



ESJ Natural/Life/Medical Sciences

Impact of Swollen Shoot Disease on the Livelihoods of Smallholder Cocoa Farmers in Côte d'Ivoire

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[Doi:10.19044/esj.2022.v18n40p58](https://doi.org/10.19044/esj.2022.v18n40p58)

Submitted: 20 October 2022

Accepted: 17 December 2022

Published: 31 December 2022

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Cite As:

Adopo W.A., Adolphe M.G., Tiehi N., Koffi C., Kouakou K. & Ballo Z. (2022). *Impact of Swollen Shoot Disease on the Livelihoods of Smallholder Cocoa Farmers in Côte d'Ivoire*. European Scientific Journal, ESJ, 18 (40), 58. <https://doi.org/10.19044/esj.2022.v18n40p58>

Abstract

Cocoa Swollen Shoot Disease (CSSD) due to badnavirus species is endemic in West Africa and has been causing significant and irreversible economy losses for smallholder cocoa farmers in infected areas in Ghana and Côte d'Ivoire. The impact of the disease on the smallholder farmers' livelihoods has been investigated at cocoa farm households level in Côte d'Ivoire. To this end, the propensity score matching method was used to construct a counterfactual and to compare groups capturing the situation of affected households before the disease affects their plantations, based on the

observable characteristics of non affected households. A total of 800 cocoa farmers were randomly interviewed using a semi-structured questionnaire. The results showed significant differences in expenditures for children's schooling and health between households with plantations infected by the disease and those with non-infected plantations. It was also found that households with swollen shoot in their cocoa plantation used less modern health services and invested less in children's education. The results imply that swollen shoot control policies and strategies should take into account socioeconomic factors.

Keywords: Cocoa; swollen shoot disease; impact; propensity score matching; livelihoods

Introduction

Cocoa plays an important economic and social role in Côte d'Ivoire. The country is the world's largest producer and exporter of cocoa beans with about 41% market share (Hütz-Adams et al., 2016). Cocoa accounts for about 14% of GDP, contributes to more than one-third of export earnings, and finances 10% of government revenues. Cocoa is grown throughout the forest zone, covering 2,176,000 hectares, or 6% of the national territory. The crop industry employs more than 5 million people, or one-fifth of the population, and is by far the largest source of foreign exchange, accounting for nearly 40% of the country's merchandise exports (World Bank, 2019) It is also the primary source of agricultural income for Ivorian cocoa farmers, 43% of whom have no other income.

However, in spite of its place of choice in the constitution of the national wealth, cocoa cultivation in Côte d'Ivoire faces several constraints such as high pest and disease pressure. Cocoa Swollen Shoot Disease (CSSD) causes important damages on farms and has been described as one of the most economically significant viral plant disease in the world (Dzahini Obiatey *et al.*, 2010). CSSD causes a drastic decrease in cocoa yield and the destruction of infected cocoa trees within 3-5 years. Yields fall by 25% in the first year of infestation of cocoa trees, 50% in the second year and there is no yield from the third to the fifth year after infestation (CNRA, 2011). Cocoa swollen shoot disease seems endemic in West African countries. It was first reported in Ghana in 1936 (Steven 1937) where 200 million of infected trees were cut down in order to stop the spreading of the disease. The disease has also been observed in the major cocoa-producing countries of West Africa such as Côte d'Ivoire (Alibert, 1946), Nigeria, Sierra Leone and Togo.

There is no chemical products for controlling CSSD. Currently, the best way to control the disease is based on cutting down infected cocoa trees

and replanting with tolerant planting material while applying good agricultural practices such as agroforestry.

CSSD propagated rapidly to many cocoa-producing areas from the outbreaks observed since 2003 in Sinfra and Bouaflé, Côte d'Ivoire, where virulent strains were involved (Kouakou, 2011; 2012; Aka *et al*, 2020; Ramos *et al*, 2021). This situation certainly had a socio-economic impact on smallholder farmers' livelihoods which needs to be addressed. This study therefore aims at estimating the impact of swollen shoot disease on the livelihoods of cocoa producers in infected areas in Côte d'Ivoire.

