a) Human labor	Hr	1.96	0.47	Yilmaz et al, 2005: Kazemi et al., 2015
b) Draft animal	Hr	12.01	2.87	Nassiri and Singh, 2009, Gliessman, 2015
STEEL/METAL	Kg	75.31	18	Pimentel, 1980a
Output Cassava (fresh)	Kg	5.6	1.34	Isaac Bangboye and Babajide S. Kosemani, 2015, Demerirean et al, 2006

* The energy for production of Glyphosphate is 440 MJ per Kg, the formulation and packaging, and transportation is 113.03 MJ per Kg. In: Savuth, 2018.
** Estimates include the drilling processing, storage and transport to sit of utilization (Rodolfo, 2008; Mendoza, 2014).
*** Estimates include the processing, storage and transport to site of utilization (Rodolfo, 2018ab).

management strategy than organic management per se to reduce energy use and GHG emissions in agriculture (Hoffman, 2018). Thus, efficient use of energy in agriculture will minimize environmental problems, prevent destruction of natural resources, and promote sustainable agriculture as an economical production system (Dalgaard et al. 2001). Since only few studies was encountered on the efficiency of energy use in cassava production and optimization of energy inputs especially none at all in BARMM areas, the researcher would like to determine the energy bill in cassava production in barangay Kandaga, Talipao, Sulu.

2. Materials and Methods

A. Study Site

The study was conducted at barangay Kandaga Talipao, Sulu. Kandaga is situated at approximately 5.9930, 121.1035, in the island of Jolo. Elevation at these coordinates is estimated at 143.4 meters or 470.5 feet above mean sea level and 23 kilometers away from the down town of Jolo, Sulu.

B. Study Design

The study was conducted using purposive sampling method and the respondents were the farmers engaging in cassava production. Proper documentation was observed. The data was analyzed through inferential statistics this is to compare the energy inputs and outputs and the adoption of work of Elderico P. Tabal, Ph. D. and Teodoro C. Mendoza, Ph. D.

C. Energy Consumption Determination

To account the Indirect Energy Inputs (IEI) are based in the following activities such as Pre-planting activity, Crop establishment activity, Crop care and management activity and Post-harvest activity. The Pre-planting activity is basing on purchasing and hauling of farm inputs while the Crop establishment activity is based from activities such as plowing, harrowing, furrowing and planting. The crop care and management activity is based from weeding. For post-harvest activity is based from the activities such as harvesting, hauling, loading, transporting the harvest into the market/consumer. To derive the energy inputs the researcher adopted the questionnaire from the work of Elderico P. Tabal, Ph. D. and Teodoro C. Mendoza, Ph. D.

D. Energy Consumption Computation

The procedure of computation of energy consumption and energy equivalent coefficient was based on the work of Tabal and Mendoza (2019), Mendoza (2011), Pimentel (2009), Pimentel (1980), Flores et al (2016), Nabavi-Pelesaraei et al (2013), Djauhari et al. (1988), Tripathi and Sah (2001), eer Organization (1990), Wilcke and Chaplin, (2000), NASS, (2003, Pimentel and Pimentel, (1996).

The energy consumption is indicated in Mcal were converted into Liter Diesel Oil Equivalent (LDOE), according to Pimentel et al (1980a) and adopted from the work of Tabal et al. (2019) 1.0 LDOE is equal to 11.414 Mcal unit^{-1} in order to have a common and easy to understand by the readers.

E. Data Analysis

The study was analyzed using mean, percentage and equations that was adapted from the works of Tabal and Mendoza, 2020.

3. Results

The total computed energy inputs (TEI) applied on cassava

Table 2
Summary of the Total Energy Inputs (TEI), Mcal ha^{-1} of different types of labor applied on cassava production

Type of Labor	DEI		IEI		EEI		TEI
	Total Mcal ha^{-1}	%	Total Mcal ha^{-1}	%	Total Mcal ha^{-1}	%	Total
I. Pre-Land Preparation	515.61	62.15	310.76	37.46	3.28	0.40	**829.65**
II. Crop Establishment	37.91	4.65	460.26	56.51	316.34	38.84	**814.51**
III. Crop Management	–		–		–		
IV. Harvest and Pre-Harvest	586.38	93.19	39.36	6.26	3.51	0.56	**629.25**
Total Energy Inputs	**1139.9**		**810.38**		**323.13**		**2,273.41**

Table 3
Direct Energy Inputs (DEI) Mcal of types of labor applied on cassava production

