The Influence of Compost Use on the Production of Lettuce (*Lactuca sativa*) in the Urban and Peri-urban Areas of Yaoundé (Cameroon)

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Summary

This paper analyzes whether it is advantageous to use compost instead of mineral fertilizer for lettuce production in the Yaoundé urban and peri-urban areas. The field survey results show that, compost use leads to higher crop yields and profits. Results from the Cobb-Douglas production function prove that compost use is statistically significant in explaining the yield variation of lettuce and more importantly, compost is the most productive input. Further results show that, compost use leads to lower the crop's irrigation requirements and to improve the organic matter content of the soil. Thus, in spite that compost farms are more labour demanding, the use of compost agronomically provides a lot of benefits to farmers living in the areas surrounding Yaoundé. Therefore, programs of popularization of this input to encourage its adoption should be highlighted among the top priorities in the agricultural policy of the Cameroon's government.

Résumé

L'influence de l'utilisation du compost sur la production de la laitue (*Lactuca sativa*) dans la zone urbaine et péri-urbaine de Yaoundé (Cameroun)

Cet article analyse s'il est avantageux d'utiliser le compost au lieu de l'engrais minéral pour produire la laitue dans la zone urbaine et péri-urbaine de Yaoundé. Les résultats de terrain montrent l'obtention de rendements et profits plus élevés lorsqu'on utilise le compost. Les résultats de la fonction de production Cobb-Douglas prouvent que l'utilisation du compost est statistiquement significative pour expliquer la variation de rendement de la laitue et que le compost est l'intrant le plus productif. D'autres résultats montrent que le compost fournit la matière organique utile au sol et que les besoins d'irrigation en eau de la culture sont réduits grâce à l'utilisation du compost. Par conséquent, malgré le fait que l'application du compost demande une main-d'œuvre beaucoup plus élevée, son utilisation est généralement bénéfique pour les agriculteurs vivant aux alentours de Yaoundé. Les programmes de vulgarisation de cet intrant pour encourager son adoption devraient donc figurer parmi les points prioritaires dans la politique agricole du gouvernement camerounais.

1. Introduction

Today, urban and peri-urban communities of big African cities have become familiar with the waste composting for urban farming as an unique local solution to address the household waste management problems in their environment. For instance, in Yaoundé, the capital-city of Cameroon, the use of compost from organic household waste for the cultivation of foodstuff crops and vegetables within and around the city is already a preferred activity for many city dwellers and unskilled migrants. The crops produced thereby are either consumed locally or sold to the market. Among the cultivated crops, the lettuce (*Lactuca sativa*) is preferred by most cultivators because of its increasing demand in the market and thus the facility to sell it at good price (14, 15, 16).

Actually, about 32% of fertilizers users in the Yaoundé urban and peri-urban areas utilise compost and animal manure to produce lettuce and other foodstuff crops. That means, more than 68% of farmers are still reticent or doubt about the efficiency, higher productivity or economic profitability of their crops by using compost from household waste (9, 14, 15, 16). With a production cost of 21,000 FCFA/t and a market selling price of 30,000 FCFA/t, the compost of Yaoundé is about 3.75 times more expensive than mineral fertilizers considering the amounts of nutrients it contains whose substitution value is 8,048 FCFA/t (10). Such a price level represents an important factor that affects the decision of farmers for using compost or a substituting fertilizer to produce lettuce and other foodstuff crops.

Furthermore, because of the compost bulkiness requiring very large amounts to be utilised, the transport cost is another important limiting factor for the distribution and use of this input. At the transport rate of 40 FCFA/t/km (i.e. 2,000 FCFA/t for a road length distance of 50 km) applicable to inputs and commodities in Cameroon, farmers (especially those living in villages far away from Yaoundé-city) think that, it is very expensive for them to transport the required compost quantities in their farms (10, 11, 21, 22). Instead of using compost, those farmers rather prefer to utilise the mineral fertilizer (which is less voluminous and thus easier to transport or less labour demanding) to cultivate lettuce or other foodstuff crops. Such situation negatively influences the compost demand discouraging many farmers to apply this input in their farms (10, 20, 21). However, the main question that arises from the reticence of all farmers to adopt compost is to know whether its use is advantageous, highly productive or not. Thus, this paper will try to answer that question using the example of lettuce produced in the Yaoundé urban and peri-urban areas.