Methods

Developing an impact study involves comparing the situation of individuals before and after a program in order to identify the own or specific effects caused by the program. A program can be a project, a public policy, or, in case of this study, a disease; and impact evaluation is about studying whether changes in well-being are due to the program and not to other factors. One of the inherent difficulties in impact studies is having a control group or sample that allows for the description of the situation of treated individuals before they are exposed to the program. This is known as the counterfactual problem. According to Ezemenari *et al*. (2018), impact evaluation methods can be classified into two groups: experimental and non-experimental or quasi-experimental approaches. With the experimental or randomized approach, the counterfactual is constructed at the outset of the program by defining a target population and randomly assigning the program to a portion of that population. From then on, random assignment of the treatment makes it possible to set up two groups, a treatment group and a control group whose average observed and unobserved characteristics are statistically equivalent. As for the quasi-experimental evaluation, the treatment and comparison groups are defined ex-post. It is conducted during or after the program.

Our study plans to investigate the impact of Swollen Shoot, a disease of cocoa trees that has been reported to be on the rise since 2003. Since there is no data available before the resurgence of this disease, the quasi-experimental approach would be best suited for this study. There are several quasi-experimental methods in the literature for evaluating impacts. The most commonly used are the double difference (DD) method, the instrumental variable (IV) method, the regression discontinuity (RD) method and the propensity score matching (PSM) method. These different methods attempt to construct the counterfactual by statistical methods from the study sample.

DD methods assume that unobserved selection is present and that it's time-invariant. The treatment effect is determined by measuring the difference in outcomes between treatment and control units before and after program intervention. DD methods can be used in both experimental and non-

experimental settings. IV designs can be used with cross-sectional or panel data. The goal is to find at least one variable that affects the occurrence of swollen shoot on the cocoa farm but does not affect livelihood variables. The main difficulty with these methods is finding valid instrumental variables. With the RD method, individuals are classified according to a specific and measurable criterion. There is a well-defined selection threshold (cutoff) that determines whether a person is eligible or not. Treated individuals are then compared to control individuals. The PSM method determines the comparison group from a sample of non-participants who resemble the participants, based on observable characteristics. In the case of our study, this will involve constructing a comparison group capturing the situation of affected households before the onset of swollen shoot in their plantations, based on observable characteristics of unaffected households. Thus, the PSM method was determined to be the most appropriate one for this study. However, it requires answering several methodological questions, which are presented below.

Presentation of the propensity score matching method

The idea of matching method is to associate each treated individual (producers with swollen shoot in their plantations) with an untreated individual (producers without swollen shoot in their plantations), whose characteristics are identical to those of the treated individual (Benedetto *et al.*, 2018). The estimation principle consists in using the information available on the untreated individuals to construct a counterfactual for each treated individual, i.e. an estimate of what his situation would have been if he had not been treated (Benedetto *et al.*, 2018). In order to check heterogeneity, a sample of the control group, composed of individuals with the same possible observable characteristics as the group of treated individuals, was chosen as the comparison group. However, it would be difficult to have a farmer among those who don't have swollen shoot in their plantations with exactly the same values of all observed characteristics as any farmer who has swollen shoot in his plantation. Indeed, it is recognized that an increase in CSSD will have a negative effect on the overall income of producers who have it in their plantations (Koffié, 2014). But how can we be sure that the difference observed between cocoa farmers who have CSSD in their plantations and those who do not is really due to the presence of CSSD ? A simple approach would be to consider, for example, the difference in average income between the two groups of farmers. However, there are many problems with interpreting this difference as a causal relationship between producers with CSSD in their plantations and producers without CSSD in theirs. The main one is the existence of selection bias (Ferri-García and Rueda, 2020). Selection bias is based solely on observed characteristics.

Therefore, the Conditional Independence Assumption must be assumed. The Conditional Independence Assumption states the following: conditional on a set of observable characteristics (X), the observed outcome is not related to whether or not the plantation has swollen shoot (Benedetto *et al.*, 2018; Scott, 2019; Caliendo and Tübbicke, 2020). Formally, this hypothesis is written as follows:

$$(Y_1, Y_0) \perp c_{ssv} | X \implies (Y_1, Y_0) \perp c_{ssv} | p(X)$$

This simply means that having swollen shoot in the plantation is independent of potential outcomes but conditional on propensity scores (X). Propensity scores represent the probability of having swollen shoot in the cocoa farm, conditional on a set of observable characteristics X . The more information we have about the producers, the better it is possible to distinguish them in their behavior. By proceeding in this way, while respecting the conditions of conditional independence, matching by propensity score makes it possible to eliminate any kind of selection bias.

