

Full Length Research Paper

Impact of the agricultural advisory service on the productivity of maize and cotton in the cotton-growing zone of North Benin

Régina Dossi Clarisse BONOU-ZIN¹, Léonard Cossi HINNOU², Alfred Oluwatogni AYEDOUN² and Esdras Abréwa Rêmilokoun OBOSOU^{3*}

¹Faculty of Agronomy, University of Parakou (FA/UP), Benin.

²National Institute of Agricultural Research of Benin (INRAB), Benin.

³Department of Agricultural Extension, University of Nigeria Nsukka, Nigeria.

Received 5 March 2022; Accepted June 21 2022

Agricultural advisory services play a key role in disseminating agricultural information and technology to farmers. This study aims to assess the impact of agricultural advisory on improving agricultural productivity in Benin. The study uses cross-sectional data collected from randomly selected maize and cotton farmers located in the cotton basin of northern Benin. A total of 809 cotton and maize farmers (with access to farm advisory services or not) from 81 villages in the study area were selected. To overcome selection bias and the problem of endogeneity associated with the impact assessment, regression with endogenous treatment effect model was used. Besides assessing the effect of the farm advisory on productivity, this model also has the advantage of highlighting the main factors determining farmers' access to advisory services. The results show that access to advisory services has a positive and significant impact on farm productivity. Maize and cotton farmers with access to the advisory services have a higher yield (yield improvement of 552.3 kg/ha and 668 kg/ha for maize and cotton, respectively) compared to their counterparts without access. In addition to access to agricultural advice, education, membership of farmers' group, use of tractor, quantity of mineral fertiliser, use of cover crops, access to credit and the number of cattle have a positive effect on productivity. On the other hand, age, household size, and use of improved varieties have the opposite effect. Furthermore, the main factors influencing farmers' access to extension services are age, gender, membership of a cooperative and distance between village and the municipal town. Strengthening the capacity of extension services is therefore essential for improving agricultural productivity.

Key words: Agriculture, advisory services, maize productivity, cotton, North Benin.

INTRODUCTION

The agricultural sector represents a strategic weight in the social and economic structure of Benin. In addition, it

*Corresponding author. E-mail: esdrasobossou@gmail.com.

Author(s) agree that this article remain permanently open access under the terms of the [Creative Commons Attribution License 4.0 International License](https://creativecommons.org/licenses/by/4.0/)

represents the country's main source of foreign exchange, contributes to more than 50% of employment and about 23% of gross domestic product, and provides about 75% of export earnings from domestic sources (Agbangba et al., 2018; MAEP, 2018). The sector is however threatened mirage of problems which militate against optimising its potential (Adekunle et al., 2012; Bocher and Simtowe, 2017). Some of the constraints include low productivity, poor marketing and distribution infrastructure, inadequate access to inputs, credit (Adekunle et al., 2012; Zhou, 2016; Bocher and Simtowe, 2017; MAEP, 2017). Yet, addressing these challenges in the agricultural sector would imply strengthening agricultural advisory services.

Advisory services constitute a vital element of the array of market and nonmarket entities and agents that provide critical flows of information that can improve farmers' and other rural peoples' welfare (Anderson, 2008). They provides farmers with decision support tools (training/information on technical aspects of the farmer's activities, specialized and skills training, linkages to solve various credit and market access problems, research and development, and skills development) that help them to improve their farms make and secure their income (Chia et al., 2015). Besides, advisory services could also serve as a bridge between research and farmers by sharing information on new tools and constraints at the farm level.

Over the past few years, the government of Benin has been investing in agricultural advisory services through its National Agricultural Advisory Strategy in order to achieve common goals in agricultural production, health and environmental protection (Paillard et al., 2010; Bocher and Simtowe, 2017). Yet, farmers' access to agricultural services remains low (an average of 23% at the national level) (Adekunle et al., 2012). Moreover, the impact of these services is not well documented. On the other hand, the relatively few studies in Benin (Zossou, 2013; Yegbemey et al., 2014; Gandonou et al., 2019) that have addressed the benefits of advisory services have not reached a consensus on the impact of these services. Surprisingly, no study has yet measured the effects of advisory services on maize and cotton productivity in Benin.

