Reuse of human's urine in market-gardening in South-Benin: financial returns analysis

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Abstract

The purpose of this paper is to highlight the financial advantages related to the reuse of human urine in the production of the vegetable *Solanum macrocarpum*. Partial budgets were established and cost/benefit analysis was performed to compare the financial returns between different practices of reuse of urine and market gardeners' practices. Financial analysis showed that, the use of urine is 3%, 5% and 4% more profitable than market gardeners' practices respectively in the cases: 1) costs of operations are shared; 2) urine is not sold; 3) urine is sold based on international price of nitrogen. Based on the results obtained, the main recommendation for future research is to study the economic advantages of the adoption of EcoSan approach.

Keywords: Benin, Ecological Sanitation, financial returns, yield, *Solanum macrocarpum*

Introduction

In Benin, the lack of sanitation is one of the major challenges. According to INSAE (2006), only 1/3 of households have an access to adequate sanitation facilities. The consequence is that the health of adults and specifically children and women is seriously threatened. According to medical statistics of 2008, diarrhea at the level of children less than five years age is the 3rd cause of consultation and the 4th cause of hospitalization in Benin. Another important challenge Benin must face is the depletion of soil fertility. In recent diagnostic survey of smallholder agricultural sector, it was revealed that exhausted soils depleted of their natural mineral and organic constituents by many years of cropping without fallow, with little fertilization or manuring were the major factors contributing to low yields and poor food security in this sector. In order to tackle these problems in Benin, the Regional Centre for Drinking water and Sanitation with low costs (CREPA) has introduced Ecological Sanitation (EcoSan) which is based on ecosystem approaches and the closure of material flow cycles. Human excreta and water from households are recognised as a resource (not as a waste), which should be made available for re-use.

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Since 2002, several studies took place and have allowed to develop technologies (latrines and urinals) which facilitate the hygiénisation and agricultural valorization of the excreta, to identify the amounts of excreta which must be applied to the crop, to appreciate the acceptance of the approach in the communities, to know the chemical characteristics of the excreta in Benin. But, very few data exist on economic and financial returns of this approach. The objective of this paper is to highlight the financial advantages of the reuse of the urine hygienised in the production of *Solanum macrocarpum* (vegetable crop). The study was based on pilot scale plots aiming at assessing the potential production based on the yield (production per unit area) and the financial return of various practices of reuse of urine compared with farmer's practices.

Methodology

Study area and discussion with market gardeners

This study was conducted in the Republic of Benin (6–12°50'N and 1–3°40'E) in West Africa. Benin covers 112,622 km2 and is located in the 'Dahomey gap' (Jenik, 1994), the dry corridor which consists mainly of savannah and splits the African rainforest block into two parts. The climate is generally dry, composed of a subequatorial Guineo–Congolean region (6°25'–7°30'N), the Sudano-Guinean region (7°30'–9°30'N) and the Sudanian region (9°30'–12°N). This study was carried out in the first region in Cotonou where EcoSan is promotes in urban area. It is one of first areas of promotion of EcoSan approach. Moreover, discussions were made with market gardeners in order to understand their fertilizers practices including urine reuse for a realistic choice of the treatments to be tested.

Materials

The plant test is *Solanum macrocarpum* which is a vegetable cultivated by 95% of gardeners (Assogba-Komlan and al. 2007). *Solanum macrocarpum* is a regenerative plant and very appreciated in the beninese kitchen. Urea, chicken manure and human urine were used as fertilizers.

Laboratory analysis

Different substrates have been analyzed in this study. The table n°1 summarized these analyses.

Substrates	Items identified	Observations
Chicken manure	Corg, N,P,K, Ca++, Na+, Mg++, pH	Before expérimentations
Urine	Corg, N,P,K, Ca++, Na+, Mg++, pH	Before expérimentations
Soil	Corg, N,P,K, Ca++, Na+, Mg++, pH, grany structure, cation capacity exchange	Before and after expérimentations

The Nitrogen is measure by Kjeldalh method. Total and absorbed phosphorus are measure by ascorbic acid method, potassium, calcium and magnesium by ionic Chromatography ICS-1000 on samples mineralised by HACH method.