This hypothesis nevertheless presupposes the consideration of a large number of variables X , the limited number of which is justified by Caliendo and Tübbicke (2020). According to them, "we must keep in mind that what is important is not a description as faithful as possible of the probability of the treatment, but simply the determination of the variables necessary to obtain the independence property. Introducing too many variables can have negative consequences on the estimation in several ways. Firstly, description of treatment variable being better, supports of distributions of scores of treated and untreated individuals are likely to be more dissociated; the possibilities of matching will then be more restricted. More importantly, introducing too many conditioning variables may make estimation impossible. It is possible that the independence property is satisfied for a set of conditioning variables, but that it is no longer satisfied when other conditioning variables are added, even if they are significant in the score estimation.

For the matching method, a second important assumption called common support must be complied with. This assumption imposes that for each treated individual, we have untreated individuals whose scores have values close to the score of the treated individual (Benedetto *et al.*, 2018). This assumption ensures that individuals in the control group with the same observed characteristics are found in the sample. Formally:

$$0 < (c_{ssv} = 1) < 1$$

For constructing the common support for the propensity score, according to Benedetto *et al.* (2018) and Caliendo and Tübbicke (2020), several techniques can be employed. The first is to exclude observations whose estimated propensity score is close to 1 or 0. One can also remove all observations in the control group for which the estimated propensity score is lower than the minimum of the estimated propensity scores in the treatment

group, and apply the same rule for the maximum. Finally, one can remove observations from the control group whose variables have a density below a certain threshold. The choice of the appropriate approach depends on the distribution of the propensity scores of the two groups.

Under the assumption of conditional independence and common support, attribution to treatment is random and the outcome of control subjects can be used to estimate the counterfactual outcome of treated individuals in case of no treatment.

In practice, propensity scores are estimated using the predicted probabilities from a binary qualitative choice model (Logit or Probit), explaining participation in a treatment or program by a large number of observable characteristics. However, the choice of the appropriate model depends on the nature of the program (Adejumo *et al.*, 2020). In our study, the logistic regression model is used to model propensity scores. The model refers to the application of the dichotomous variable $CSSV_i$ reflecting the presence or absence of swollen shoot in households' cocoa plantations i . It takes the value 1 if the household has swollen shoot in its cocoa plantation and 0 otherwise. This binary variable is associated with a latent variable $CSSV_i^*$ that is a function of a matrix of explanatory variables X_{ij} that refer to observable characteristics of producing households (gender of the household head, age, household size, etc.) translated into the following equation:

$$CSSV_i^* = \alpha + \sum_{j=1}^i \beta_j X_{ij} + \varepsilon_i \dots\dots\dots(1)$$

Where ε_i is a random term whose distribution is given by the density function f .

$$\begin{cases} CSSV_i = 1 \text{ si } CSSV_i^* > 0 \\ CSSV_i = 0 \text{ si } CSSV_i^* \leq 0 \end{cases} \dots\dots\dots(2)$$

Replacing (1) in (2), we get:

$$P(CSSV_i = 1) = P[\varepsilon_i > -(\alpha + \sum_{j=1}^j \beta_j X_{ij})] = P[-\varepsilon_i \leq (\alpha + \sum_{j=1}^j \beta_j X_{ij})] = F[\alpha + \sum_{j=1}^j \beta_j X_{ij}] \dots\dots\dots(3)$$

Where F is the distribution function corresponding to the density function f . Thus, the Logit model to be estimated can be specified as follows:

$$\ln \left(\frac{P(CSSV_i)}{1-P(CSSV_i)} \right) = \alpha + \sum_{j=1}^i \beta_j X_{ij} + \varepsilon_i \dots\dots\dots(4)$$

Where $\beta_j X_{ij}$ represents the matrix of explanatory variables, β_j the coefficients to be estimated,, ε_i the error term and α the constant term.

The value of the score, i.e. the probability of having swollen shoot in the plantation given the observable characteristics, is deduced for each producing household. The results of the logistic regression model should provide statistics for interpreting the factors favoring the presence or absence of CSSV in cocoa plantations. We will refer to chi-square statistic (Chi-square) to test the significance of the model and its parameters; and the pseudo

R-square to test adequacy of the model and also to see the different significance levels and the marginal effects.

