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Determinants of Post-Harvest Losses of Tomato (Solanum Lycopersicum L.) Crop among Producers in the Loma Valley in Mbanza-Ngungu in the Democratic Republic of Congo

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Summary

Post-harvest losses in sub-Saharan Africa are a major problem because they are a waste of production factors. More than half of agricultural production is lost while food imports exceed $35 billion each year. It makes sense to protect agricultural production from post-harvest losses. This study evaluated the main determinants of post-harvest losses among producers at the Loma market garden site in Mbanza-ngungu. To do this, data on the socio-demographic characteristics of the producer and the characteristics of the farm were collected from 102 producers. The estimation of the model using the ordinary least squares method provided statistical evidence that educational attainment, agricultural experience, farm size and the number of people involved in crop management affect post-harvest losses.

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Introduction

For decades, the main objective of many agricultural policies has been to increase production to achieve food self-sufficiency [1]. This objective has been accentuated by the fact that the world population has been projected to reach 9 billion by 2050, which requires a 70% increase in production upstream to ensure food self-sufficiency [2]. The increase in agricultural production around the world is underway, but a large part of the population does not have access to adequate food supplies. There are several reasons for this. One of them is the huge amount of agricultural products lost in the post-harvest period [3]. The issue of combating post-harvest losses is part of the 2030 Sustainable Development Goals (SDGs). Limiting food loss could halve the amount of food waste per capita globally by 2030 [4]. Indeed, huge quantities of waste are produced along the production, supply and consumption chains [2,5]**.** Reducing post-harvest losses is part of sustainable agriculture and food security strategies [6]. In sub-Saharan Africa, a considerable amount of agricultural products are lost due to inappropriate post-harvest processes, while an estimated 374 million people are severely food insecure [2]. Thus, the fight against post-harvest losses remains crucial as millions of Africans still suffer from malnutrition and food imports exceed $35 billion per year [7]. In the Democratic Republic of the Congo, post-harvest loss estimates are in the range of 10 to 60% for beans in the Stock More than 50% for yams and 40% for the safous [8-10]. Following this reality, a The National Pact to Combat Food Waste (PNLGA) was set up by the Ministry of Agriculture in 2021. Tomatoes, a highly perishable product, are among the most affected by post-harvest losses [7,11]. According to (FAO, 2018), It is the product with the highest annual total loss rate [6]. These losses sometimes reach up to half of the production [12]**.** Estimates of the extent of the phenomenon suffer from insufficient data available [13]**.** Hence the reason for this study, which aims to answer the question of what are the determinants of post-harvest losses for tomato cultivation among producers in the Loma Valley in Mbanza-ngungu; the most large supply centre for the city of Kinshasa in tomatoes.

Materials and Methods

Study Environment

The survey was conducted among tomato producers in the Loma Valley in Mbanza-ngungu (695m above sea level, 05°15' south latitude and 14°51' east longitude). The climate is AW4 according to the Köppen classification; Sudanese humid tropical climate, characterized by a large rainy season lasting eight months from late September to late May, interspersed with a short dry season from January to February, and a large dry season from June to September [14]. The average annual temperature is 23.6°C. The hottest months are February, March and April with a maximum of 32.5°C and a minimum of 25.2°C. The coolest months are July and August with a maximum of 28.9°C and a minimum of 15.9°C. About 1358mm of precipitation falls each year [15].

Material and Method

Data Collection

Data were collected from tomato producers from a survey questionnaire comprising 3 modules, namely: socio-demographic characteristics of the producer (gender, marital status, level of education, age of the producer, household size, experience and membership of a public transport organisation); characteristics of the farm (area allocated to tomato cultivation, variety used, type of labour, etc.). post-harvest agricultural assets, production season, harvest maturity, packaging materials, place of sale and quantity produced) and measurement of post-harvest loss (mishandling, pests and diseases, adverse climatic conditions and theft). The sample size was calculated according to the formula: n = $\frac{1}{e^2}$ = 100 (with $\frac{1}{0,01}$e² = error threshold = 10%). With a response rate of 90%, the final sample size was = 111 producers. Given the unavailability of some producers and the refusal of others, only 102 forms were correctly completed. As there was no list of tomato growers in the Loma Valley, the sample was drawn using the blind sampling technique. There was a homogeneity among producers in terms of production methods and technical constraints. : $\frac{100}{0,9}$

Empirical Model of Analysis

The dependent variable considered was the total amount of tomato lost measured in kg. Twelve explanatory variables were taken into account to explain the amount lost: gender of producer, age, level of education, household size, agricultural experience, membership in a farmers' organization, area allocated to tomato cultivation, number of agricultural workers in post-harvest, production season, harvest maturity, packaging material and place of sale.

