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ENERGY USE AND GROSS MARGIN ANALYSIS FOR SESAME PRODUCTION IN ORGANIC AND INORGANIC FERTILISER USER FARMS IN NIGERIA

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ABSTRACT

As the negative impacts of energy by-products affect the climate, the knowledge and efficient use of energy in crop production will minimise environmental problems and promote sustainable agriculture as an economic production system in Nigeria and else where. The aim of the study was to evaluate energy use and gross margin estimate between sesame (*Sesamum indicum*) production using organic and inorganic fertilisers in North-central Nigeria. A sample of 120 sesame farmers comprising of 60 organic and 60 inorganic fertilisers user-farmers was used. A structured questionnaire was used in data collection. The results show that the total energy input expended in the production of sesame using organic and inorganic fertilisers were 2,377 and 2,960 MJ ha^{-1} respectively. Diesel and labour energy inputs dominated the total energy inputs for the two systems. The energy outputs obtained were 13,900 and 15,000 MJ, respectively. Renewable energy input utilisation was higher (50%) in organic than in inorganic fertilised farms (24%). Energy efficiency and productivity was higher in organic than inorganic sesame farms by 14 and 13%, respectively. The gross margin earned per hectare by organic fertiliser user- farmers was lower by only 5% than that of inorganic fertiliser farmers; but returns on investments were equal at (US$0.02). Hence, since organic farms were more energy efficient and productive, and returns on investment was equal, it is recommended that sesame production using organic fertiliser should be encouraged across Nasarawa State in Nigeria, for environmental and income sustainability.

Key Words: Energy- efficiency, sesame

RÉSUMÉ

Etant donné que des impacts négatifs des sous produits énergétiques affectent le climat, la connaissance et l'utilisation efficiente de l'énergie en production agricole pourra minimiser les problèmes environnementaux et promouvoir une agriculture durable en tant que système de production économique au Nigeria et ailleurs. L'objet de cette étude était d'évaluer l'utilisation de l'énergie et l'estimation de la marge brute entre la production de la sesame (*Sesamum indicum*) en utilisant des fertilisants organiques et inorganiques dans la partie Nord centrale du Nigeria. Un échantillon de 120 fermiers de sesame comprenant 60 fermiers utilisateurs des fertilisants organiques et 60 utilisateurs des fertilisants inorganiques était considéré. Un questionnaire structuré était utilisé lors de la collecte des données. Les résultats montrent que l'énergie totale dépensée dans la production de la sesame à travers les fertilisants organiques et inorganiques était de 2,377 et 2,960 MJ ha-1 respectivement. L'énergie en diesel et la main d'oeuvre ont dominé le total d'énergie produite dans les deux systèmes. Le rendement énergétique obtenu était de 13,900 et 15,000 MJ, respectivement. La production de l'énergie renouvelable utilisée était plus élevée (50%) dans des fermes avec fertilisants organiques que celles avec des fertilisants inorganiques (24%). L'efficacité énergétique et la productivité était plus élevée dans des fermes à sesame avec fertilisants organiques (14%) que dans celles avec fertilisants inorganiques (13%). La marge brute acquise par hectare par les fermiers utilisateurs des fertilisants organiques était plus basse d'environ 5% que celle des fermiers utilisant des inorganiques;

mais les bénéfices sur les investissements étaitent égaux à US$0.02. Ainsi, parce que les fermes organiques étaient plus énergétiquement efficientes et productives, et le bénéfice sur investissements égal, la production de la sesame par les fertilisants organiques pourrait être encouragée à travers tout le pays pour la durabilité de l'environnement et le revenue.

Mots Cles: Energie- efficacité, sesame

INTRODUCTION

Nigeria is a major exporter of sesame, which rated second to cocoa in export volume. Sesame from Nigeria is exported to markets in North America, Europe and East Asia. Benue and Nasarawa States are the major sesame producers in Nigeria with annual outputs of not less than 40,000 metric tonnes each per *annum* (Raw Materials Research and Development Council, 2004).

Sesame production relies on renewable and nonrenewable energy resources, such as fossil fuels, organic and inorganic fertilisers as well as human and animal labour. According to Ziesemer (2007), energy consumption is gaining attention on a global scale, as dwindling fossil fuel stores inspire exploration of renewable energy sources and as the negative impacts of energy by-products begin to affect the climate.

The method of agricultural production, whether organic or conventional, modern or traditional, mechanised or non-mechanised, determines to a large extent the amount of energy used in cultivation of crops including sesame. In Nigeria, like in other developing countries, there is lack of data on energy expenditure and returns in crop production (Abubakar and Ahmed, 2010). Even though much attention is not given to the knowledge about energy expenditure in crop production, the energy-agriculture relationship is becoming very important in view of an increasing demand for food production to meet the pressure from an ever-increasing population.