2. Materials and methods

2.1. The study area and data collection

The field survey was carried out in Cameroon during the period from August 2003 to February 2004. It was undertaken precisely in the Yaoundé urban and peri-urban areas i.e. Yaoundé, the capital-city of Cameroon and 11 chosen surrounding villages with homogeneous/similar soil and climatic characteristics located in concentric zones with an average road length distance of 50 km from the

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city. That locality is characterized by an equatorial climate of Guinean type with moderate precipitations (varying from 1565 to 1600 mm annually) and two annual dry seasons, with soils of ferrallitic types which are poor in organic matter (16). It was chosen because of its high production amount of compost (from household waste) in the country, the availability of data and the large number of compost users practising in the location (19).

A stratified random sampling was used to select a total of 108 farmers (from the 11 surrounding villages) comprised of 52 compost users and 56 non-compost users. The selected compost users were farmers using compost as main fertilizer whereas the non-compost users were those using mineral fertilizer as major fertilizer. Using a prepared questionnaire and interview schedule, cross-sectional primary data of the cropping season 2002/2003 were collected from those two groups. The data collected were estimation made from own assessment of each farmer and concerned mainly the lettuce yield and the intensity of utilisation of inputs (compost, mineral fertilizer, animal manure, labour and irrigation) used to produce the crop. Those data were supplemented by secondary data such as the selling prices of inputs and lettuce, the transport rate of compost and other data collected from available literature in the domain of waste composting for urban farming in developing countries and Cameroon in particular.

2.2. Data analysis

To analyse the effect of compost use on lettuce production, the literature suggests three main types of production function: linear, quadratic and Cobb-Douglas (8). Among the three functional forms, the Cobb-Douglas Type production function is preferred in this paper mainly due to its convenience in estimation which employs an ordinary least squares (OLS) technique, its simplicity in the interpretation of coefficients (the coefficients of this function represent the elasticities of production) and its perfect inputs substitution property (8, 10). For the purpose of estimating the linear regression, this function has been transformed into natural logarithms and computed by using the SPSS software program (version 11.5). The mathematical form of the Cobb-Douglas Type production function used is expressed by equation (a):

$$\ln Y_i = \ln \beta_0 + \sum_{j=1}^{k} \beta_j \ln X_{ji} + u_i \qquad \text{(a)}$$

Where: Y_i is the yield of crop at i^{th} farm; X_j is the number of independent variables (inputs) ranging from 1 to k; i = 1,2,3,…………,n is the number of farmers interviewed in each of the two groups (compost users and non-compost users); β_j is the elasticity of variable inputs, β_0 represents the intercept and u is the stochastic disturbance term.

More precisely, the statistical form of the Cobb-Douglas Type of yield function, in equation (a), is further specified as:

$$\ln Y_i = \ln \beta_0 + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \beta_4 \ln X_{4i} + \beta_5 \ln X_{5i} + u_i \qquad \text{(b)}$$

Where: Y= Yield or output of lettuce grown in the study area (in t/ha); X_1= Compost intensity (in t/ha); X_2= Mineral fertilizer intensity (in t/ha); X_3= Animal manure intensity (in t/ha); X_4= Labour (in manday/ha); X_5= Irrigation intensity (in m³/ha); u= Error term; ln= Natural logarithmic function; β_0= Constant, to be estimated; β_1, β_2, β_3, β_4 and β_5 are the partial elasticities of the respective inputs, to be estimated.

Nevertheless, during the manipulation of data utilised in the Cobb-Douglas regressions, the transformation to logarithms becomes mathematically a problem for the “zero observation” of mineral fertilizer and compost in the compost users and non-compost users groups respectively (8). To avoid that problem, the mineral fertilizer variable was excluded for estimating the production function in the compost users group whereas the compost variable was not considered in the non-compost users group.

