Full Length Research Paper

Financial profitability and technical efficiency of horticultural crops in the Nakanbé River Watershed in Burkina Faso

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In the watershed of the Nakanbé River in Burkina Faso, horticultural crops are financially profitable with high gross incomes, cost/revenue ratios and attractive hourly returns to labor. Based on a 6-h work day, profitability indicators of horticultural crops show that farmers are better-off compared to the 'less than one dollar' situation of people in Burkina Faso; horticultural crop production could thereby be an important part of a poverty reduction strategy in the studied sites and other rural areas. The proportion of efficient producers ranged from 35% for tomato in Ouonon to 100% for onion in Zekeze. Considering efficiency for individual crops, onion production in Zekeze was the most efficient, with a maximum score of (100%), followed by the production of cucumber in Ouonon and green beans in Kongoussi with respective scores of 98%. Inputs (seeds, fertilizers and pesticides) are used in excessive quantities which tend to reduce technical efficiency and could have negative environmental impacts. Improving horticultural crop producers' capacities to use appropriate rates of chemicals and organic inputs or biological treatments is recommended since the survival as well as the development of this kind of farming increases rural households' incomes and supplies fresh food to an increasing urban population at a reasonable price.

Key words: Horticulture, cost/revenue ratio, hourly return, efficiency, input excess, environment, Burkina Faso.

INTRODUCTION

Burkina Faso is one of the poorest countries in the world; the incidence of poverty is 43.9% at the national level (INSD, 2010). Poverty is greater in rural than urban areas. In order to ensure their economic and nutritional survival, rural, urban as well as peri-urban populations produce horticultural crops under irrigation, particularly during the dry season. In Burkina Faso, only 12% of the total irrigable land is under irrigation (Government of Burkina Faso, 2005), and 30% of the irrigated area produces horticultural crops. Burkina Faso has been an exporter of fruit and vegetables such as fresh green beans since 1970, but in recent years the competitiveness of this sector has sharply declined. This decline in competitiveness of horticultural products and the sub-sequent reduction of exports has been 'the result of an intrinsic decline in the quality of the product" (Government of Burkina Faso, 2005). Any loss of competitiveness leads to a loss of market and therefore, to a reduction of exports earnings. Since the daily income per capita is less than one U.S. dollar in Burkina Faso,

any decline in export earnings reduces per capita income and then worsens poverty.

Reduced quality of horticultural products not only has a negative influence on the competitiveness of the sector, but also leads producers to use excessive amounts of inputs (fertilizers and pesticides) during production, which poses environmental problems.

According to the definition of Koopmans (1951), 'a producer is efficient if he maximizes output given the input he uses; that is, transforming inputs to outputs he needs a certain kind of technology. Since this type of efficiency deals solely with technology this type of efficiency is called technical efficiency', while allocative efficiency measures the ability of the farmer to use inputs in optimal proportions, given input prices.

Technical efficient is rather the ability of the farmer to produce maximum output from a given level of inputs, whatever these inputs are.

It is therefore important to identify bottlenecks and weaknesses in horticultural production to understand the production decline in recent years in order to improve production in the future. This objective of this study is to analyze the profitability and technical efficiency[1] of horticultural crop production in the Nakanbé River watershed in Burkina Faso.

METHODOLOGY

Data collection

The first step in data collection was the choice of study sites in the watershed with farmers' cooperatives and associations. The selection criteria were (i) the volume of horticultural crop production during the dry season of candidate sites, (ii) ease of access to the production area, and (iii) the level of cooperation of the producers in the sites.

Using the above criteria, four (4) sites were chosen (Figure 1): Kongoussi, in the Bam province; Titao, in the Loroum province; Ouonon, in the Passore province and Zekeze in the Boulgou province.