Energy is used not only in planting, cultivating and harvesting of crops and animals but also in the manufacture and transport of inputs such as pesticides, fertilisers, machinery, and in processing, packaging and distribution of final product. Agriculture and food systems play an important role in fossil fuel consumption and climate change because of their significant energy use and because of agriculture's potential to serve as a sink for the negative externalities of energy use and a source for renewable energy (Ziesemer, 2007). In addition, efficient use of the energy resources is vital in terms of food production for an increasing population, improving the productivity, competitiveness as well as sustainability of agriculture (Hatirli *et al.*, 2006). The share of energy in agricultural production expenses varies widely by activity, production practice and locality (Erdal *et al.*, 2007). The knowledge and efficient use of energy in crop production will minimise environmental problems and promote sustainable agriculture as an economic production system in Nigeria and else where.

The high cost of inorganic fertiliser, their non-availability at the right time, adulteration associated with them, and other set backs such as decreasing soil productivity leading to nutrient imbalance, imply that farmers would find an alternative in the use of organic fertilisers in crop production particularly for less-nutrient demanding crops like sesame. The amount of income from and sustainability of crop production are the major factors for consideration among farmers in chosen a method of agricultural production.

Several studies in Nigeria (Rahman *et al*., 2002; Aruna and Ibrahim, 2004; Haruna *et al*., 2009; Umar *et al*., 2010) reported an impressive performance for organic fertiliser in crop production. However, none of these studies examined the performance of organic and inorganic fertilisers in terms of energy efficiency and productivity. The knowledge about energy use in agriculture is very essential as it can be used by policy makers for developing sustainable food production systems for countries. Furthermore, it provides additional empirical data for making comparison among different crops in terms of energy use. The only available study on energy analysis in crop production in Nigeria is the study by Abubakar and Ahmed (2010) on energy consumption patterns in millet production in North –western Nigeria. This study sought to evaluate the technical and economic of energy use efficiency and productivity in sesame production in farms using organic and inorganic fertilisers in Nigeria.

MATERIALS AND METHODS

The study was conducted in Nasarawa State in North-central Nigeria during 2009/2010 cropping season. The state with a land mass of 12000 km^2, lies between latitude 7° and 9°N and longitude 7° and 10°E. Its mean temperature range from 25 to 36 °C and rainfall varies from 1310.73 mm in some places to 1450 mm in others.

Multi-stage sampling technique was used for selecting respondents for this study. The first stage of sampling involved a random selection of two Local Government Areas from each of the three Agricultural Zones of the State. In the second stage of sampling, two communities were randomly selected from each of the six Local Government Areas. Finally, five organic and five inorganic fertilisers-user-farmers were purposively selected from each of the communities. The reason for purposive selection was to ensure easy identification of target farmers. Thus, the sample size for this study was 120 sesame farmers; made up of 60 organic and 60 inorganic fertilisers user- farmers.

The primary data were collected through field survey using a structured questionnaire. The primary data focused on input-output variables such as output of sesame, quantity and type of farm inputs used: seeds, fertilisers (manure or NPK), pesticides, man labour, land area cultivated, diesel oil and tractor power.

The energy equivalent of inputs and output of sesame production using organic and inorganic fertilisers were derived from the following sources (Table 1).

The common chemical fertilisers used in the study area were NPK 15:15:15 (that is a mixture of N, P and K combined in a ratio of 15:15:15 and urea packaged in a 50 kg bag. According to Hatirli *et al*. (2006) and Erdal *et al.* (2007), the energy equivalent of a unit of elemental N, P and K was 66.14, 12.44 and 11.5 MJ kg^{-1}, respectively. According to Kang (1995), a bag (50 kg) of NPK 15:15: 15 contains 7.5 kg of N, P and K each. Hence the total energy equivalent of NPK 15: 15:15 in a 50 kg bag is 672.975 MJ. A unit energy equivalent of per kg of NPK 15:15:15 is 13.5 MJ.