The main objective of this study is to analyse how advisory services can influence the productivity of certain crops, in particular, maize and cotton in Northern Benin. The study did not aim to simply establish access to advisory services as a causal origin or an explanatory factor for productivity improvement but to highlight the existence of causal relationships between agricultural advisory service and the factors that can influence farm productivity. Thus, as a first step, the authors seek to identify the salient factors relating to the factors of production likely to determine on-farm productivity.

The novelty of this study lies in the fact that it seek to account for the obvious influence of advisory services,

reflecting on the behaviour of farmers concerning the options available to them in a situation of complexity and diversity of agrarian systems, on access to and use of other factors as inputs in agricultural production. Specifically, this involved (i) assessing the productivity of maize compared to cotton in the cotton in North Benin; (ii) determining the factors that influence the productivity of maize and cotton, and (iii) assessing the influence of the advisory services on the levels of access and use of production factors (inputs).

Agricultural advisory system and on-farm productivity: An interdependence

The study used the economic theory of production developed by Bradford and Johnson (1953). Firstly, the theory provides a theoretical basis for the management of production units and more specifically farms. Secondly, it is an indispensable component in the study of the functioning of the economy as a whole. The theory is based on the maximization of the utility function which can be assimilated to profit to take into account the specificity of family farms and, on the other hand, the law of diminishing returns. Thus, the production function relates the quantities produced to the number of factors used and thereby characterises all the constraints that define the boundary of a possible farm.

This corresponds to the maximum quantity of gross production (Q) that can be produced using primary production factors (X) such as land, labour and capital or intermediate inputs (M) such as chemical inputs. Such a production function is assigned a parameter $A(t)$ which highlights the technological variation resulting from research and development activity and is written as follows: $Q = H(A, X, M) = A(t) \cdot F(X, M)$. Moreover, focusing on-farm decisions, the production theory mainly answers a series of questions (what to produce? How much? How to produce? With what resources? In what quantities? With what techniques? On these farms, a part of the productive resources (labour, land and capital) self-provided by the farmer and his family, which are considered free, have opportunity costs that are linked to their best possible use. However, production inputs (seeds, chemical fertilizers, etc.), improved production techniques and equipment that can enhance productivity come mainly from extension structures or sometimes from markets (Fuglie and Rada, 2013).

This study focused on the social capital arising from farmers' interactions with farm advisory structures. Indeed, farm productivity measures the efficiency of the use of production factors (land, capital, labour) (Sissoko et al., 2015) in a given agro-ecological environment and political and socio-economic context. Generally, two indicators are considered to measure productivity: (i) total productivity of production factors, which reflects the efficiency of the use of all production factors, and (ii)