The survey was conducted during the 2004 dry season to a total of 131 randomly selected farmers: 31 in Kongoussi, 24 in Titao, 36 in Zekeze and 40 in Ouonon. The questionnaire used for data collection included the (i) farmers' socio-demographic characteristics (ii) land parcel identification, crops and cropped areas, and land tenure, (iii) cropping calendar describing the succession of farming operations (iv) quantity and cost of inputs used, (v) family labor indicated by the number of persons and amount time spent working by gender, age, crop produced, and cropping operation, (vi) amount of hired labor in hours and payments in cash and in-kind (vii) inventory of equipment used (purchased or borrowed), (viii) cost of equipment repair and maintenance, (ix) quantities harvested and sales by crop, and (x) marketing problems.

Method of analysis

The method of analysis included profitability, technical efficiency and measures of excess inputs use.

Indicators of financial profitability

Production budgets were used to assess profitability, especially cost/revenue ratio and hourly payment, during the dry season. For a given crop, the household average production was computed and valued at average sale prices to get the gross income (GI).

The corresponding cost/revenue ratio (C/RR) is calculated as: C/RR= GI/VC where VC is total variable costs to produce the crop. The related hourly payment (HP) is obtained, dividing GI by the number of family hours (FL), that is HP=GI/FL.

The higher the gross income and hourly payment, the more profitable is the crop[2].

Technical efficiency

The Data Envelopment Analysis (DEA) method was used to analyze the technical efficiency of horticultural crops producers which is a non-parametric method, a deterministic measurement of technical efficiency. This method is based on models of optimization and linear programming techniques. The analysis was performed using the DEAP (Data Envelopment Analysis Program) (Coelli, 1996); in addition to the level of efficiency it provides, this software also gives information on the variables which are the sources of the inefficiency.

The method is based on the measurement of the ratio output/input in the form u'yi/v'xi where u is a Mx1 vector of relative weights of outputs and v a Kx1 vector of relative weights of inputs. Optimal weights are obtained by solving a problem of mathematical programming, specified as follows:

Max u,v   (u'yi/v'yi),

st u'yj/v'yj ≤1, j= 1.2 , … . ,N
    u,v≥0.

The objective is to find values for u and v such that the measure of the efficiency of the unit of decision i (a farmer in our case) is maximized under the constraint that all measures of efficiency are less than or equal to 1. This formulation of ratio has the disadvantage of having an infinite number of solutions since if (u*, v*) is a solution of the program, then so is (αu*, αv*).

To overcome such a difficulty, an additional constraint is imposed and the problem is reformulated after transformation; the DEAP model developed by Coelli (1996) uses the dual program as reformulated (Coelli, 1996).

Some authors such as Boles (1966) and Afriat (1972) proposed methods of linear programming to estimate the isoquant frontier; such methods did not receive attention until Charnes et al. (1978) introduce the term "Data *Envelopment Analysis*". The model developed by Charnes et al. (1978) focused on the inputs[3] and based on the assumption of the constancy of returns to scale. Later on, alternative hypotheses were introduced; Banker et al. (1984) proposed a model rather based on the assumption of variable returns to scale.

Inputs excess

Referring to Figure 2 illustrating this idea of input excess, it can be seen that on the same linear segment of the isoquant convex frontier SS', you can have an optimal point with the possibility of

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[1] This technical efficiency differs from the agronomic efficiency (fertilizer or irrigation).

[2] Gross income was preferred to net income due to difficulties to get required data, that is, opportunity cost of labor in the absence of a rural labor market, costs related to crop production.