Energy use efficiency, energy productivity and gross margin analysis were estimated as follows:

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

$$\text{Energy productivity} = \frac{\text{Output of sesame (kg ha}^{-1}}{\text{Energy input (MJ ha}^{-1})}$$

Gross margin (Gm) = GI – TVC

Where;

Gm = Gross margin (US$ ha^{-1})

TABLE 1. Energy equivalent of inputs and output in agricultural production

Variables	Unit	Energy equivalent (MJ $unit^{1}$)	References
Human labour	(h)	01.96	Erdal *et al*., 2007; Akpinar*et al*., 2009
Machinery	(h)	62.70	Erdal *et al*., 2007; Akpinar*et al*., 2009
Pesticides	(Lt)	10.00	Abubakar and Ahmed, 2010
Manure	(kg)	0.30	Hatirli *et al*., 2006; Erdal *et al*., 2007
Diesel oil	(Lt)	56.31	Erdal*et al*.,2007; Akpinar *et al*., 2009
Sesame seed	(kg)	15.2	Akpinar *et al*., 2009
Sesame yield	(kg)	25.0	Akpinar *et al*., 2009
Fertiliser			
(NPK 15:15:15)	(kg)	13.5*	

*Refer to last paragraph under Materials and Method column 2

GI = Gross income (US$ ha^{-1})
TVC = Total variable cost (US$ ha^{-1}) which include:

Seeds (US$ kg^{-1}); labour (US$ $man\text{-}hour^{-1}$); fertilisers (animal manure or NPK) (US$ kg^{-1}) and pesticides (US$ lt^{-1}).

RESULTS AND DISCUSSION

Energy inputs and outputs for sesame production. The total energy expenditure and returns per hectare of sesame production using animal manure (organic fertiliser) and NPK fertiliser (inorganic fertiliser) are shown in Tables 2 and 3. A total of 2,377 MJ of energy input was used in production per hectare for organic fertiliser, against 2,960 MJ for the inorganic fertiliser. This shows that energy input required in production of sesame using inorganic fertiliser is higher by 20% than using organic fertiliser, though the difference is not significant statistically. Diesel and human labour constituted major sources of energy inputs for both technologies (organic and inorganic fertilisers) as they contributed 43, 28, and 38, 19.7% of total energy inputs, respectively.

Machine power was used for tillage operation by few farmers (18 and 27% in both categories of respondents) due to the high cost of hiring (on average, \$40 ha^{-1}) and unavailability of tractors in the study area. The amount of labour energy input used for routine practices (seed planting, fertiliser application, spraying of pesticides and weeding), accounted for the dominant share (34 and 31%) in the total labour energy input used in organic and in inorganic fertilised farms, respectively.

Energy output of sesame production per hectare using organic and inorganic fertilisers were 13,900 and 15,000 MJ, respectively. This shows an increased of 7% over energy output from organic fertilised sesame farms.

The energy output/input ratio (energy efficiency) for sesame production per hectare using organic fertiliser was 5.8, against 5 for

TABLE 2. Energy input and output for Sesame production using organic fertiliser

Variable	Qty ha^{-1}	Energy equivalent (MJ)	%
Human labour (h)			
Land clearing/ridging	96.0	188.2	28.0
Cultural practices	116.0	227.4	34.0
Harvesting	77.0	150.9	23.0
Threshing and bagging	51.0	100.0	15.0
Total labour input	340.0	666.5	100.0 (28.0)
Machinery (h)			
Tillage	02.5	156.8	6.6
Organic fertiliser (kg)			
Manure	1381.0	418.6	17.6
Pesticides (lt)	1.5	15.0	0.6
Diesel (lt)	18.0	1,014.0	42.7
Sesame seed (kg)	7.0	106.0	4.5
Total energy input (MJ)		2,377.0	100.0
Yield (kg)	556.0	13,900.0	
Energy output/input ratio		5.8	
Energy productivity (kg MJ)		0.23	

Figure in parenthesis represents percentage share of total labour energy input in the total energy input inorganic fertilised sesame farms. Energy productivities were 0.23 and 0.20 kg MJ ha^{-1} of sesame production using organic and inorganic fertilisers. This implies that sesame production using organic fertiliser is more energy efficient (14%) and productive (13%) than using inorganic fertiliser. Higher energy efficiency from organic farming was also reported by Mendoza (2002).

Energy input in form of renewable and non-renewable. Table 4 shows the total energy input in form of direct, indirect, renewable and non-renewable used in production of sesame using organic and inorganic fertilisers. The direct energy sources were human and diesel oil; while indirect sources of energy were machinery, manure, pesticides, NPK and sesame seed.

TABLE 3. Energy input and output for sesame production using inorganic fertiliser

Variable	Qty ha^{-1}	Energy equivalent (MJ)	%
Human labour (hr)			
Land clearing/ridging	78.0	152.9	26.0
Cultural practices	93.0	182.3	31.0
Harvesting	69.0	135.2	23.0
Threshing and bagging	58.0	113.7	20.0
Total labour input	298.0	584.1	100.0 (19.7)
Machinery (hr)			
Tillage	2.8	175.6	5.9
Inorganic fertiliser			
NPK 15:15:15 (kg)	69.0	938.0	31.7
Pesticides (lt)	1.9	19.0	0.7
Diesel (lt)	20.0	1,126.0	38.0
Sesame seed (kg)	7.7	117.0	4.0
Total energy input (MJ)		2,960.0	100.0
Yield (kg)	600.0	15,000.0	
Energy output/input ratio		5.0	
Energy productivity (kg MJ)		0.20	