The following table presents the expected measures and signs of each explanatory variable.

Table 1: Expected Signs of the Explanatory Variables

Variable	Definition	Measurement	Expected sign
X1	Producer's gender	1 = Male; 0 = Female	Negative
X2	Level of education	1 = Uneducated; 2 = Primary level; 3 = Secondary level; 4 = Graduation level; 5 = License Level	Negative
X3	Membership of a farmers' organization	1 = Yes; 0 = No	Negative
X4	Harvest maturity	1 = Complete maturity; 0 = Incomplete maturity	Positive
X5	Packaging Material	1 = Plastic bin; 0 = Wooden crate	Negative
X6	Production season	1 = Dry; 0 = Rainy	Negative
X7	Place of sale	1 = Kinshasa ; 0 = Mbanza-ngungu	Positive
X8	Age of the producer	Number of years since birth	Negative
X9	Household size	Number of people at home	Positive
X10	Agricultural experience	Number of years in agriculture	Negative
X11	Area allocated to tomato cultivation	Number of beds × area of beds	Positive
X12	Number of agricultural workers	Number of persons who worked on the holding	Positive

The multivariate analysis consisted of ordinary least squared multiple regression with a Cobb-Douglas production function. The logarithmic model Log (y) = Log (Xi) has made it possible to transform the initial equation into linear form. The overall significance of the model, with the Fischer test, is checked if the probability is less than the 10% error alone (p-value<0.1). Individual significance, on the other hand, with the Student's test, compares the probabilities of each explanatory variable with the error threshold (10%). A variable will be said to be significant if its probability is below the error threshold of 10% (p-value<0.1).

Results

The following figure shows the different factors that have caused post-harvest losses of tomatoes among producers. The greatest losses are caused by pests and diseases. Indeed, it is because of the presence of Tuta Absoluta, a tomato leafminer caterpillar. Producers have tried in vain to limit its spread. And this failure resulted in enormous damage to the harvest in terms of rot.

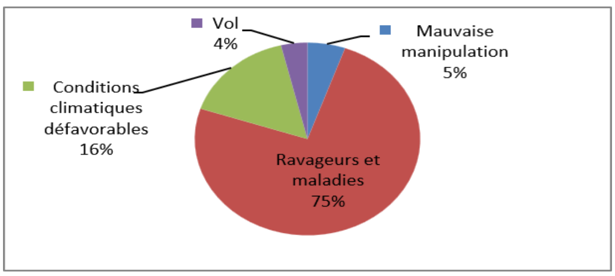

Figure 1: Causes of Post-Harvest Losses (source: author based on survey data)

The following image shows an overview of the damage caused by Tuta absoluta on the crop

Figure 2: Overview of the Damage caused by Tuta absoluta (source: the author on the survey site)

The following table presents the quantification of post-harvest losses for tomatoes. On average, a producer loses 469.4kg of tomatoes per crop cycle. This is equivalent to 26.5% of total production. In extreme cases, such as the invasion of the field by the leafminer Tuta absoluta, losses can reach up to 81% of total production.

Table 2: Quantification of Post-Harvest Losses for Tomatoes

Variables	Medium	Standard deviation	Minimum	Maximum
Quantity lost (kg)	469,4	313,9	45	1500
Percentage loss	26,5	14,8	2	81

The following table presents the modelling of the quantity of tomatoes lost by the different explanatory variables. It appears that the model is good overall; The quantity of tomato lost is explained at 38% by all the explanatory variables. The individual significance reveals that the educational level variable negatively influences the amount of tomatoes lost while the agricultural experience, tomato area and farm assets variables positively influence it.