[3] Some models are centered on the output but we use here the option input-oriented DEA software.
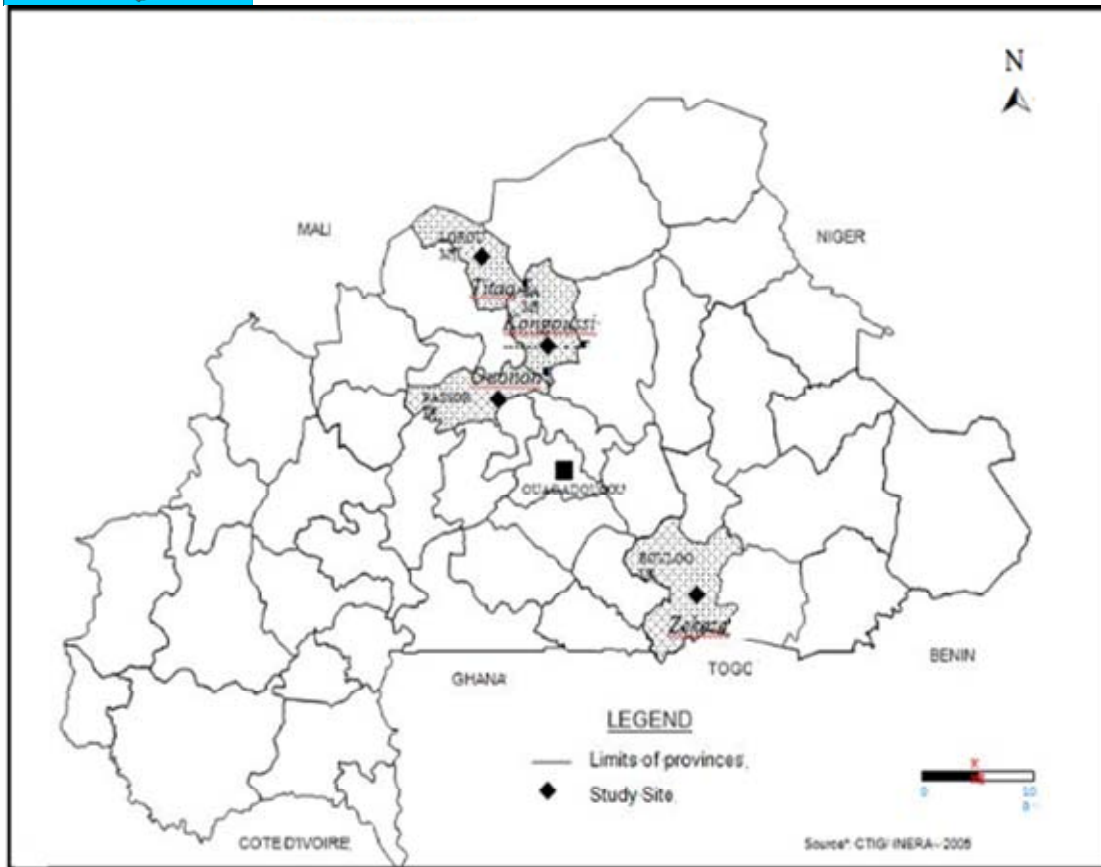
Figure 1. Location of study sites.

reducing the quantity of inputs (x_1 and x_2) used without reducing the level of production (y). We may then wonder if such a point is optimal; it is an excess of inputs used, that could have been saved, since this does not increase the level of production. The technical efficiency for decision units A and B are respectively of OA'/OA and OB'/OB; the question that can be raised is whether point A' is efficient since the quantity of input x_2 can be reduced by CA' without reducing the level of production; CA' is therefore the input excess of x_2. The Data Envelopment Analysis software provides options for the calculation of the excess inputs.

## RESULTS AND DISCUSSION

Main crops production

The main crops in Titao are onion and potato; green beans predominate in Kongoussi while at Zekeze, onion,

tomato and banana are the most important vegetable crops. In Ouonon, the main crops are tomato, eggplant and cucumber (Table 1).