Table 1
Average crop yield and inputs intensity of compost users and non-compost users

Input or yield		Compost users (N=52)	Non-compost users (N=56)
Input	Compost (t/ha)	23.10	0
	Mineral fertilizer (kg/ha)	0	546
	Animal manure (t/ha)	3.06	5.53
	Labour (manday/ha)	53	40
	Irrigation (m³/ha)	3,562	5,328
Yield (t/ha)		12.80	10.50

Table 2
Lettuce crop budget for compost users (one hectare)

Item		Unit	Quantity	Price (FCFA/Unit)	Amount (FCFA)
Input	Compost input	t	23.10	30,000	693,000
	Compost transport	FCFA/t	23.10	2,000	46,200
	Mineral fertilizer	kg	0	200	0
	Animal manure	t	3.06	30,000	91,800
	Labour	manday	53	1,500	79,500
	Irrigation	m³	3,562	337	1,200,394
TOTAL INPUT COST (C)					2,110,894
Sales of lettuce production or TOTAL REVENUE (R)		t	12.80	339,000	4,339,200
TOTAL PROFIT (R-C)					+ 2,228,306

Notes: In this table,

(i) The compost transport price of 2,000 FCFA/t has been computed by multiplying the compost transport rate of 40 FCFA/t/km by 50 km which is the average road length distance of all the selected villages from city-center.

(ii) The amount of each input is equal to: the input quantity multiplied by its price.

(iii) The total input cost (C) is equal to: the sum of amounts of compost input, compost transport, mineral fertilizer, animal manure, labour and irrigation.

(iv) The sales of lettuce production i.e. the total revenue (R) is equal to: the lettuce yield (12.80 t) multiplied by its selling price (339,000 FCFA/t).

(v) The total profit is equal to: the total revenue (R) minus the total input cost (C).

Source: Computed from Jaza Folefack, 2005; Ministère de l’Agriculture, 2003

Table 3
Lettuce crop budget for non-compost users (one hectare)

Item		Unit	Quantity	Price (FCFA/Unit)	Amount (FCFA)
Input	Compost input	t	0	30,000	0
	Compost transport	FCFA/t	0	2,000	0
	Mineral fertilizer	kg	546	200	109,200
	Animal manure	t	5.53	30,000	165,900
	Labour	manday	40	1,500	60,000
	Irrigation	m^3	5,328	337	1,795,536
TOTAL INPUT COST (C)					2,130,636
Sales of lettuce production or TOTAL REVENUE (R)		t	10.50	339,000	3,559,500
TOTAL PROFIT (R-C)					+ 1,428,864

Notes: In this table,
(i) The compost transport price of 2,000 FCFA/t has been computed by multiplying the compost transport rate of 40 FCFA/t/km by 50 km which is the average road length distance of all the selected villages from city-center.
(ii) The amount of each input is equal to: the input quantity multiplied by its price.
(iii) The total input cost (C) is equal to: the sum of amounts of compost input, compost transport, mineral fertilizer, animal manure, labour and irrigation.
(iv) The sales of lettuce production i.e. the total revenue (R) is equal to: the lettuce yield (10.50 t) multiplied by its selling price (339,000 FCFA/t).
(v) The total profit is equal to: the total revenue (R) minus the total input cost (C).
Source: Computed from Jaza Folefack, 2005; Ministère de l'Agriculture, 2003.

Table 4
Estimated Cobb-Douglas production elasticities for lettuce

Independent variables	Compost users (N=52)	Non-compost users (N=56)
Constant	1.195*** (4.891)	2.333*** (3.861)
Compost	0.972*** (7.819)	-
Mineral fertilizer	-	0.734*** (5.574)
Animal manure	0.035* (1.695)	0.146* (1.915)
Labour	0.465*** (4.479)	0.327* (1.788)
Irrigation	0.427** (2.446)	0.632*** (9.862)
TOTAL	R^2= 0.791 F-value= 34.739*** ∑elasticity= 1.899	R^2= 0.765 F-value= 32.560*** ∑elasticity= 1.839

*** Significant at 1% ** Significant at 5% * Significant at 10% ( )= t-value

3. Results

3.1. Results of field survey

The results of field survey in table 1 indicate that on average, the lettuce yield for compost users (12.80 t/ha) is about 21.90% higher than the crop output in the non-compost users group (10.50 t/ha). However, the intensity of inputs used for lettuce production differs between the two groups. For instance, the intensity of animal manure is lower for compost users (3.06 t/ha) compared to non-compost users (5.53 t/ha). The labour needed by compost users (53 mandays/ha) is higher than in the non-compost users group (40 mandays/ha). The irrigation intensity is lower for compost users (3,562 m^3/ha) compared to the non-compost users (5,328 m^3/ha). Furthermore, the compost users do not use mineral fertilizer and utilise on average 23.10 t/ha of compost whereas the non-compost users do not utilise compost but use on average 546 kg/ha of mineral fertilizer (Table 1).