Experimental design

The study was designed as a two factor experimental design consisting of 50,8 m by 7,8 m randomized blocks with four (4) repetitions to ensure statistical validity. The major factor investigated was nutrients and the period of urine application. The nutrient factor was assessed on (4) four levels and the period of urine application was assessed on three (3) levels of treatments consisting of the following:

Treatment 0: (market-gardener's practice) : control: 5,5kg/m² of chicken manure +58,32g of urea/m².

Treatment 1 : 5,5kg/m² of chicken manure + 0,84L/m² of urine brought to the plant in one split

Treatment 2 : 5,5kg/m² of chicken manure + 0,84L/m² of urine brought to the plant in two splits

Treatment 3 : 5,5kg/m² of chicken manure + 0,84L/m² of urine brought to the plant in three splits

Treatment 4: 5,5 kg/m² of chicken manure + 0,7 L/m² of urine + 9,72 g of urea/m².

Treatment 5 : 5,5kg/m² of chicken manure + 2L/m² of urine brought to the plant in one split

Treatment 6 : 5,5kg/m² of chicken manure + 2L/m² of urine brought to the plant in two split

Treatment 7 : 5,5kg/m² of chicken manure + 2L/m² of urine brought to the plant in three splits

0,84L and 2L are respectively the quantity of urine applied by market gardeners and the quantity advised by extension services.

Data collected and calculated

During the field experimentations, the data which were collected are followings: the height of the plant, the number of leafs the width of the leaves, the length of the leaves, the number of ramifications, the cost of labour for nutrient application (urine, urea, and chicken manure), the selling price of *solanum macrocarpum*. Data calculated were, the yield in fresh and dry biomass and the price of the urine.

Methods of analysis of data

By the means of Variance Analysis (ANOVA) and Student Newman Keuls, the means of the above data were compared between the production of *Solanum macrocarpum* resulting from market gardeners' practices of chicken manure and urea and the one resulting from various practices of chicken manure and urine. In order to evaluate the financial profitability, partial budgets as advised by Alimi and Manyong (2000) were established and cost/benefit analysis was performed to compare the financial returns between different practices of reuse of urine and market gardeners' practices. Partial budgets include only costs that vary from one technology to other. Partial budgets are completed by a dominance analysis. According to this method, all technology with a net impact lower or equal to another which has total cost change more weak is said technically dominated (Quenum, 1995 et Manyong, 2000). In our context, because the urine has not yet any market, the urine price is estimated based on four scenarios:

Scénario1: The selling price of urine= cost of nitrogen on the international market + local transport cost of urine
Scénario 2 : The selling price of urine = local transport cost of urine from production site to reuse site
Scénario 3 : The selling price of urine covers all of exploitation cost of urinals and include local transport cost of urine
Scénario 4 : The selling price of urine covers 50 % of exploitation cost of urinals and include local transport cost of urine

Results and discussion

Characteristics of the substratesused during the field experimentation

The analysis of the substrates used revealed that:
• The hygienized urine (i.e. stored during 30 days) is rich in nitrogen (4,3 g/l) and potassium (0,83 g/l) and has a basic pH;
• The chicken manure used is very rich in potassium (74,92 méq/100 g), organic carbon (28,52%) and total phosphorus (1,04%); chicken manure contains 0,92 % of nitrogen;• The soil is low in nutritive elements. Indeed, contents of major elements as the nitrogen (0,22%), phosphorus (0,13%) and potassium (0,006%) are weak. Characterized by a neutral pH, this soil has a sandy texture, therefore filter and light.

Effects of the various treatments on the agronomy parameters

The effects of the various treatments on the agronomy parameters are summarized on figures 1 and 2.