The impact of swollen shoot on farmers who have it in their cocoa plantations (ATT) is estimated by the difference in mean scores between treated farmers and matched control.

$$ATT = E[Y_i^T | p(x), cssv = 1] - E[Y_i^C | p(x), cssv = 0] \dots\dots\dots(5)$$

There are several methods for estimating this. As noted above, these methods associate producer households with swollen shoot in their cocoa plantations with those that don't have swollen shoot in their cocoa plantations that are closest in terms of propensity scores based on observable characteristics. Empirically, the measure of impact is given by the following expression (Clément, 2006; Ravallion, 2008):

$$ATT = \frac{1}{T} \sum_{j=1}^T (Y_{j1} - \sum_{i=1}^C w_{ij} Y_{ij0}) \dots\dots\dots(6)$$

In this equation, Y_{j1} represents the outcome for the j^{th} swollen shoot affected household, Y_{ij0} the outcome for the i^{th} swollen shoot unaffected case joined to the j^{th} affected, T the total number of swollen shoot-affected households, C the total number of unaffected households, and w_{ij} the weights or weighting function used for averaging the outcomes of unaffected households.

There are several propensity score matching methods, the most used of which are radius (with various calipers), Kernel, and nearest-neighbors according to the literature. Latter method combines One-Nearest Neighbor and Multiple Nearest Neighbors. We propose to use the Nearest Neighbour Matching method to assess the impact of swollen shoot on the livelihoods of cocoa-producing households.

Data

Data were collected from a random sample of 800 cocoa farmers in the main cocoa-producing regions of Côte d'Ivoire. The distribution of the sample across regions and the number of villages visited is presented in Table 1. Out of the 800 producers selected, 18.87% had cocoa plantations affected by swollen shoot disease, compared to 81.13% with uninfected plantations. Producers were surveyed using an individual questionnaire on the socio-economic characteristics of the cocoa producer's household (gender, age, number of active farmers, contact with extension, etc.), the characteristics of the cocoa plantation (area planted, age of cocoa trees, presence of swollen shoot, etc.) and cultivation practices (type of labor, varieties of cocoa grown, other perennial crop grown, etc.).

Table 1. Number of producers surveyed

Regions	Number of villages visited	Number of producers with plantations not affected by CSSD	Number of producers with plantations affected by CSSD	Total producers	% Total
Nawa	16	110	41	151	18.87
Loh Guiboua	8	103	17	120	15.00
Haut-Sassandra	10	89	7	96	12.00
San Pedro	6	65	10	75	9.38
Goh	5	46	23	69	8.62
Agnéby Tiassa	3	63	3	66	8.25
Sud Comoé	4	43	5	48	6.00
Guemon	5	34	10	44	5.50
Indénié	2	32	7	39	4.88
Mé	3	27	8	35	4.38
Marahoué	6	7	18	25	3.12
Tonkpi	1	20	2	22	2.75
Bélier	2	10	0	10	1.25
Total	71	649	151	800	100

Source : Field Survey 2019

Results

Comparative characteristics between producer groups

Table 2 presents the characteristics that differ between farmers who have swollen shoot in their cocoa plantations and those who don't have it. These are the socio-economic characteristics of the cocoa farmer's household, the characteristics of the cocoa plantation and cultivation practices.

The table shows that producers who have swollen shoot and those who don't have it have significantly different socioeconomic characteristics. Indeed, 37.75% of producers with swollen shoot have access to credit, compared to 25.58% of those without swollen shoot in their cocoa plantations. Producers who don't have swollen shoot have more off-plantation sources of income than those who have it (76.27% versus 64.24%). Regarding experience in cocoa farming, 85.37% of producers without swollen shoot have more than five (5) years of experience compared to 76.76% of those with swollen shoot. In addition, 25.73% have had contact with the extension service as opposed to 11.92% of those with swollen shoot.

In terms of agricultural practices in cocoa plantations, there are also significant differences between the two groups of producers. It can be observed that among producers who don't have it, 97.53% do at least two manual weeding operations per year, compared to 88.08% among those who have it. Also 69.80% of them use chemical fertilizer against 60.93% of those who have swollen shoot in their plantations. However, 92.72% of producers

with swollen shoot in their plantations use family labor in cocoa production compared to 56.55% of producers without swollen shoot in their plantations.