The corresponding lettuce crop budgets for compost users and non-compost users (respectively in tables 2 and 3) show that, in total, non-compost users spend much more money for purchasing inputs (2,130,636 FCFA/ha) as compared to compost users (2,110,894 FCFA/ha). The total revenue gained is higher for compost users (4,339,200 FCFA/ha) as compared to non-compost users (3,559,500 FCFA/ha). Therefore, the total profit benefited by compost users (+ 2,228,306 FCFA/ha) is also higher than in the non-compost users group (+ 1,428,864 FCFA/ha). The difference of total profit between the two groups indicates that, farmers not using compost lose about 799,442 FCFA/ha per cropping season (Tables 2 and 3).

3.2. Results of the estimated lettuce production functions

Table 4 presents the results of the estimated lettuce production functions (Cobb-Douglas Type) for compost users and non-compost users, as computed using the ordinary least squares (OLS) method. The common problem in studies of this type, multicollinearity, was examined through estimation of the Pearson correlation coefficients for all independent variables (8). In most cases, these were found to be insignificant, indicating the absence of serious multicollinearity. In all cases (Table 4), the regression coefficients have the expected positive signs, indicating that an additional use of any of the inputs utilised would have a positive impact on lettuce yield.

In the compost users group, the t-value proves that the coefficient of compost is statistically significant (at 1% level) and the highest among the variable inputs. This shows that,

Table 5
Effect of a 10% increase in compost or mineral fertilizer intensity (one hectare)

Item	Compost users (N=52)	Non-compost users (N=56)
Average field compost/mineral fertilizer (t)	23.10	0.546
10% increase quantity in compost/mineral fertilizer (t)	2.31	0.0546
Compost/mineral fertilizer price unit (FCFA/t)	30,000	200,000
Compost transport price unit (FCFA/t)	2,000	-
Compost transport cost of the 10% increase of compost quantity (FCFA/t)	4,620	-
COST INDUCED BY SUPPLEMENTARY COMPOST/MINERAL FERTILIZER (FCFA)	69,300 + 4,620 = 73,920	10,920
Average lettuce yield (t)	12.80	10.50
Partial elasticity compost/mineral fertilizer	0.972	0.734
Lettuce yield gain from 10% compost/mineral fertilizer increase (t)	1.24416	0.7707
Lettuce price unit (FCFA/t)	339,000	339,000
SUPPLEMENTARY REVENUE GAINED (FCFA)	421,770	261,267
SUPPLEMENTARY PROFIT GAINED (FCFA)	+ 347,850	+ 250,347

Notes: In this table, in each group (compost users and non-compost users),

(i) The compost was taken as input for computing figures in the compost user group whereas the mineral fertilizer was considered as input in the non-compost user group.
(ii) The 10% increase quantity in compost/mineral fertilizer intensity is equal to: the average field compost/mineral fertilizer intensity multiplied by 10%.
(iii) The compost transport cost is equal to: the compost transport price unit multiplied by the 10% increase in compost intensity.
(iv) The cost induced by supplementary compost/mineral fertilizer is equal to: the 10% increase quantity in compost/mineral fertilizer multiplied by the compost/mineral fertilizer price unit.
(v) The lettuce yield gain from 10% compost/mineral fertilizer increase is equal to: 10 times the partial elasticity of compost/mineral fertilizer multiplied by the average field survey lettuce yield.
(vi) The supplementary revenue gained is equal to: the lettuce yield gain (from 10% compost/mineral fertilizer increase) multiplied by the lettuce price unit.
(vii) The supplementary profit gained is equal to: the supplementary revenue gained minus the cost induced by supplementary compost/ mineral fertilizer.

Source: Computed from tables 1, 2, 3 and 4 data; Jaza Folefack, 2005.

compost is the most productive input within this group. The estimated partial elasticity suggests that, a 10% increase in compost intensity would be associated with an increase in lettuce yield by 9.72% for the compost users (Table 4).
As proved by its highest partial elasticity which is significant at 1% level, mineral fertilizer is the most productive input within the non-compost users group. The coefficient for mineral fertilizer suggests that, a 10% increase in mineral fertilizer intensity would be associated with an increase in lettuce yield by 7.34% in the non-compost users group (Table 4).
The use of animal manure is statistically significant (at 10% level) in explaining lettuce yield variation within the compost users and non-compost users groups. The computed production elasticities indicate that, a 10% increase in animal manure intensity would be associated with an increase by 0.35% and 1.46% in lettuce yield in the compost users and non-compost users groups respectively (Table 4).