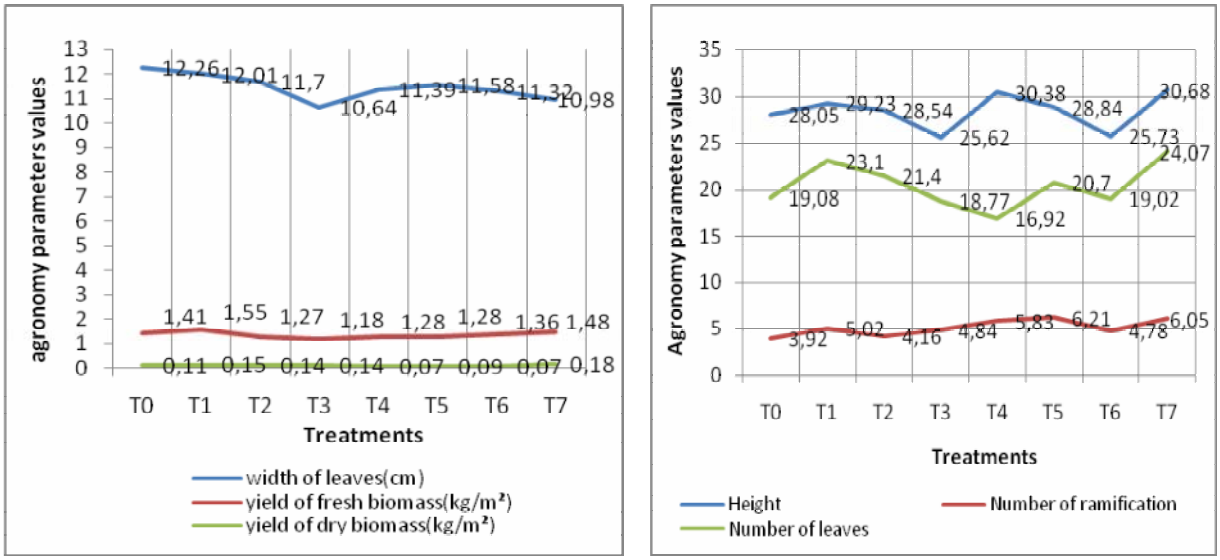

Figure n° 1: Effects of treatments on the agronomies parameters at the first harvest