Figures in parenthesis represents percentage share of total labour energy input in the total energy input

TABLE 4. Energy input per hectare in sesame production in organic and inorganic fertilised farms in Nigeria

Farm type	Total energy (MJ ha^{-1})	Direct[D]	Indirect[I]	Renewable[R]	Non renewable[N]
O farm*	2377.0	1681.0 (71)	696.4 (29)	1191.1 (50)	1186.0 (50)
I farm**	2960	1710.1 (58)	1250.0 (42)	701.1 (24)	2259.0 (76)

*Organic fertilised sesame farm ; ** Inorganic fertilised sesame farm
[D] = include human and diesel oil ; [I] = include machinery, manure, pesticides, NPK and seed; [R] = include human, manure and seed
[N] = include machinery, pesticides, NPK and diesel oil
Figure in parenthesis represents percentage share of total energy input

TABLE 5. Gross margin analysis for sesame using organic and inorganic fertiliser in Nigeria

Variables	Organic fertiliser			Inorganic fertiliser		
	Ave. Qty (ha^{-1})	Ave. Unit price	Value (US$ ha^{-1})	Ave. Qty (ha^{-1})	Ave. Unit price	Value (US$ ha^{-1})
Gross returns	556.0*	1.20	686.0	600.0**	1.22	732.0
Inputs						
Seed (kg)	7.0	1.90	13.30	7.7	1.68	13.0
Fertiliser (kg)	1381.0	0.007	9.20	69.0	0.40	27.60
Pesticides (Lt)	1.5	8.0	12.0	1.9	8.3	15.74
Labour (man hour)	340.0	0.57	193.8	298.0	0.65	194.0
Total variable cost ha^{-1}			228.3			250.34
Gross margin ha^{-1}			458.60			483
Returns to investment (1/3)			0.02			0.02

* and ** = Yields of organic and inorganic fertilised sesame farms. Note: US$ = ₦150 at the period of data collection

Human, manure and sesame seed were sources of renewable energy, while machinery, pesticides, NPK and diesel oil constituted non-renewable sources of energy used in production of sesame in the study area. Table 4 shows that the sesame production using organic fertiliser consumed 71% of direct energy, against 58% for inorganic fertilised sesame farms. The renewable energy utilisation was higher (50%) in organic fertilised sesame farms than those of inorganic fertilised farms (24%). That is, inorganic fertilised sesame farms used more (76%) of nonrenewable energy.

Gross margin analysis. The average output of sesame production using organic and inorganic fertilisers were 556 and 600 kg ha^{-1}, respectively (Table 5). This implies that on average, sesame output under organic fertiliser was lower by7% than that produced under inorganic fertiliser, though the difference in output was not significant statistically. The 600 kg ha^{-1} of sesame output produced using inorganic fertiliser tallied with the estimated average output for the State (GTZ, 2009). The gross returns were US$686 and 732 ha^{-1} for organic and inorganic fertilisers user-farmers. Table 5 also shows that the total variable cost incurred per hectare by both categories of farmers were US$227 and 249, respectively. Labour cost constituted 84 and 76% of total variable costs for organic and inorganic fertilised sesame farms. The gross margins per hectare for both farmers were US$459 and 483. On average, the gross margin accruing to inorganic fertiliser user-farmers was slightly higher (5%) than that enjoyed by organic fertiliser user-farmers. This agrees with the findings of Umar *et al.* (2010). However, the rate of returns on both investments was the same (US$0.02). That is, for every US$1 invested on each category of enterprises, US$0.02 was made as profit.

CONCLUSION

The energy input required for production of sesame per hectare using organic and inorganic fertilisers in Nigeria is 2,377 and 2,960 MJ, respectively. This shows an increased of 20% over amount of energy input required for production of sesame using organic fertiliser. Energy outputs of sesame production per hectare using organic and inorganic fertilisers is 13,900 and 15,000 MJ, respectively. This shows an increased of 7% over energy output from organic fertilised sesame farms. Sesame production using organic fertiliser is more efficient (5.8) and productive (0.23 kg MJ) in terms of energy utilisation than inorganic fertilised farms (5 and 0.20 kg MJ, respectively). Sesame production using organic fertiliser consumes 71% of direct energy, against 58% for inorganic fertilised sesame farms. Renewable energy utilisation is higher (50%) in organic fertilised sesame farms than those of inorganic fertilised farms (24%). Gross margin per hectare is slightly lower in organic fertilised sesame farms (US$459) than that of inorganic farms (US$483). However, the rate of returns on both investments is the same (US$0.02).

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