The t-values of labour in each of the two groups prove that, labour is statistically significant (at 1% level for the compost users group and 10% level for the non-compost users group) in explaining lettuce yield. Nevertheless, it can be remarked that the partial elasticity of labour is higher in the compost users group compared to the non-compost users group, indicating that labour is more productive in compost farms. The estimated labour coefficients suggest that, a 10% increase in labour would be associated with an increase in lettuce yield by 4.65% and 3.27% respectively for the compost users and non-compost users groups (Table 4).
Irrigation is statistically significant in explaining lettuce yield variation in each of the two groups. However, the level of significance differs per group: 5% level for the compost users and 1% level for the non-compost users. The production elasticities for irrigation suggest that, a 10% increase in irrigation intensity would be associated with an increase in lettuce yield by 4.27% and 6.32% respectively for the compost users and non-compost users groups. Therefore, it can be remarked that the partial elasticity of irrigation is lower in the compost users group compared to the other group, indicating that irrigation is less productive in compost farms compared to non-compost farms (Table 4).
The sum of elasticities is more than 1 in each group, expressing an increasing return to scale of yield with respect to all variable inputs. The estimated sum of elasticities indicate that, a 10% increase in all the variable factors would lead to an increase in lettuce yield by 18.99% and 18.39% respectively for the compost users and non-compost users (Table 4). Generally, the values of the coefficient of determination R^2 are very high and indicate

Table 6
Effect of a 10% increase in animal manure intensity (one hectare)

Item	Compost users (N=52)	Non-compost users (N=56)
Average field animal manure (t)	3.06	5.53
10% increase quantity in animal manure (t)	0.306	0.553
Animal manure price unit (FCFA/t)	30,000	30,000
COST INDUCED BY SUPPLEMENTARY ANIMAL MANURE (FCFA)	9,180	16,590
Average lettuce yield (t)	12.80	10.50
Partial elasticity animal manure	0.035	0.146
Lettuce yield gain from 10% animal manure increase (t)	0.0448	0.1533
Lettuce price unit (FCFA/t)	339,000	339,000
SUPPLEMENTARY REVENUE GAINED (FCFA)	15,187	51,969
SUPPLEMENTARY PROFIT GAINED (FCFA)	+ 6,007	+ 35,379

Notes: In this table, in each group (compost users and non-compost users),
(i) The 10% increase quantity in animal manure is equal to: the average field animal manure intensity multiplied by 10%.
(ii) The cost induced by supplementary animal manure is equal to: the 10% increase quantity in animal manure multiplied by the animal manure price unit.
(iii) The lettuce yield gain from 10% animal manure increase is equal to: 10 times the partial elasticity of animal manure multiplied by the average field survey lettuce yield.
(iv) The supplementary revenue gained is equal to: the lettuce yield gain (from 10% animal manure increase) multiplied by the lettuce price unit.
(v) The supplementary profit gained is equal to: the supplementary revenue gained minus the cost induced by supplementary animal manure.
Source: Computed from tables 1, 2, 3 and 4 data; Jaza Folefack, 2005.

Table 7
Effect of a 10% increase in labour intensity (one hectare)

Item	Compost users (N=52)	Non-compost users (N=56)
Average field labour (mandays)	53	40
10% increase quantity in labour (mandays)	5.3	4
Labour price unit (FCFA/manday)	1,500	1,500
COST INDUCED BY SUPPLEMENTARY LABOUR (FCFA)	7,950	6,000
Average lettuce yield (t)	12.80	10.50
Partial elasticity labour	0.465	0.327
Lettuce yield gain from 10% labour increase (t)	0.5952	0.34335
Lettuce price unit (FCFA/t)	339,000	339,000
SUPPLEMENTARY REVENUE GAINED (FCFA)	201,773	116,396
SUPPLEMENTARY PROFIT GAINED (FCFA)	+ 193,823	+ 110,396