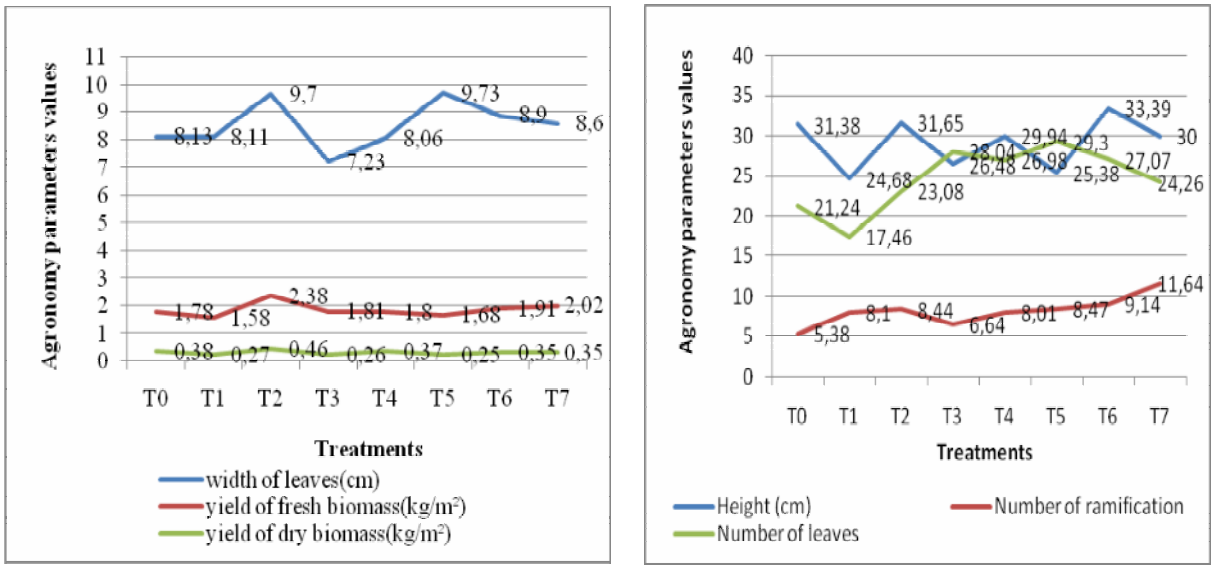

Figure n° 2: Effects of treatments on the agronomies parameters at the second harvest

The analysis of figure above show no great difference between the differents treatments of the parameters measured (Width of leaves, yield of fresh and dry biomass, height of plant, number of ramification, number of leaves). The statistical analysis of variance with the Student Newman Keuls test showed that there is no significant statistical difference between the treatments for all of the parameters measured (table n°2). This imply that the splitting (5, 15, and 25 days after transplantation) of the quantity of urine brought to *Solanum macrocarpum* produces the same effects as one direct application of the same quantity of urine on the number of leaves, the width of the leaves, and on the yield of fresh and dry biomass. Also, these results suggested that there was no significant statistical difference between the yields in dry and fresh biomass of market gardeners practices and the various practices of reuse of urine (yields in dry and fresh biomass are respectively 0,22 kg/m² and 1,5 kg/m²). The meaning of this result is that urine is an alternative as nitrogen fertilization. Moreover, table n°2 shows that there was a significant statistical difference at p=0,01 between the two harvests about parameters such as number of leaves, width of leaves and yields in dry and fresh biomass. At the second harvest, the parameters measured are higher than those measured at the first harvest. These results could be explained by the addition of effects and back-effects of different fertilizers that are used. Finally, table n°2 shows that there was any interaction between treatments and harvests. This suggests that, from a harvest to other, the back-effects of different treatments on agronomy parameters are statistically the same.

The dose of 5,5 kg of chicken manure per m² corresponds to 506 kg N/ha. The quantity of N added with the chicken manure gives enough nitrogen to the soil, which diminishes the impact of the nitrogen in urea and urine. A control plot with only chicken manure would have been useful to determine the yield with only the base fertilizer.

Table n°2: Analysis of variance

Sources of variations	DF	Probability				
		Height	Number of leaves	Width of leaves	Yield in fresh biomass	Yield in dry biomass
harvest	1	0,60 ns	0,008**	<0,0001***	<0,0001***	<0,0001***
Treatment	7	0,61 ns	0,74 ns	0,55 ns	0,68 ns	0,65 ns
harvest*Treatment	7	0,45 ns	0,16 ns	0,82 ns	0,37 ns	0,56 ns
Error	48	-	-	-	-	-
cv%	-	19,4	27.6	17.24	14,6	40,8

ns : no significant difference at p<0,05 ; *** : significant difference at p< 0,01 ; data had been submitted to logarithm transformation

Financial profitability analysis

The results of partial budgets and analysis of dominance according to each scenario are summarized in the table n°3 :

