International Journal of Progressive Sciences and Technologies (IJPSAT)
ISSN: 2509-0119.

Vol. 32 No. 1 April 2022, pp. 112-118

Drivers Of Safe Pesticide-Management Practices Of Cotton Farmers In Benin

Soulé EL-HADJ IMOROU[1] and Arouna ASSOUMA Z.[2]

University of Parakou, Faculty of Letters, Arts and Human Sciences, Department of Anthropological Sociology, Parakou, Benin

Abstract – Smallholder farmers usually apply large amount of agrochemicals without sufficient protective measures in most developing countries, which may result in severe health and environment problems. This study aimed to identify the drivers of the use of protective measures when spraying synthetic pesticides and of the disposal of agrochemical containers. We use cross-sectional data collected from cotton growing households in Benin, that are typically known as using intensive amount of chemical inputs. Regression analysis show that educational level, training on pesticides management strategies, wealth and farm size are the most relevant factors that drive the adoption of safe practices when handling agrochemicals. Thus, we suggest policies makers to strengthen farmers' education level or literacy through suitable educational programs, and assist farmers with adequate training materials on pesticides handling practices.

Keywords – Pesticides, handling, safe practices, cotton farmers.

I. Introduction

It is well documented that the use of agrochemicals in agriculture is important to increase or sustain productivity growth despites the tremendous pests that impede high harvest. However, the use of these harmful products is associated with environmental and health problems (Kane & Sembène, 2021). Pesticides can have acute or chronic effects on the health of applicators. Human health problems resulting from the use of chemical pesticides in agriculture have also been reported in the literature (Doumbia & Kwadjo, 2009;Tomenson & Matthews, 2009; Ahouangninou et al., 2011; Biswas et al., 2014; Soro et al., 2018).

Smallholders' farmers in Benin as in many developing countries apply excessive amount of synthetic pesticides in order to maintain a high productivity. This is particularly relevant in cotton production where, a vast amount of chemical inputs is provided to farmers on credit. Synthetic pesticides are also applied for weed control on most staple foods plots. The reason is that labor shortage lead to a shift in the production systems, from extensive to intensive production systems with the use of synthetic products.

With the aim to improve agricultural productivity in cotton production, the National Strategic Plan for the Revival of the agricultural sector encourages smallholder cotton farmers to use synthetic inputs for weed and pest controls. Given that, these farmers applying these harmful inputs are insufficiently trained about their appropriate application, health and environmental problem can induce some negative externalities that would compromise the sustainability of current production systems.

In response to negative concerns associated with conventional cotton farming, organic cotton production has been promoted since some decades with the goals of making cotton production sustainable, because organic cotton restricts from the use of chemical inputs, and thus at first glance may not induce negative health and environment effects for smallholder cotton farmers. However, it is highly shown that organic farming is associated with several production constraints including insufficient access to biopesticides and their inefficiencies, and lower yield, which slows down the farm economic performance. In this context, providing farmers with adequate tools that can increase awareness towards safe behaviors is highly desirable. For instance developing information and training campaign about the use of personal protective equipments (APPE) and safe disposal of chemical containers is expected to sustain human health.

There is little statistical evidence on the role of education campaigns and training programs on the use of APPE since the focus has been more on assessing the role of training on the quantity of pesticides used. Moreover, exposure to synthetic pesticides by cotton farmers during application, for a long time and without adequate protective equipment, is a major source of risk to their health. The risk of exposure could be significantly reduced if farmers wear full personal protective equipment (Dümmler, 1993). Personal protective equipment plays a very important role in reducing operator exposure to plant protection products (Toe et al., 2013). It is necessary for the person who sprays synthetic pesticides to respect hygiene standards including the wearing of Personal Protective Equipment (APPE) in order to minimize health risks (Ahouangninou et al., 2019).

Using cross-sectional data for cotton smallholders from Benin, we examine the drivers of farmers' use of personal protective equipments when applying pesticides, and farmers' disposal of agrochemical containers. We specifically put emphasis on education and training about suitable pesticides management practices. Applying probit regression suggests that education level, farm size and training on pesticides management practices drive the use of APPE and proper disposal of chemical containers. Wealth has significant positive effects only on the use of APPE.