Notes: In this table, in each group (compost users and non-compost users),
(i) The 10% increase quantity in labour is equal to: the average field labour intensity multiplied by 10%.
(ii) The cost induced by supplementary labour is equal to: the 10% increase quantity in labour multiplied by the labour price unit.
(iii) The lettuce yield gain from 10% labour increase is equal to: 10 times the partial elasticity of labour multiplied by the average field lettuce yield.
(iv) The supplementary revenue gained is equal to: the lettuce yield gain (from 10% labour increase) multiplied by the lettuce price unit.
(v) The supplementary profit gained is equal to: the supplementary revenue gained minus the cost induced by supplementary labour.
Source: Computed from tables 1, 2, 3 and 4 data; Jaza Folefack, 2005.

that, a percentage of 79.1% and 76.5% of the variation in the (log of) lettuce yield are explained by the (log of) inputs used for the regression in the compost users and non-compost users groups respectively. The F-values of the R^2 are also highly significant for the two groups, implying that the data pertaining to the selected variables significantly fit the regression line (Table 4).

3.3. Results from assessment of the efficacy of production factors

The efficacy of production factors are assessed from tables 5 to 8 by comparing the cost of each input to the financial value of the yield gain (supplementary revenue) induced by a 10% increase in the intensity of application of this input. The results (Tables 5 and 7) show that, as compared to non-compost users, the supplementary revenue gained by compost users is higher when there is a 10% additional application of either compost or labour. In table 5, concerning the compost input, the supplementary revenue gained is 421,770 FCFA/ha for compost users and 261,267 FCFA/ha for non-compost users. In table 7, concerning the labour, the supplementary revenue gained is 201,773 FCFA/ha for compost users and 116,396 FCFA/ha for non-compost users.

In opposite (Tables 6 and 8), non-compost users gain higher supplementary revenue than compost users when a 10% additional quantity of either animal manure or irrigation is applied in their farms. In table 6, concerning the animal manure, the supplementary revenue gained is 15,187 FCFA/ha for compost users and 51,969 FCFA/ha for non-compost users. In table 8, concerning the irrigation, the supplementary revenue gained is 185,284 FCFA/ha for compost users and 224,960 FCFA/ha for non-compost users.

Table 8
Effect of a 10% increase in irrigation intensity (one hectare)

Item	Compost users (N=52)	Non-compost users (N=56)
Average field irrigation (mandays)	3,562	5,328
10% increase quantity in irrigation (m^3)	356.2	532.8
Irrigation price unit (FCFA/m^3)	337	337
COST INDUCED BY SUPPLEMENTARY IRRIGATION (FCFA)	120,039	179,554
Average lettuce yield (t)	12.80	10.50
Partial elasticity irrigation	0.427	0.632
Lettuce yield gain from 10% irrigation increase (t)	0.54656	0.6636
Lettuce price unit (FCFA/t)	339,000	339,000
SUPPLEMENTARY REVENUE GAINED (FCFA)	185,284	224,960
SUPPLEMENTARY PROFIT GAINED (FCFA)	+ 65,245	+ 45,406

Notes: In this table, in each group (compost users and non-compost users),
(i) The 10% increase quantity in irrigation is equal to: the average field irrigation intensity multiplied by 10%.
(ii) The cost induced by supplementary irrigation is equal to: the 10% increase quantity in irrigation multiplied by the irrigation price unit.
(iii) The lettuce yield gain from 10% irrigation increase is equal to: 10 times the partial elasticity of irrigation multiplied by the average field lettuce yield.
(iv) The supplementary revenue gained is equal to: the lettuce yield gain (from 10% irrigation increase) multiplied by the lettuce price unit.
(v) The supplementary profit gained equal to: the supplementary revenue gained minus the cost induced by supplementary irrigation.
Source: Computed from tables 1, 2, 3 and 4 data; Jaza Folefack, 2005.

4. Discussion

4.1. Compost use leads to higher crop yields and profits

The results of field surveys prove that, as compared to non-compost users, the yield of lettuce is 21.90% higher for compost users (Table 1). In opposite, the total cost for purchasing inputs is 0.94% higher for non-compost users (Tables 2 and 3). Thus, the total profit gained is 55.95% higher for compost users meaning that, using compost for lettuce production could be economically advantageous for farmers (Tables 2 and 3). The higher lettuce yield or total profit gained by compost users could be explained by the good follow up of compost farms by Cameroonian agricultural technicians and mainly by the various agronomic benefits or sustainable effects of compost (slow-release store of nutrients, water holding, erosion protection, good soil structure and texture, plant diseases control, weeds reduction, etc) (2, 3, 4, 5, 6, 9, 13).