Direct Energy Inputs (DEI) MCAL HA^{-1}			
Type of Labor	Tractor Mcal ha^{-1}	Tamaraw jeep Mcal ha^{-1}	DEI Total
I. Pre-Land Preparation			
a. Purchase of inputs		515.61	515.61
Total			**515.61**
II. Crop Establishment			
a. Land Preparation			
1. Plowing	37.91		37.91
Total			**37.91**
III. Crop Management	–	–	–
TOTAL			
IV. Harvest and Pre-Harvest			
Hauling & Transport		586.38	**586.38**
TOTAL DEI			**1,139.9**

Table 4
Embedded Energy Inputs of different types of labor applied on cassava production

EMBEDDED ENERGY INPUTS (DEI) MCAL HA^{-1}						
Type of Labor	Moldboard	Tamaraw Jeep	bolo	Scythe	Harrow board	EEI Total
I. Pre-Land Preparation						
a. Land clearing				0.15		0.15
c. Purchase of inputs		3.13				3.13
Total						**3.28**
II. Crop Establishment						
1. Plowing	312.98					312.98
2. Harrowing					3.32	3.32
b. Planting						
c.Weeding			0.04			0.04
Total						**316.34**
III. Crop Management						
Insecticide						
Total						
IV. Harvest and Pre-Harvest						
Harvest				0.38		0.38
Transport		3.13				3.13
TOTAL						**3.51**
Total Embedded Energy Inputs						**323.13**

production in Barangay Kandaga is shown in Table 2.

The total computed energy inputs on cassava production are 2,273.41 Mcal ha^{-1} (199.18 LDOE ha^{-1}). Lowest energy inputs is obtained by Harvest and Pre-Harvest activities with 629.25 Mcal ha^{-1} (55.13 LDOE ha^{-1}), of this total, DEI, IEI, EEI contributed 93.19%, 6.26%, 0.56%, while the Crop Establishment got in middle of the two activities at 814.51 Mcal ha^{-1} (71.36 LDOE ha^{-1}), the DEI, IEI, EEI contributed 4.65%, 0.54%, 56.51, 38.84%, the pre-land Preparation got the highest energy inputs at 829.65 Mcal ha^{-1} (72.69 LDOE ha^{-1}), of this total, DEI, IEI, EEI contributed 62.15%, 37.46%, 0.40%, Within the whole activity in cassava production, the value for DEI, IEI, EEI ranged from 0.56% - 93.19%, 4.65% - 56.51%, 0.40% - 62.15%, respectively. Among the entire activities on cassava production the crop management obtained no data this due to no activities implemented on this particular activity such as application of insecticide, fungicide and herbicide.

In table 3 revealed the direct energy inputs in the cassava production. The computed direct energy input includes; Diesel and Gasoline that used as fuel for Tamaraw-Jeep while purchasing of inputs and hauling and transport during harvesting, tractor during the land preparation. The lowest direct energy inputs were obtained from the activities on crop establishment with 37.91 Mcal ha^{-1} (3.32 LDOE ha^{-1}) followed by the activities in crop establishment obtained 515.61 Mcal ha^{-1} (45.17 LDOE ha^{-1}) were next to lowest direct energy inputs, while the harvest and pre-harvest obtained the highest direct energy inputs at 586.38 Mcal ha^{-1} (51.37 LDOE ha^{-1}). Among the entire production system, the direct energy inputs for crop management obtained no data, this was attributed from lack of activities implemented on the production system.

In table 4 showed the embedded energy in cassava

Table 5
Indirect Energy Inputs (IEI) Mcal ha^{-1} of different activities applied on cassava production

Indirect Energy Inputs (DEI) MCAL HA^{-1}					
Type of Labor	UNIT	Cuttings	Animal labor	Human labor	Total
I. Pre-Land Preparation					
a. Land clearing	hr			94	94
b. Cuttings	kg	215			215
c. Purchase of inputs	hr			1.76	1.76
TOTAL					**310.76**
II. Crop Establishment					
a. Land Preparation					
1. Plowing	hr			3.76	3.76
2. Harrowing	hr		88.96	15.04	104
b. Planting				188	188
c. Weeding	hr			164.5	164.5
TOTAL					**460.26**
III. Crop Management					
Insecticide	hr	–	–	–	–
TOTAL					
IV. Harvest and Pre-Harvest					
Harvesting	hr			37.6	37.6
Hauling and Transport	hr			1.76	1.76
Total					**39.36**
Total Indirect Energy Inputs					**810.38**