The rest of this paper is structured as follows. We present the methodology including data collection, and econometric modeling, followed by the results and discussion sections. Finally come conclusion, along with the implications of our study.

II. Methods

2.1. Data collection

We conducted this study in four main cotton growing districts in Benin, selected on the basis of the weight of cotton production and the diversity in terms of agro-ecological areas. A total of 951 households were surveyed during the data collection stages. These households were surveyed randomly proportionate to the total number of conventional farmers in each selected district and village. Detailed data about farmers demographic and socio-economic characteristics including sex, age, education, household size, assets holdings, training on pesticides management practices, etc. information regarding the use of different personal protective equipment such as goggle, coat, etc., various practices for disposal of handling of chemical containers such as thrown in a river, in a crevasse, in the bush, buried, burned, etc. were collected. Precisely, the household head or the main cotton growing household member was asked to respond to our questions.

2.2. Outcome variables

We refer in this paper to two different outcomes variables that capture safe practices about handling of chemical pesticides and containers. The first one is the use of personal protective equipment for pesticides handling. Instead of using a dummy variable that denotes whether a given household uses at least one personal protective equipments as done in Zapata Diomedi & Nauges (2016), we ensure that wearing at least one APPE would not sufficiently proxy for safe practices regarding the use of APPE, since the majority of households in our data uses at least one APPE. In order to capture most variations regarding appropriate use of APPE, we define a dummy variable that takes the value of one, if the household uses at least four APPE. This variable proxies for appropriate protection during pesticides preparation and application.

As, it is also documented that smallholders in developing countries mishandle pesticides containers by using them for other households purpose, we use WHO (1999) classification of safe and risky practices when handling chemical pesticides containers, although all practices are potential inappropriate for human health and environment. Thus, this variable takes the value of one, if the household either burned or buried, but these practices are considered as appropriate although they stand as less damaging practices. Risky behaviors such as throwing the chemical containers in a river, into the bush, or disposing them in a natural hole, gully or crevasse, take the value 0, and are considered as the most dangerous practices. It is important to note that households that used both least damaging and most dangerous disposal of chemical containers are classified as relying on unsafe practices, thus take the value of 0.

2.3. Modelling

In studies of agricultural innovation adoption or adaptation several analytical methods are used, mainly econometric models. Logit or Probit models are the two logistic regression models commonly used to analyse the adoption or adaptation decision. Depending on the nature of the dependent variable (dichotomous dummy or with more than two modalities), multinomial models are also used (Lansink et al., 2003; Yegbemey et al., 2014; Afouda et al., 2020). The bivariate Probit model was chosen in this study because for both models of personal protective equipment adoption and chemical container use, the dependent variable is dichotomous (yes or no). We express the probability of adopting safe practices when handling pesticides as:

$$A_i = \beta_0 + \beta X_i + u_i$$

Where A is the probability of using personal protective equipment for the first model and the probability of adopting safe practice for the disposal of chemical containers for the second model. β_0 represents the constant, X_i the socio-economic factors that influence the use of protective equipment or the appropriate disposal of chemical containers. Thus, the influence of the socio-economic factors on the probability of adopting APPE or on the probability of adopting safe practice for the disposal of chemical containers, is judged through the sign of the vector of the coefficient β. Considering this specification, socio-economic characteristics such as: household head age, experience in cotton farming, sex, years of education, household size, dependency ratio, cotton area, total land owned, household assets, training on pesticides management practices are included as explanatory variables in each equation.

III. Results

3.1. Descriptive evidence

3.1.2. Personal protective equipments

The average age of cotton farmers in the study area is 42.14 years. Farmers using appropriate personal protective equipments are slightly older than those who do not use them. But this difference is not statistically significant. Similarly for experience in cotton cultivation and gender, the differences in the average values between farmers wearing protective equipments and those without wearing, are not statistically significant. On the other hand, the average years of education are respectively 1.41 years, 1.88 years, 1.28 years for all farmers, farmers using and those who do not use appropriate protection. This difference between farmers using protective equipments and their counterparts, is statistically significant at the 5% level. This implies that education level is different between the two groups regarding the appropriate use of personal protective equipments. We also observe a significant difference in dependency ratio at the 5% level. The difference in area for cotton cultivation for APPE users and non-users is significant at the 1% level. Therefore, the larger the area cultivated with cotton is, the more the producer uses the APPE. As well, there is also a significant difference in the total area owned by the households. For the types of APPE use, 90% the households in our sample use long trousers, 38% use boots, 34% use mask, 30% use gloves and 14 and 13% use coat and goggles respectively.