With regard to factors related to the plantation, there is a significant difference in the age of the plantations. The plantations of producers with swollen shoot are slightly over twenty-two (22) years old on average, compared to twenty (20) years old for those without swollen shoot.

Table 2. Presentation of the variables of the econometric analysis

Variables	Untreated Group (without CSSD)	Treated Group (with CSSD)	Pool	T-test ¹
Socio-economic factors				
Male producer (%)	93.68	96.69	94.25	0.153
Age of producers (year)	47.69	47.99	47.74	0.784
Producers educated (%)	50.69	56.29	51.75	0.215
Access to credit (%)	25.58	37.75	27.88	0.003**
Possession of off-plantation income source (%)	76.27	64.24	74.00	0.002**
Experience in cocoa production greater than 5 years (%)	85.67	76.16	83.88	0.004**
Contact with extension (%)	25.73	11.92	23.13	0.000***
Factors related to cultivation practices				
Two or more manual weeding (%)	97.53	88.08	95.75	0.000***
Use of family labor (%)	56.55	92.72	63.38	0.000***
Use of chemical fertilizer (%)	69.80	60.93	68.13	0.035**
Plantation factors				
Age of the cocoa farm (year)	19.73	22.44	20.24	0.005**
Cocoa farm surface area (ha)	3.17	3.22	3.18	0.793

***, **and * indicates that the variables are statistically significant at 1% 5% and 10% risk thresholds, respectively.

Source : Field Survey 2019

Determinants of swollen shoot status in cocoa plantations

Analysis of the results of logit model provides information on the factors that determine infestation of cocoa trees by swollen shoot disease. The variables that significantly determine the probability of having swollen shoot disease on the farm are the age of the farmer, level of education, access to credit, possession of off-farm income, number of years of experience in cocoa

¹ Student test for quantitative variables and Chi-2 test for qualitative variables

production, contact with extension, number of weeding, family labor, use of chemical fertilizer, and age of the cocoa farm.

The age of the producer is significant at 5% threshold and has a positive coefficient indicating that it is important. Indeed, older farmers are more exposed to swollen shoot compared to younger farmers. If we consider the results of the marginal effect, the probability of an older producer having swollen shoot is 0.24% compared to a younger producer.

It can be seen at the level of education, in reference to the no-education modality, that the educated modality is significant at 1% threshold with a positive coefficient reflecting a positive effect on the probability of having swollen shoot in the plantation. Thus, the probability of having swollen shoot among educated farmers is 4.17% higher than among farmers with no education.

Access to credit is significant at 1% threshold and has a positive coefficient. We can see that in reference to producers who don't have access to credit, those who have access thereto have cocoa plantations that are more exposed to swollen shoot. With marginal effects, relative to a farmer without access to credit, the probability that a farmer with access to credit has swollen shoot in his plantation increases by 8.13%.

Possession of off-plantation source of income is significant at 1% threshold and has a negative coefficient. Thus, compared to producers who do not have off-plantation source of income, those with off-plantation source of income have cocoa plantations that are less exposed to swollen shoot. In terms of marginal effects, in reference to a producer who does not have off-plantation source of income, the probability that a producer with off-plantation source income will have swollen shoot in his cocoa plantation is less than 7.56%. Indeed, cocoa cultivation is an activity that requires maintenance. It is necessary to invest and without financial resources the producer is exposed to diseases and pests in his plantation.

The number of years of experience in cocoa farming is significant at 1% threshold. The coefficient of the variable is negative, indicating a negative relationship between the number of years of experience in cocoa production and the probability of having swollen shoot in the field. With marginal effects, we note that the probability decreases by 14.39% when the producer's number of years of experience in cocoa cultivation increases.

The results also show that contact with extension has a significant effect on the probability of having swollen shoot. Coefficient of extension contact variable is negative at 1% threshold. Marginal effects show that it reduces the probability of having swollen shoot by 18.95%. This result can be justified by the fact that contact with the extension service allows the farmer to have access to information on swollen shoot as well as on control methods.

The number of weeding carried out by the farmers per year, in reference to the one-weeding modality, is significant at 1% threshold, with negative coefficients reflecting a negative effect on the probability of having swollen shoot in the plantation. With respect to marginal effects, the probability of having swollen shoot in households that do two or three or more manual weeding operations is less than 38.20% and 41.73% respectively, compared to farmers who do only one operation. This result shows the importance that should be given to good agricultural practices in cocoa farming recommended by research (Kébé *et al.*, 2016).