Table 7
Total Energy Output (Mcal ha^{-1})

Total Energy Output (Mcal ha^{-1})						
Type of Activity	TEI Mcal ha^{-1}	OUTPUT Kg ha^{-1}	TEO Mcal ha^{-1}	EnROEI Mcal ha^{-1}	EP Mcal ha^{-1}	NE Mcal ha^{-1}
Crop Establishment	**2273.41**	**11,500**	**15,410**	**5.06**	**6.68**	**13,136.59**

production. The lowest embedded energy inputs as computed in the table obtained by the pre-land preparation with the total EEI of 3.28 Mcal ha^{-1} (0.29 LDOE ha^{-1}) followed by the harvest and pre-harvest at 3.51 Mcal ha^{-1} (0.31 LDOE ha^{-1}) means the second lowest EEI in the cassava production, and the highest EEI were obtained by the crop establishment with a total of 316.34 Mcal ha^{-1} (27.72 LDOE ha^{-1}). The results also revealed that in the crop management activity obtained no data due to no activity applied in the production system.

In table 5 showed the indirect energy inputs (IEI) in cassava production. The basis of computations includes the human labor performing the purchase of inputs, land clearing, cuttings, plowing, harrowing, weeding, harvesting and hauling & transporting of crops. The lowest IEI in cassava production obtained by harvest and pre-harvest activities with the total of 39.36 Mcal ha^{-1} (3.45 LDOE ha^{-1}) followed by pre-land preparation obtained the IEI with a total of 310.76 Mcal ha^{-1} (27.23 LDOE ha^{-1}) and the highest IEI with 460.26 Mcal ha^{-1} (40.32 LDOE ha^{-1}) were obtained by the crop establishment. In the absence of activities on crop management the researchers were not able to acquired data indirect energy inputs on this particular activity.

Table 6
Energy Hotspot (Mcal ha^{-1})

Direct Energy Inputs		
Type of Activity	Diesel	%
Pre-Land Preparation	515.61	62. 15
Harvest and Pre-Harvest	586.38	93.19

Table 6 showed the energy hotspot in the production of cassava. The energy hotspot is the activities and practices that need high energy inputs in the production of many crops or particular crops in its stages of growth. Direct energy inputs activity has the highest total energy inputs as being computed and discussed in the tables previously. Pre-land preparation obtained 62.15% energy share, hauling and transport activity marked as the energy hotspot in the production of cassava among activities with 93.19% energy share. As shown in the table, the used of fuel is very crucial in accounting energy, in order the crops be transported to the market fuel must be available for the vehicle.

In the cassava production system particularly in the harvest and pre-harvest activity obtained the EnROEI of 5.06 Mcal ha^{-1}, EnRoei is used to measure the required amount of energy intended to produce goods or foods. To determine EnRoei, it is the total economic yield in the unit of kilogram per hectare divided by total energy inputs (TEI). The energy productivity (EP) was computed to determine the energy equivalent yield; it is the ratio of total energy output (TEO) divided by total energy inputs (TEI). The energy productivity (EP) in cassava production obtained the energy productivity of 6.68Mcal ha^{-1}, lastly, the net energy in cassava production obtained the net energy (NE) of 13,136.59Mcal ha^{-1}, it is the result total energy output (TEO) subtracted with the energy inputs (TEI). The high net energy was attributed by high energy output and low in energy inputs.

4. Discussion and Conclusion

The total computed energy inputs on cassava production are 2,273.41 Mcal ha^{-1} (199.18 LDOE ha^{-1}). Lowest energy inputs is obtained by Harvest and Pre-Harvest activities with 629.25 Mcal ha^{-1} (55.13 LDOE ha^{-1}), while the Crop Establishment got in middle of the two activities at 814.51 Mcal ha^{-1} (71.36 LDOE ha^{-1}), the pre-land Preparation got the highest energy inputs at

829.65 Mcal ha^{-1} (72.69 LDOE ha^{-1}). The variation is caused majorly by the different amount of biological energy input, chemical energy input and difference in method of equipment acquisitions. Tractor and Tamaraw jeep used in the cassava production in this region were obtained through rental. The distance the tractor has to travel to get to the farm and the fuel used in transporting the tractor down to the farm was accounted for.

High energy input was attributed to high amount of fuel used in transporting the tractor to the storage to the experimental site for plowing and harrowing, and Tamaraw jeep for transporting outputs from experimental site to market and purchasing cuttings (seedlings).

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