Table 1: descriptive statistics regarding appropriate use of APPE

	All	APPE (No)	APPE (Yes)	P-value
Household head				
Age	42.14	42.16	42.04	0.887
Number of years in cotton farming	14.87	14.74	15.38	0.346
Sex (1=male)	0.94	0.94	0.96	0.176
Years of education	1.41	1.28	1.88	0.019
Household Household size	7.19	7.10	7.50	0.193

Dependency ratio	0.41	0.41	0.38	0.035
Cotton area (ha)	3.36	3.11	4.29	<0.001
Total land owned (ha)	13.86	12.92	17.43	0.041
Household assets (million FCFA)	2.16	2.09	2.44	0.272
Pesticide application Training in pesticide application	0.17	0.16	0.19	0.371
Appropriate Protective Equipments				
long trousers	0.90	0.89	0.95	0.017
coat	0.15	0.14	0.19	0.108
boots	0.38	0.24	0.91	<0.001
gloves	0.30	0.14	0.89	<0.001
goggles	0.13	0.06	0.41	<0.001
mask	0.34	0.25	0.66	<0.001
Observations	951	753	198	

3.1.3. Disposal of chemical containers

We only observe a significance difference between households that appropriately dispose chemical containers and those who do not dispose them appropriately regarding dependency ratio and total land cultivated with cotton. In regards to the disposal of chemical containers, 34% of the households in our data appropriately dispose pesticides containers. As part of risky practices, 38% of households in our sample, left empty chemical containers on the plot, 27% threw them into the bush, 11% reused them for household purposes, 3% disposed them in a natural hole, gully or crevasse, and 1% threw them in a river of stream. Two practices are considered as subjectively safe, because they avoid direct contact with human. 36% and 26% of the surveyed households burned or buried the empty chemical pesticides containers.

Table 2: descriptive statistics regarding the disposal of chemical containers

	All	Risky disposal	Safe or acceptable disposal	P-value
Household head Age	42.14	41.74	42.93	0.129
Number of years in cotton farming	14.87	14.66	15.28	0.306
Sex (1=male)	0.94	0.94	0.94	1.000
Years of formal education	1.41	1.47	1.30	0.388
Household size	7.19	7.30	6.96	0.139
Dependency ratio	0.41	0.43	0.37	<0.001
Cotton area (ha)	3.36	3.19	3.68	0.037

Land owned (ha)	13.86	13.57	14.42	0.402
Household assets (million FCFA)	2.16	2.11	2.26	0.621
Left on the plot	0.38	0.58	0.00	<0.001
Thrown into the bush	0.27	0.40	0.00	<0.001
Buried	0.26	0.16	0.47	<0.001
Thrown in a river or stream	0.01	0.01	0.00	0.260
Burned	0.36	0.25	0.57	<0.001
Reused for household purposes	0.11	0.17	0.00	<0.001
Disposed in a natural hole, gully or crevasse	0.03	0.04	0.02	0.252
Other	0.02	0.03	0.00	0.009
Observations	951	630	321	

3.3. Econometric results

3.3.1. Drivers of use of APPE

In the regression model, several variables were introduced to determine those that influence the use of APPE. Among these variables we have: gender, age of the household head, number of years of education, experience in cotton growing, household size, dependency ratio, household capital, training in fertilizer application, and the districts dummy. The binary probit regression model shows that the number of years of education positively and significantly influences the use of APPE at the 1% level. So, an additional one-year increase in education increases the probability of using appropriate personal protective equipment by 0.01. Also the household capital variable has a significant and positive effect on the use of the APPE at the 10% threshold. Thus, the more the household has financial capital, the more the producer is inclined to use APPE. Cotton area also positively influences the use of APPE at 1% threshold. In other words, larger farms apply relevant protective measures. From the analysis of the data, it stands out that training in the application of the pesticide increases the probability of using APPE by 0.09 at the 5% statistical threshold.