Profitability of horticultural crops[4]

Potato and onion in Titao have the highest gross incomes per hectare, followed respectively by onion in Zekeze, green beans in Kongoussi, banana in Zekeze, onion and tomato in Ouonon, tomato in Zekeze, eggplant and cucumber in Ouonon (Table 2). However, the cost/revenue ratio of 8.77 reveals the greatest profitability for onion in Ouonon. Potato and green beans, despite good gross incomes, recorded relatively poor cost/revenue

[4] US dollar 1.00= FCFA 500.
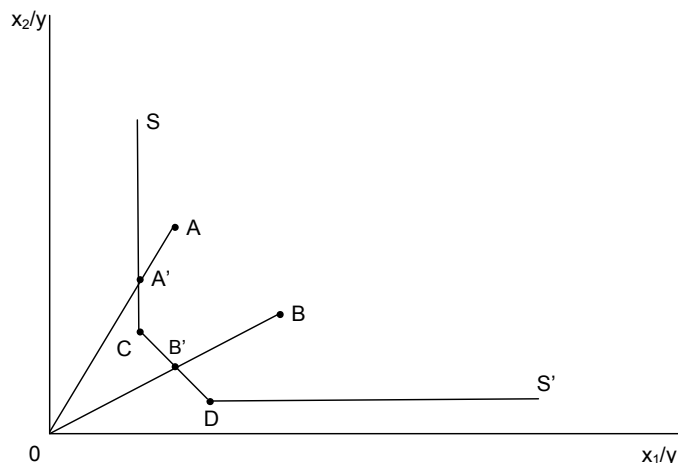
Figure 2. Measure of efficiency and excess inputs. x_1/y : quantity of input x_1 to produce a unit of production y; x_2/y: quantity of input x_2 to produce a unit of production y. Source: Coelli (1996).

Table 1. Main crops areas by study site.

Sites	% of households	Area (m²)
Kongoussi-Bam		
Green Beans	87	2,978
Titao-Lorum		
Onion	58	433
Potato	39	511
Ouonon-Passoré		
Tomato	80	8,113
Onion	75	7, 993
Eggplant	53	3,640
Cucumber	40	3,700
Zekeze- Boulgou		
Banana	56	11,000
Tomato	47	6,147
Onion	47	4,755

Source: Author's computations.

ratios due to high input costs, especially for seeds and water. Green beans producers had to pay a water fee of 400,000 FCFA/year and the seed cost was estimated at 225,650 FCFA per hectare, while potato required 2,126,600 FCFA of seed per hectare for its production.

The cost/revenue ratio was significantly higher for tomato in Ouonon than in Zekeze. Eggplant and cucumber had the lowest gross revenues, but still financially rewarding with revenue/cost ratios of 1.72 and 1.77, respectively.

Potato had the highest gross margin per hour (1733 FCFA). The hourly remuneration of green beans was

intermediate in Kongoussi (525 FCFA), and lowest for cucumber in Ouonon (206 FCFA) and banana in Zekeze (260 FCFA) which was the most labor-demanding.

Onion had a higher hourly payment in Ouonon than in Titao and Zekeze. Tomato recorded a higher hourly remuneration in Ouonon than in Zekeze.

Based on a 6-h work day, profitability indicators show that farmers are better-off compared to the 'less than one dollar' situation of people in Burkina Faso. Pro-poor rural economic policy could therefore be promoted through the production of horticultural crops.

Technical efficiency

Scores of efficiency

Scarce studies are available on horticulture efficiency in Africa and in Burkina Faso. However, Jema (2008) conducted an interesting one in Ethiopia and found that mean technical efficiency for vegetable production was 96% in two districts of eastern Ethiopia.

In our study, it is found that technical efficiency scores (Table 3) showed that the proportion of efficient producers ranged from 35% for tomato in Ouonon to 100% for onion in Zekeze.

Cucumber production in Ouonon, green beans in Kongoussi, tomato in Zekeze, potato in Titao and eggplant in Ouonon also recorded a technical efficiency score greater than 70%.