The use of family labor is positively significant at 1% threshold. According to the marginal effects, farmers who use family labor increase their probability of having swollen shoot by 31.55% compared to those who use other labor in their cocoa plantations. The use of chemical fertilizer is negatively significant at 1% threshold. Marginal effects show that, with reference to farmers who do not use chemical fertilizer for cocoa production, the probability of having swollen shoot decreases by 8.84% for farmers who use chemical fertilizer in their cocoa plantations.

The age of the cocoa plantation is significant at 1% threshold. The coefficient of the variable is positive. This result shows that older cocoa plantations have a high probability of having swollen shoot compared to younger plantations. According to the marginal effects, the probability of an old field having swollen shoot is 0.38% compared to a young field.

Table 3. Results of the Logit model for estimating propensity scores

Variables	Modalities		Coefficients (Sd)	marginal Effets
Sex of producer	Female	Ref.		
	Male		0.440(0.603)	0.0514
Age of producer			0.021(0.009)**	0.0024
Educated producers	Not enrolled	Ref.		
	enrolled		0.356(0.215)*	0.0417
Access to credit	No	Ref.		
	yes		0.696(0.223)***	0.0813
Possession of off-plantation source of income	No	Ref.		
	yes		- 0.647(0.226)***	-0.0756
Experience in cocoa production			- 1.232(0.292)***	-0.1439
Contact with extension	No	Ref.		
	yes		- 1.622(0.342)***	-0.1895
Number of manual weeding	One	Ref.		
	Two		- 2.517(0.494)***	-0.3820

	Three or more		-	-0.4173
Surface area of cocoa farm			2.823(0.484)***	
Use of family labor	No	Ref.	0.127(0.319)	0.0149
	yes		2.700(0.372)***	0.3155
Use of chemical fertilizer	No	Ref.		
	yes		-	-0.0884
Age of cocoa farm			0.757(0.235)***	0.0038
Constant			0.032(0.011)***	
			-1.365(0.928)	
Number of observation			800	
LR chi2(17)			187.23	
Prob > chi2			0.0000	
Pseudo R2			0.2425	
Log likelihood			-292.445	

***, **and *: indicates that the variables are statistically significant at 1.0% 5.0% and 10.0% risk thresholds, respectively.

Source : Field Survey 2019

Propensity scores

From the logistic regression model we have just built, we calculate the propensity scores. Figure 1 below shows the distribution of propensity scores in the sample. The average propensity score for households without swollen shoot in the plantation is 0.15. Those with the swollen shoot have an average score of 0.35. This result shows that there is a significant difference in observable characteristics between the two groups of cocoa-producing households.

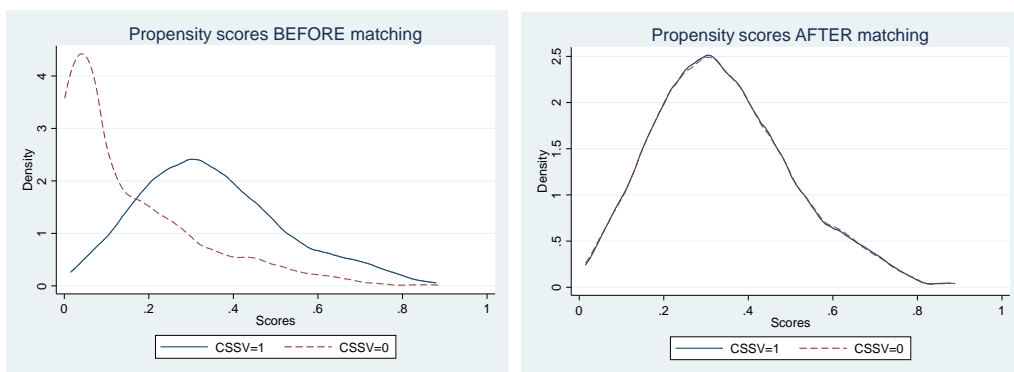


Figure 1. Distribution of propensity scores

After estimating the propensity scores, it's important to check the quality. We need to ensure that there is a common support in the distribution of propensity scores. It allows us to ensure that for each treated producer, there are producers in the untreated group with the same characteristics. To accomplish this, we compare the maxima and minima of the propensity score

distribution for the two groups of producers. This condition consists in removing observations from the treated population whose propensity score is either lower or higher than the minimum and maximum scores of the control group households, respectively. Based on these considerations, seven (7) producers in the treatment group do not belong to the common support. One hundred and forty-three (143) households in the treatment group out of the seven hundred and ninety-three (793) have swollen shoot in their cocoa plantations and six hundred and fifty (650) households do not. Respecting this assumption therefore removes less than 1% of our observations.