3.3.2. Drivers of disposal of pesticides containers

The second regression consisted in identifying the factors that influence the risky or safe behavior of cotton producers in the study area. Indeed, the factors introduced in the model are the same as those introduced in the first model. It appears that: household size influences significantly and negatively the behavior of the producers. The analysis results show that an increase of one person in the household decreases the probability of adopting a safe behavior by 0.01. On the other hand, the area under cotton cultivation positively and significantly influences one of the safe behaviors. According to these analytical results, the increase of one hectare of cotton area increases the probability of adopting safe practices by a very small portion (0.0008) at the 1% threshold. Training of producers in pesticides application also positively and significantly influences behavior with regard to synthetic pesticides at the 1% statistical threshold. The training received reduces the risk behavior of cotton producers by 0.27. This can be explained by the fact that trained farmers are aware about risks behaviors associate with poor handling of residues of synthetic pesticides.

Table 3: Probit regression results for use of APPE

Drivers of appropriate pesticides handling practices		
	Use of APPE (Yes/No)	Container disposal
	(1)	(2)
Gender (male)	−0.04 (0.07)	−0.09 (0.08)
Age of household head	−0.001 (0.002)	0.001 (0.002)
Years of education	0.01∗∗∗ (0.004)	−0.001 (0.01)
Number of years in cotton farming	0.002 (0.002)	0.002 (0.003)
Household size	−0.0004 (0.005)	−0.01∗∗ (0.01)
Dependency ratio	0.003 (0.07)	−0.12 (0.08)
log(Household assets)	0.03∗ (0.01)	0.01 (0.02)
log(Cotton area)	0.07∗∗∗ (0.02)	0.08∗∗∗ (0.02)
Training in pesticide application	0.09∗∗ (0.04)	0.27∗∗∗ (0.05)
District dummy	Yes	Yes
Observations	951	951

Asterisks denote the following: *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

3.3.3. Discussion

Farmers with the goal of obtaining high yield, apply large amount of chemical inputs in cotton production, for weeds and insecticides control (Ahouangninou et al., 2011; Gouda et al., 2018). Cotton farmers in the study area are on average 42.14 years old and are most of them are male (94%). These descriptive trends are similar to those of Gouda et al. (2018), where in their study area the majority of cotton farmers is men. Although the crop grown is different, similar results are obtained by Ahouangninou et al., (2019) who find that 86.35% of market gardeners use phytosanitary products.

The analysis shows that education influences the use of APPE, consistent with the empirical literature. Zapata Diomedi & Nauges (2016) show that human capital (education) and training are important drivers of farmers' pesticide-handling practices. Moreover, Toe et al. (2013) and Soro et al. (2018) also reveal that the level of education positively influences the use of APPE. Ahouangninou et al. (2019), find that the professional experience and site location drive the use of APPE among market gardeners in Ouidah.

As for the appropriate disposal of chemical containers, our descriptive results are consistent with those of Gouda et al. (2018) who found that empty pesticides containers are either abandoned in nature, on cotton plots (73%), and are in some cases used for domestic purposes (25%). This is for storing oil for the kitchen, as a container for transporting porridge or drinking water for children going to the field or to school. They are rarely incinerated or buried in the ground. The types of equipments for protection during pesticide application noted in this study are the same as stated by Yuantari et al. (2015). These are protective glasses, masks, long shirts, hats, pants, boots and gloves.

IV. Conclusion

There is enough evidence that using synthetic pesticides is highly relevant for weeds and pests control, and thus for productivity gains. In sub-Saharan African countries, pesticides are highly used in cotton production in order to ensure high yield. However, intensive use of PPE without using adequate personal protective equipments or safe disposal practices of empty chemical containers can induce costly negative externalities on health and on the environment. Using cross-sectional data collected from cotton farmers in Benin, we examine the drivers of safe practices of pesticides handling such as the appropriate use of personal protective equipments, and disposal of synthetic pesticides containers. We use probit regression, and find that education, training on pesticides management practices, farm size and wealth drive the appropriate handling practices of chemical pesticides. We suggest policies makers to design educational and training program that aim at increasing the adoption of these appropriate measures.