Considering efficiency for individual crops, onion production in Zekeze was the most efficient, with a maximum score of 100%, followed by the production of cucumber in Ouonon and green beans in Kongoussi with respective scores of 98%. Onion had a lower efficiency score in the northern site of Titao, and in Ouonon (88% and 84% respectively); the lowest technical efficiency score was recorded in Ouonon for tomato with a score of 68.4%. Green beans and potato producers were less efficient than onion producers in the southern site of Zekeze and cucumber producers in Ouonon. The reasons for this inefficiency should be investigated in order to improve the profitability and competitiveness of horticultural crops.

Excess inputs

The use of excessive levels of inputs is one source of technical inefficiency. In Kongoussi, the inputs that most farmers used in excessive quantities, included seeds (probably because of poor quality) and fertilizers (NPK and urea) (Table 4).

The use of fertilizers in excess quantities reflects the decline in soil fertility that producers tried to compensate yield decrease by increasing application rates which might result in environmental pollution. Less important excess uses were observed on family labor, energy and

Table 2. Per hectare production budgets (FCFA).

Item	Kongoussi	Titao		Ouonon				Zekeze		
	Green beans	Potato	Onion	Onion	Eggplant.	Tomato	Cucumber	Banana	Tomato	Onion
Gross Income (FCFA)	2 091 486	8 369 262	3 534 948	1 463 926	447 564	1 201 404	388 080	2 074 317	708 985	2 148 133
Variable costs (FCFA)	856 747	3 080 201	1 141 320	166 857	260 427	181 767	219 372	673 327	354 995	598 704
Seeds	225 650	2 126 600	291 288	15 844	13 968	15 996	15 189		33 000	175 882
NPK fertilizer	77 750	480 066	428 260	32 743	45 120	39 432	31 654	107 803	40 500	82 536
Urea	35 424	-	65 869	11 508	24 000	12 393	20 003	177 680	26 059	44 469
Organic manure	28 703	196 929	121 580	18 333	25 038	22 386	24 720	-	8 437	56 666
Insecticide	23 350	124 645	100 595	12 450	25 717	13 743	14 167		17 312	17 500
Water fee	400 000	-	-	-	-	-	-	-	-	-
Labor Cost	20 000									
Diesel/gasoline	-	131 361	131 361	15 180	38 909	18 935	26 500	224 607	132 326	138 300
Repairs and maintenance	4 100	20 600	2 367	9 522	2 511	9 960	2 524	93 467	20 173	23 133
Hired labor	41 770	-	-	51 277	85 164	48 922	84 615	69 770	77 188	60 218
Cost/revenue ratio	2.44	2.72	3.10	8.77	1.72	6.61	1.77	3.08	2.00	3.59
Family labor (hours)	3 980	4 830	4 025	1 654	2000	1549	1884	7967	2979	3878
Hourly payment based on gross margin (FCFA)	525	1 733	878	885	224	776	206	260	238	554

Source: Author's computations.

Table 3. Technical efficiency by site and crop in the Nakanbé River watershed.

Item	Kongoussi	Titao		Ouonon				Zekeze		
	Green beans	Potato	Onion	Onion	Egg-plant	Tomato	Cucumber	Banana	Tomato	Onion
Technical efficiency (%)	97.5	95.8	88.2	84.3	91	68.4	98.2	88.5	91.1	100
Proportion of efficient producers (%)	74	82	61	60	79	35	94	68	82	100

Source: Author's computations.

depreciation for 43% inefficient farmers.

In Titao, excess use of inputs was observed in the production of potato and onion: excess use of seeds and NPK fertilizer for 513,059 FCFA/ha and 150,111 FCFA/ha respectively for potato. For onion production, excess levels were of 293,697 FCFA/ha for seed, 203,695 FCFA for NPK fertilizers,

61,919 FCFA for urea, 201,739 FCFA for the organic manure and 106,795FCFA for pesticides. On the production site of Ouonon, not only inputs were used in excess quantities; hired labor also recorded a peak of excess level of 39,778 FCFA/ha and 50,117 FCFA/ha for onion and tomato, respectively.