Previous researches undertaken in this domain in Cameroon also showed very significant response of lettuce crop to the newly applied compost input (6, 10). For instance, during the year 1993, a trial was made to compare the yield of lettuce and maize cultivated with compost with the crops' outputs produced with mineral fertilizer in the Centre province of Cameroon. A remarkable yield increase of 26% and 23% was observed respectively in lettuce and maize produced using compost (17, 18). Another survey in 2005 by Jaza Folefack (10) indicates that, as compared to non-compost farms, the use of compost to produce the 11 main foodstuff crops and vegetables of the villages surrounding Yaoundé results in an increase in yield ranging between 4 to 42% depending on the crop type (10). This testifies that, compared to mineral fertilizer, the use of compost leads to higher crop yields.

The first trials of compost use to produce foodstuff crops in other developing countries have also provided encouraging results. In China and Japan for instance (during the period of 1965-1968), compost was used to produce rice, wheat, maize, soybeans, cotton, sugar cane, groundnuts and the results gave very significant response of these crops to the newly applied compost input (2, 6). In India (in 1970), mineral fertilizer substitution by compost contributed to an increase in crop yields till 25% (2, 6). Likewise, in Senegal (in 1991), the use of compost at a dosage of 100 tonnes/ha has yielded to the multiplication of cabbage weight by four (7). Consequently, promoting the use of compost for crop production is agronomically advantageous for farmers.

4.2. Compost is more productive and beneficial than mineral fertilizer

By comparing together the coefficients of all the variables inputs in the compost users group (Table 4), it can be remarked that the production elasticity of compost is the highest, proving that compost is the most productive input of the group. In the non-compost users group however (Table 4), the coefficient of mineral fertilizer is the highest proving that mineral fertilizer is the most productive input of that group. Nevertheless, the compost coefficient in the compost users group is still higher than the mineral fertilizer coefficient in the non-compost users group (Table 4). This confirms that, compost is the most productive input in both groups and thus using compost is more advantageous than mineral fertilizer.

From the results in table 5, one can observe that, the cost induced by the supplementary 10% application of compost (73,920 FCFA/ha) is higher compared to the cost induced by the supplementary 10% increase of mineral fertilizer intensity (10,920 FCFA/ha). However, in spite of the higher compost cost, the compost users generally gain higher supplementary revenue (421,770 FCFA/ha) compared to non-compost users (261,267 FCFA/ha). The supplementary profit gained is also higher for compost users (+ 347,850 FCFA/ha) as compared to non-compost users (+250,347 FCFA/ha). Hence, using compost is financially more beneficial than mineral fertilizer (Table 5).

A previous survey by Asomani-Boateng *et al.* (1) confirming this result indicates that, farmers near Kano (Nigeria) prefer compost as fertilizer since its effects once applied might last for 2 or 3 years, whereas 2 or 3 applications of mineral fertilizer might be required during the growing season (1, 12). Another research by Jaza Folefack (10) shows that, because of its long term effects, using compost could alternatively help to save the mineral fertilizer costs for many cycles of production. For instance, about 8.47% (132,640 million FCFA) can be yearly saved in total import expenditures of Cameroon when the totality of collected household waste in the main cities of the country is composted for substituting the mineral fertilizer (10). Hence, it could be advantageous for government authorities to implement policies which encourage farmers to substitute mineral fertilizer by compost. This will not only benefit cultivators but also it will minimize the need for imported mineral fertilizers which in Cameroon averages 100,000 tonnes per year (9, 14, 15).

4.3. Compost farms are more labour demanding

The labour intensity needed by compost users is higher than in the non-compost users group meaning that, compost farms are more labour demanding than non-compost farms (Table 1). Since compost is a voluminous or bulky input, many people are often employed in compost farms to carry and spread it into the land (11, 20). In table 4, the production elasticity of labour is also higher for compost users proving that, labour is more productive in compost farms.

The results in table 7 suggest that, the cost induced by the supplementary 10% labour utilised by compost users (7,950 FCFA/ha) is higher compared to non-compost users (6,000 FCFA/ha). This high demanding labour requirement could justify the reticence of some farmers to use compost in the Yaoundé urban and peri-urban areas. Such farmers would alternatively prefer to use mineral fertilizer which is less labour demanding thus less costly for labour (9, 10, 11, 20). However, in spite of higher labour cost they supported, the compost users would generally gain higher supplementary revenue (201,773 FCFA/ha) compared to non-compost users (116,396 FCFA/ha). This clearly justifies the higher productivity of labour in compost farms (Table 7).