Référence

[1] Afouda, A. P., Hougni, A., Balarabe, O., Kindemin, O. A., & Yabi, A. J. (2020). Determinants de l'adoption de la pratique d'integration agriculture-elevage dans la Commune de Banikoara (Benin). *Agronomie Africaine*, *32*(2), 159-168.

[2] Ahouangninou, C., Boko, S. Y. W., Logbo, J., Komlan, F. A., Martin, T., & Fayomi, B. (2019). Analyse des déterminants des pratiques phytosanitaires des producteurs maraîchers au sud du Bénin. *Afrique SCIENCE*, *15*(5), 252-265.

[3] Ahouangninou, C., Fayomi, B., & Martin, T. (2011). *Évaluation des risques sanitaires et environnementaux des pratiques phytosanitaires des producteurs maraîchers dans la commune rurale de Tori-Bossito (Sud-Bénin).*

[4] Biswas, S., Rahman, S., Kobir, S. M., Ferdous, T., & Banu, N. (2014). A Review on Impact of Agrochemicals on Human Health and Environment : Bangladesh Perspective. *Plant Environment Development*, *3*, 31-35.

[5] Dümmler, C. (1993). *Pesticides et agriculture tropicale. Danger alternatives.* Verlag Josef Margraf.

[6] Gouda, A.-I., Toko Imorou, I., Salami, S.-D., Richert, M., Scippo, M.-L., Kestemont, P., & Schiffers, B. (2018). Pratiques phytosanitaires et niveau d'exposition aux pesticides des producteurs de coton du nord du Bénin. *Cahiers Agricultures*, *27*.

[7] Kane, A., & Sembène, M. (2021). Choix et utilisation des pesticides dans la zone des Niayes : Cas de Notto Gouye Diama. *Afrique SCIENCE*, *19*(2), 55-67.

[8] Lansink, A. O., Van den Berg, M., & Huirne, R. (2003). Analysis of strategic planning of Dutch pig farmers using a multivariate probit model. *Agricultural Systems*, *78*(1), 73-84.

[9] Soro, G., Koffi, N. M., Kone, B., Kouakou, Y. E., M'bra, K. R., Soro, P. D., & Soro, N. (2018). Utilisation de produits phytosanitaires dans le maraîchage autour du barrage d'alimentation en eau potable de la ville de Korhogo (nord de la Côte d'Ivoire) : Risques pour la santé publique. *Environnement, Risques & Santé*, *17*(2), 155-163.

[10] Toe, A. M., Ouedraogo, M., Ouedraogo, R., Ilboudo, S., & Guissou, P. I. (2013). Pilot study on agricultural pesticide poisoning in Burkina Faso. *Interdisciplinary toxicology*, *6*(4), 185-191.

[11] Tomenson, J. A., & Matthews, G. A. (2009). Causes and types of health effects during the use of crop protection chemicals : Data from a survey of over 6,300 smallholder applicators in 24 different countries. *International archives of occupational and environmental health*, *82*(8), 935-949.

[12] WHO, G. (1999). *Guidelines for the management of small quantities of unwanted and obsolete pesticides*.

[13] Yegbemey, R. N., Yabi, J. A., Aïhounton, G. B., & Paraïso, A. (2014). Modélisation simultanée de la perception et de l'adaptation au changement climatique : Cas des producteurs de maïs du Nord Bénin (Afrique de l'Ouest). *Cahiers Agricultures*, *23*(3), 177-187.

[14] Yuantari, M. G., Van Gestel, C. A., Van Straalen, N. M., Widianarko, B., Sunoko, H. R., & Shobib, M. N. (2015). Knowledge, attitude, and practice of Indonesian farmers regarding the use of personal protective equipment against pesticide exposure. *Environmental monitoring and assessment*, *187*(3), 1-7.

[15] Zapata Diomedi, B., & Nauges, C. (2016). Pesticide-handling practices : The case of coffee growers in Papua New Guinea. *Australian Journal of Agricultural and Resource Economics*, *60*(1), 112-129.