In Zekeze, banana inefficient producers recorded on average an excess inputs use of 112,076 FCFA/ha for the NPK fertilizer, 138,237 FCFA for urea and 125,064 FCFA for energy. Unlike banana, the recorded major excess input use was in tomato production: 169,889 FCFA/ha (100% of farmers) for energy and 116,780 FCFA

Table 4. Excess production factors (in FCFA/ha).

Input/factor	Kongoussi	Titao		Ouonon				Zekeze		
	Green Beans	Potato	Onion	Onion	Eggplant	Tomato	Cucumber	Banana	Tomato	Onion
Seeds	18016 (57)	513059 (100)	293697 (71)	9924 (25)	2492 (100)	8489 (55)	0	0	7667 (67)	0
NPK fertiliser	21374 (71)	150111 (100)	203695 (71)	14069 (67)	27352 (40)	21461 (80)	110 (100)	112076 (100)	6891 (100)	0
Urea	7957 (71)	0	61919 (86)	5265 (75)	24000 (20)	8937 (65)	555 (100)	138237 (67)	6482 (100)	0
Organic manure	7700 (85)	22211 (50)	201739 (100)	10274 (58)	20984 (100)	12985 (90)	13 (100)	0	2221 (67)	0
Insecticide	6291 (71)	60173 (50)	106795 (57)	4648 (75)	4927 (40)	9138 (55)	625 (100)	0	5040 (33)	0
Energy	3347 (43)	0	46864 (43)	5995 (92)	1343 (20)	15072 (100)	0	125054 (67)	169889 (100)	0
Hired labor	0	0	0	39778 (33)	0	50117 (60)	0	50345 (33)	116780 (33)	0
Depreciation	700 (43)	18120 (50)	4704 (71)	4490 (75)	2181 (60)	8772 (75)	0	6067 (33)	0	0
Family labor	1021 (43)	0	14501 (71)	584 (67)	2245 (40)	738 (70)	110 (100)	6695 (33)	2330 (67)	0

Source: Author's computations. Figures in parentheses are the proportion of inefficient producers in the use of input or factor of production. Energy=diesel/gasoline repairs and maintenance.

for hired labor (33% of farmers).

In general, all sites recorded excess inputs including fertilizers (NPK, urea) and insecticides. This means that producers are losing money by applying such high quantities of fertilizers and insecticides. In addition to the reduced profitability, excessive use of fertilizer and insecticides can reduce the sustainability of their production system due to negative long-term effects on the environment. Furthermore, this would contribute to reduce market demand as consumers are more and more demanding for use of ecological and healthy production practices.

CONCLUSION AND RECOMMENDATIONS

The results of the study show that production of horticultural crops is financially profitable in the Nakanbé River watershed in Burkina Faso. Satisfactory cost/revenue ratios were found, especially in Ouonon for tomato and onion. Horticulture has relatively high hourlypayment: 525 FCFA/hour for green beans in Kongoussi,

1,733 FCFA for potato in Titao, 885 FCFA and 776 FCFA in Ouonon, respectively. Promotion of horticultural crop production could be part of a sound pro-poor strategy in rural areas. Despite good financial performance, horticultural crop producers are not totally efficient and improvements are possible. Farmers exhibited technical inefficiencies, which indicates that they have not mastered existing technologies and that improvements are needed. These inefficiencies should be addressed before new costly investments are made and future research should investigate the causes of the technical inefficiency. Agronomic studies are necessary to assess the impact of excess input use (particularly of fertilizer and insecticides) on the environment. Producers need training on input rates, substitution of organic for chemical inputs, and use of biological techniques, and sensitization on the environmental risks associated with excessive chemical rates.

The survival as well as development of horticultural crop production is important to increase rural household income while supplying

fresh food to an increasing urban population at a reasonable price.

Conflicts of Interest

The authors have not declared any conflict of interest.

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