Nevertheless, this high demanding labour property of the compost input should not be a problem in Cameroon where the unemployment rate is more than 30% and thus, a lot of young people are currently seeking jobs in the farming sector or are willing to work on compost farms (10, 16). Therefore, in order to attract more people to work on compost farms, programs for popularizing the compost input should be organized to explain its higher productivity and agronomic benefits to farmers living in the areas surrounding Yaoundé.

4.4. Compost use leads to lower the crop's irrigation requirements

The intensity and production elasticity of irrigation are lower for compost users as compared to the non-compost users (Tables 1 and 4). Table 1 results indicate that, compost farms demand 33% less irrigation water compared to the non-compost farms. This can be explained by the fact that, added to soils, the organic matter in compost reduces evaporation from the soil surface and increases the soil's water holding ability so that both rain and irrigation water are held in the root zone for plant use (2, 3, 4). According to Duane (5), this can significantly lower the irrigation requirements by 10 to 90% in the farming practices and other applications where water use is restricted or prohibitively expensive (5). This is especially beneficial in areas with low annual rainfall and drought (2, 3, 4, 5).

The results in table 8 suggest that, the cost induced by a supplementary 10% increase in irrigation intensity is lower for compost users (120,039 FCFA/ha) as compared to non-compost users (179,554 FCFA/ha). The supplementary revenue gained thereby in compost farms (185,284 FCFA/ha) is lower than in non-compost farms (224,960 FCFA/ha). This justifies that, irrigation is less productive in compost farms and thus, using compost is economically advantageous because it would help to save part of the irrigation costs in the Yaoundé urban and peri-urban areas characterized by water scarcity due to its moderate precipitations (1565 to 1600 mm annually) with two annual dry seasons (10, 16).

4.5. Compost and animal manure provide organic matter beneficial to soil

As compared to the non-compost users, the intensity and production elasticity of animal manure are lower for compost users (Tables 1 and 4). The non-compost users utilise higher animal manure because it is their sole source of organic matter whereas this matter is partly provided by compost in the compost users group. The results in table 6 suggest that, the cost induced by a supplementary 10% increase in animal manure intensity is lower for compost users (9,180 FCFA/ha) as compared to non-compost users (16,950 FCFA/ha). The supplementary revenue gained thereby in compost farms (15,187 FCFA/ha) is lower than in non-compost farms (51,969 FCFA/ha). This testifies that, animal manure is less productive in compost farms.

As already mentioned, soils in the Yaoundé urban and peri-urban areas are poor in organic matter, so one of the main advantages of using compost for crops' production in this region would be the organic matter brought to the soil through this input. According to Ngnikam (19), with a Carbon to Nitrogen (C/N) ratio of 16 and its total organic matter content which is about 17.7% of dry matter, the compost of Yaoundé is suitable for restoring the soil fertility and to maintain the microbiological equilibrium of soil helping thereby to reduce soil erosion or weed growth by at least 60% (5, 13, 19). Thus, this compost can be conveniently used as fertilizer for crop production.

5. Conclusion

Under the observed field situation (soil and weather characteristics, inputs and crop prices, transport rate, etc), the use of compost for lettuce production is agronomically and economically advantageous for farmers in the urban and peri-urban areas of Yaoundé (Cameroon). In spite that compost farms are more labour demanding, this paper proves that: compost use leads to higher crop yields and profits, compost is more productive and beneficial than mineral fertilizer, compost use leads to lower the crop's irrigation requirements, and that both compost and animal manure provide organic matter beneficial to soil. This organic matter confers a sustainable or long term effect property to the compost input (compost nutrients are released progressively over a period of up to three years i.e. six cycles of production). However, this long term effect of compost was difficult to quantify in our calculations and thus, the quantities of compost considered in this paper refer to the first season of compost application on the land. So, the profits gained would be higher by considering in calculations the long term effect or intangible benefits of compost application during the subsequent years. Therefore, the Cameroon's government would better gain by popularizing the new compost input to all farmers and by implementing policy measures which encourage its massive adoption or better organize this sector. For instance, the country's agricultural policy should in priority favour the creation of education centers to train farmers on the compost benefits and utilisation or the organization of farmers into cooperatives which will help them to lower the transport and handling/labour costs of compost.

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