Table n°3 : Results of partial budget and analysis of dominance

		To	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**
Scénario1	Total costs change (FCFA/m²)	27	17	17	17	18	48	48	48
	Net impact (FCFA/m²)	251	261	261	261	260	230	230	230
	Marginal cost/To (FCFA/m²)		9,92	9,92	9,92	8,75	-21	-21	-21
	Marginal net impact/To (FCFA/m²)		-9,9	-9,9	-9,9	-8,7	21	21	21
	Marginal rate of profitability/To (%)		-100	-100	-100	-100	-100	-100	-100
	Analysis of dominance	T1=T2=T3>T4>T0>T5=T6=T7							
	Profitability of reuse of urine compared to market-gardeners practices (T0)	4%							
Scénario2	Total costs change (FCFA/m²) (FCFA/m²)	27	14	14	14	16	41	41	41
	Net impact (FCFA/m²)	251	264	264	264	262	237	237	237
	Marginal cost/To (FCFA/m²)		12,38	12,38	12,38	10,58	-14	-14	-14
	Marginal net impact/To (FCFA/m²)		-12	-12	-12	-10,6	14,07	14,07	14,07
	Marginal rate of profitability/To (%)		-100	-100	-100	-100	-100	-100	-100
	Analysis of dominance	T1=T2=T3>T4>T0>T5=T6=T7							
	Profitability of reuse of urine compared to	5%							

		To	T1	T2	T3	T4	T5	T6	T7
	market-gardeners practices (T0)								
Scénario3	Total costs change (FCFA/m²)	27	34	34	34	37	122	122	122
	Net impact (FCFA/m²)	251	244	244	244	240	156	156	156
	Marginal cost/To (FCFA/m²)		-6,98	-6,98	-6,98	-10,7	-95	-95	-95
	Marginal net impact/To (FCFA/m²)		6,98	6,98	6,98	10,71	95,17	95,17	95,17
	Marginal rate of profitability/To (%)		-100	-100	-100	-100	-100	-100	-100
	Analysis of dominance	T0>T1=T2=T3>T4>T5=T6=T7							
	Profitability of reuse of urine compared to market-gardeners practices (T0)	-							
Scénario4	Total costs change (FCFA/m²)	27	20	20	20	24	70	70	70
	Net impact (FCFA/m²)	251	258	258	258	254	208	208	208
	Marginal cost/To (FCFA/m²)		6,62	6,62	6,62	2,88	-43,4	-43,4	-43,4
	Marginal net impact/To (FCFA/m²)		-6,62	-6,62	-6,62	-2,88	43,4	43,4	43,4
	Marginal rate of profitability/To (%)		-100	-100	-100	-100	-100	-100	-100
	Analysis of dominance	T1=T2=T3>T4>T0>T5=T6=T7							
	Profitability of reuse of urine compared to market-gardeners practices (T0)	3%							

The analysis of the table n°3 shows that the use of urine is 3%, 5% and 4% more profitable than market gardeners' practices respectively in the cases costs of operations are shared, urine is not sold, urine is sold based on international price of nitrogen. On the other hand, the splitting of the quantity of urine does not have any significant influence on the profitability of the Solanum macrocarpum production (net impact is the same for T1, T2, T3 for example). The net impact is the highest when urine is not sold or when operations costs of urinals are shared on users of urinal and consumer of urine. We could notice that treatments relate to quantity of urine advised by extension services are technically dominated by those relate quantity of urine applied by market-gardeners.

Conclusion

Most of research in EcoSan area is focused on technical, health, agronomy and cultural aspects. However financial and economic aspects have hardly been adressed. This paper is a contribution for filling the gap. The investigations showed that the splitting of the quantity of urine brought to *Solanum macrocarpum* produces the same effects as one direct application

of the same quantity of urine on the number of sheets, the width of the sheets, and on the yield of fresh and dry biomass. Market gardeners' practices produce yields not significantly different from those obtained with the various practices of reuse of urine in the production of *Solanum macrocarpum.* Financial analysis showed that, the use of urine on Solanum macrocarpum production is more profitable than gardener's practices on a range from 3 to 5%. The very small difference in of the different treatments is probably due to the very strong base fertilizer (chicken manure), which shadows the effect of extra nitrogen fertilizer (urea and urine). It would have been necessary with a control plot with only chicken manure to evaluate this effect. This research is focused on financial return of reuse of urine in market gardening not on the all EcoSan system. The methods used here for financial evaluation can be replicated in other contexts. However, the economic aspects were not taken up such as environment cost. It will be very important in future research to tackle these research challenge about EcoSan approach.

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