Once the common support is delineated, producer households that have CSSD in their plantations and those that don't have it are matched. However, note that before matching, Table 2 above shows us that there are significant differences between the two groups depending on variables used for matching. If the matching is correct, there should no longer be any significant differences between the two groups of producers; this is the principle of the test of equality of means. The standardized differences test, in contrast, determines the reduction in bias due to matching by the propensity score. Rosenbaum and Rubin (1985) point out that a standardized difference greater than 20 should be considered too large.

Table 4 shows that after matching, there are no significant differences between the two groups of producer households for all explanatory variables used. These results show that households that do not have swollen shoot in their plantations are indeed identical (in terms of observable characteristics X) to producing households that have swollen shoot in the plantations. In light of these tests, the quality of propensity score seems correct, validating the relevance of the results obtained, which we are going to analyze in the following sections.

Table 4. Characteristics of producers after matching

Variables	Mean Treated	Mean Control	%bais	t-test	p>
Socio-economic factors					
Male producer (%)	.96503	.97203	-3.3	-0.34	0.736
Age of producers (year)	48.042	49.79	-13.8	-1.09	0.275
Educated producers (%)	.56643	.53846	5.6	0.47	0.636
Acces to credit (%)	.37762	.31469	13.6	1.12	0.265
Possession of off-plantation source of income (%)	.65035	.69231	-9.2	-0.75	0.452
Experience in cocoa production > 5 years (%)	.76224	.79021	-7.1	-0.57	0.572
Contact with extension (%)	.12587	.07692	12.7	1.37	0.171
Factors related to cultivation practices					
Two or more manual weeding (%)	2.4545	2.5245	-11.2	-0.94	0.350
Use of family labor (%)	.92308	.95804	-8.8	-1.25	0.213
Use of chemical fertilizer (%)	.62238	.65035	-5.9	-0.49	0.624

Plantation factors					
Age of the cocoa plantation (year)	.12587	.13287	-2.0	-0.18	0.861
Cocoa surface area (ha)	21.839	21.559	2.5	0.22	0.830

Source : Field Survey 2019

Results of the CSSD impact estimation

The impact of swollen shoot on the livelihoods of cocoa-producing households is reported in Table 5. The indicators of livelihoods used here reflect the ability of cocoa-producing households to satisfy basic needs such as food, housing, healthcare, children's education, clothing, and means of communication. A distinction is made between food and non-food expenditures. The latter includes expenditures on health, education, housing, clothing, ceremonies, construction, and communication made by households in the last six months preceding the surveys. Food expenditures provide information on the total amount spent by the household in the week prior to the survey (last seven days) on food and beverages, including food consumed at home and elsewhere.

Based on these estimates, swollen shoot has a negative impact on the livelihoods of farmers who have it in their plantations. All the indicators of livelihoods used are negative. However, the impact remains significant for total non-food expenditures, and particularly for household health expenditures and expenditures on schooling for children. It reduces health and schooling expenses for households that have it in their plantations by 46.63% and 31.62%, respectively. In terms of non-food expenses, the decrease represents 30.15%. This result shows that producer households that have swollen shoot in their cocoa plantations invest less in their health and in their children's education.

Table 5. Results of swollen shoot impact estimates

Household expenditures (CFAF)	Average expenditure after matching		Average effect of CSSD on treated	Proportion
	Treated	Untreated	(ATT)	(%)
Total food expenditure	5,358	5,557	-199 (358)	-3.58%
School expenditure	125,324	183,280	-57,956 (23.814)**	-31.62%
Healthcare expenditure	67,100	125,728	-58,628 (18.240)**	-46.63%
Clothing expenditure	27,741	30,848	-3,107 (2.685)	-10.07%
Ceremonial expenditure	120,042	154,042	-34,000 (17.455)	-22.07%
Construction and housing expenditure	132,420	174,667	-42,247 (56.329)	-24.19%
Communication expenditure	15,500	15,915	-415 (1.618)	-2.61%
Total non-food expenditure	684,273	979,610	-295,337(140.841)**	-30.15%

***, **and *: indicates that the variables are statistically significant at 1.0% 5.0% and 10.0% risk thresholds respectively; (): standard deviations

Source : Field Survey 2019

Discussion

The discussion focuses on the impact of swollen shoot disease on farmers' livelihoods.