Table 3: Modelling of the Quantity of Tomato Lost

Log Quantity Lost	Coefficient	P-value	LIVE
Gender	+0,078	0,364	1,36
Log N.I	-0,55 *	0,058	1,29
OP Member	+0,53	0,505	1,09
Harvest maturity	+0,64	0,596	1,28
Packaging Material	+0,05	0,349	1,09
Production season	-0,07	0,238	1,13
Place of sale	+0,02	0,791	1,35
Log age	-0,23	0,423	2,32
Log Household Size	-0,12	0,475	1,26
Log Exp. Agricultural	+0,25 **	0,024	2,09
Surface Log	+0,28 **	0,012	1,70
Log Agricultural Assets	+0,43 **	0,032	1,59
Constant	+2,03 ***	0,000	
Prob > F = 0,0000 ; R^2 = 0,38			

The function of the quantity of tomatoes lost can therefore be written as follows: Log Q.P = 2.03 - 0.55 log N.I + 0.25 log E.A + 0.28 log S + 0.43 log A.A (With Q.P = quantity lost in kg; N.I = level of education; E.A = Agricultural experience; S = Surface area in m² and A.A = Number of agricultural workers). After eliminating the logarithmic form, the function of the quantity of tomatoes lost becomes: Q.P = 107 - 3.6 N.I + 1.7 A.A + 1.9 S + 2.7 A.A

There is a negative correlation between the level of education of the producer and post-harvest losses. The more educated the producer, the less losses he makes. Casualties are reduced by 3.6 kg for every additional increase in the level of education by one additional degree. On the other hand, there are positive correlations between the experience of the producer, the area allocated to the crop, the number of agricultural workers and post-harvest losses. The more experienced the producer, the more losses he makes. The more the area allocated to cultivation and the number of agricultural workers increases, the more losses there are. Losses increased by 1.7kg; 1.9kg and 2.7kg respectively for each additional year of farming experience, for each additional m² increase in crop acreage, and for each addition of an additional farm asset in post-harvest. The other parameters not taken into account by the study increased the losses by 107kg overall. The variance inflation (VIF) values further indicate that no explanatory variable is subject to multicollinearity. The model specification test indicated that at the 5% threshold, the model is well specified. The heteroscedasticity test indicated that the variance is constant in the sample. The residue normality test indicated that residues are normally distributed (see annexes).

Discussion

Regarding the causes of losses, the study found that a large part of post-harvest losses are caused by pests and diseases. This reality is justified by the presence in the study area of a tomato leafminer named Tuta absoluta, which has been responsible for tomato fruit rots. These results are similar to those of (Limunga, 2018) for whom the majority of losses were also caused by pests and diseases. In relation to the measurement of post-harvest loss, the study noted that the average loss rate is 26.5%. This loss rate was also found in Ethiopia by Sisay, Abegaz, & Fisseha [3]. Moreover, this loss rate is lower than those of producers in Ghana and Nigeria, by 40% and 41% respectively [16,17]. But still higher than those of Cameroonian producers which is 12% [2]. In relation to multiple regression, the study found that educational attainment negatively impacts post-harvest losses while agricultural experience, farm area and number of agricultural workers have a positive impact. Indeed, in accordance with our a priori expectations, the fact of being more educated predisposes the producer to minimize post-harvest losses by the fact that the instruction provides the producer with the means and skills to better manage the harvest. These results are consistent with those of Fatahi, Baba, & Aminu [18].

Conclusion

The purpose of this study was to assess the magnitude and determinants of post-harvest tomato losses among producers in the Loma Valley in Mbanza-Ngungu. The concern was to quantify post-harvest losses in order to assess the determinants. A priori, our expectation was that the quantity lost would depend on the socio-demographic characteristics of the producer and the farm. Our expectations proved to be correct by the fact that the determinants of post-harvest losses are the producer's level of education and agricultural experience on the one hand, and the area allocated to the crop and the number of agricultural workers on the other. The negative correlation between the producer's level of education and the quantity lost requires more education for producers on harvest management and not only on cultivation techniques and practices. In addition, research on the leafminer Tuta absoluta, the main cause of tomato losses in Loma, should be stepped up with the aim of popularizing producers on the means of eradicating it.

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