Overall impact on livelihoods

The results of the estimation of swollen shoot impact on producers' livelihoods are consistent with previous studies showing that plant diseases reduce agricultural yield. Authors (Kouakou *et al.*, 2011; Akrofi *et al.*, 2014; Agyeman-Boaten and Fumey, 2021) have shown that swollen shoot, like any other plant disease, obviously leads to a significant decrease in yield and thus affects the standard of living of producers. However, this study further shows livelihood indicators that are affected by swollen shoot.

Considerable impacts on schooling and healthcare expenditures

The results show that swollen shoot has a considerable negative impact on education and health indicators and a relatively low impact on other livelihood indicators. The results of the impact of swollen shoot on education are in line with those of Adolphe *et al.* (2016) who studied the socioeconomic impact of coconut lethal yellowing disease on smallholder coconut farmer families in Côte d'Ivoire.

Plant diseases are often considered agricultural shocks. In this sense, the study reinforces the general view of some authors. Indeed, several studies have highlighted the impact of agricultural shocks on the livelihoods of households. However, the most recurrent ones concern their impact on children's schooling and the demand for or consumption of healthcare by agricultural households. In terms of schooling, most studies show that the uncertainty induced by shocks affects the investment in human capital of school-age children, with households making a trade-off between school and work in order to absorb the negative impacts of shocks (Jensen, 2000; Beegle *et al.*, 2006; De Janvry *et al.*, 2006; Guarcello *et al.*, 2010). At the health level, studies on healthcare utilization and household health expenditures during an illness episode have shown that household income plays an important role (Tape, 2007; Kochou and Rwenge, 2014; Dieng *et al.*, 2015). However, the results on health expenditures are contrary to those of Lechtenfeld and Lohmann (2014). Indeed, they showed through their study on the impact of drought on health outcomes and health expenditures in rural Vietnam that drought-affected people have significantly higher health expenditures than others. But the impact is felt in households with a high degree of dependence on agriculture and limited access to coping mechanisms such as selling assets or tapping into off-plantation sources of income.

Furthermore, the results show that swollen shoot contributes to non-monetary poverty of cocoa farmers who have it in their plantations referring

to the presentation made by Diarra (2018) as well as the one shown by Agyeman-Boaten and Fumey (2021) in their study in Ghana. The concept of non-monetary poverty can be presented in the aspects of livelihoods' poverty, capability poverty, and relative deprivation. Livelihoods' poverty refers to the deprivation of access to basic services such as health, education, water and sanitation. While capability poverty is defined in terms of factors that prevent individuals or households from enjoying sufficient well-being. Relative deprivation poverty refers to the low accessibility of households to the basic services that are essential for a better well-being (access to healthcare, education, comfort, etc.).

Conclusion

This study has shown that the probability of having swollen shoot in cocoa farm is related to the socioeconomic characteristics of producers, cultivation practices and farm characteristics. Among these factors, those that positively influence the probability of having swollen shoot are the age of producer, his level of education, access to credit, use of family labor, and age of cocoa plantation. Inversely, possession of off-plantation income, experience in cocoa production, contact with extension service, number of manual weeding operations, and use of chemical fertilizer have a negative influence. The study has revealed that swollen shoot has a negative impact on the livelihoods of producer households. All indicators of livelihoods used are negative. However, the impact remains significant for total non-food expenditures, particularly for health and schooling expenditures. Considering the results of this study, it's recommended to reinforce producer awareness and training on cocoa swollen shoot disease. Moreover, cocoa-farming households need to diversify their income so as to mitigate the negative impact of swollen shoot.

Acknowledgments

The authors would like to thank the Fonds Interprofessionnel pour la Recherche et le Conseil Agricole (FIRCA) in Côte d'Ivoire and the International Institute of Tropical Agriculture (IITA) in Ghana. Data were collected during the implementation of FIRCA 2QC and IITA/CocoaSoils projects by CNRA in Côte d'Ivoire.

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