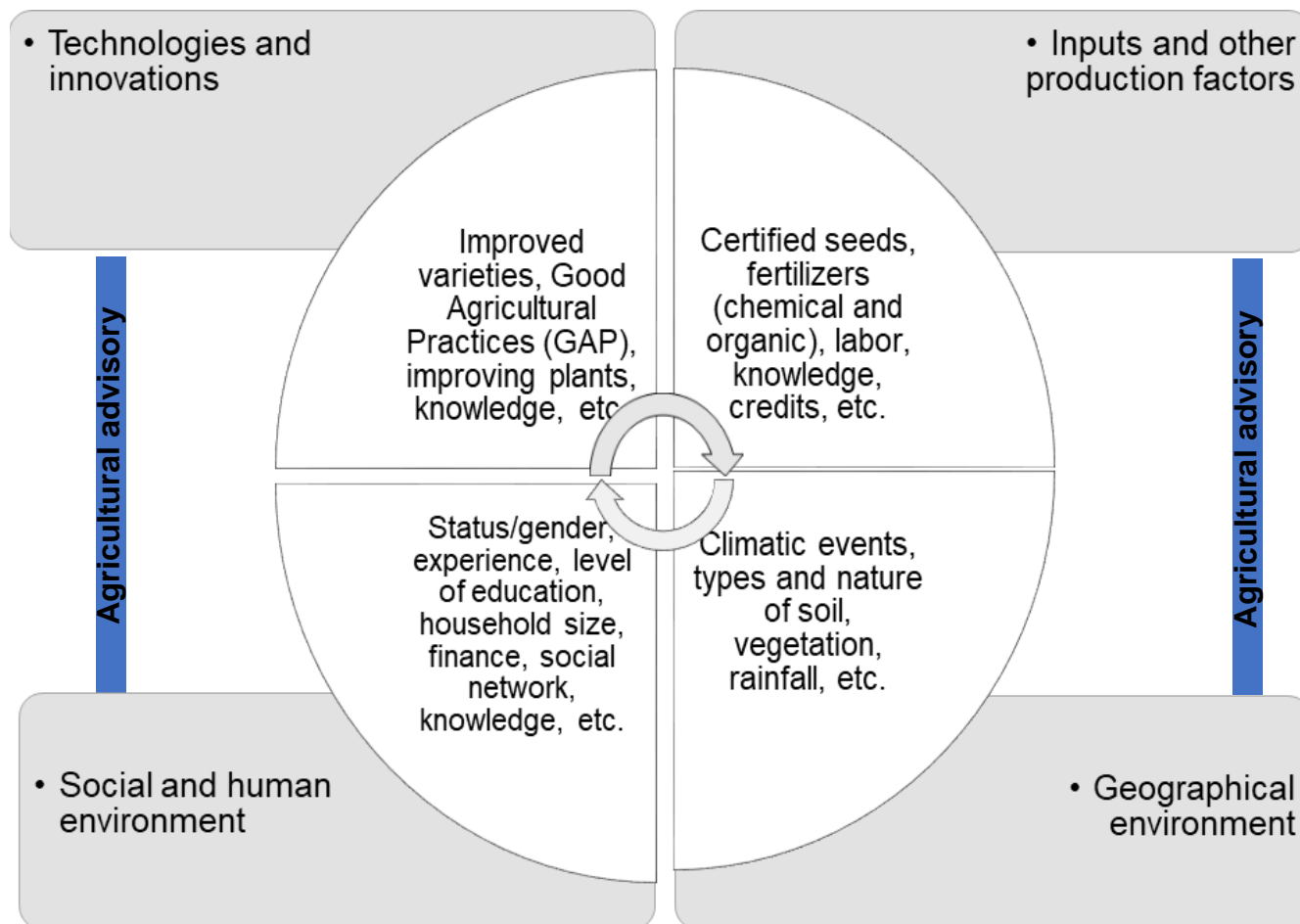


Figure 1. Conceptual framework.

partial productivity (land, labour, capital) of production factors, which shows the evolution of agricultural production following the change in the use of a single factor. Land and labour productivity are the two most widely used partial productivity indicators. In this study, the focus is on farm productivity, which is considered as the change in agricultural production resulting from the change in the area of land under cultivation. This is calculated by dividing the total agricultural production by total of land area in use. The agricultural production used here generally includes the production of all the crops grown on the same piece of land in a year. Farm productivity is therefore distinguished from land yield and can be measured by taking as a unit the amount of food plant calories produced per hectare (Coulibaly, 2012) or by expressing agricultural production in monetary value, which is an original alternative (Sissoko et al., 2015).

The improvement of farm productivity is only possible through the methodological support provided to farmers by the farm advisory service through the technical and organizational innovations that are disseminated (Adégbola et al., 2018). The latter not only enables

farmers to meet their input supply needs more efficiently, but also constitutes a transmission and dissemination channel for new technologies/innovations and useful information that are likely to improve farm productivity (Zhou, 2016; Adégbola et al., 2018). In other words, research and extension, rural training, resource quality, infrastructure and institutions are important levers for increasing the productivity of production factors (Gebrehiwot, 2015). Thus, advisory services play a key role in improving factor productivity on farms. Because of the complexity and the predominant role that farm advisory services play in improving the productive performance of farms, it is important to quantify their impact. The conceptual framework presented in Figure 1 illustrates the interdependent relationships between the productivity of land and the factors of production to which access is facilitated by the farm advisory service on the one hand and the backward effects of the inputs used for cotton production on the other. Indeed, it has been accepted for years that cereal yields remain largely linked to the after-effect of cotton fertilization (Danso-Abbeam et al., 2018). In other words, the downward trend in cotton

Table 1. Number of villages and farms per PDA.

PDA	Municipality	Number of village	Number of farmer
PDA1: Vallée du Niger	Karimama	4	21
PDA2: Alibori Sud, Borgou Nord et 2KP	Banikoara, Gogounou, Kandi, Kerou, Ouassa-pehunco, Segbana, Sinende	40	411
PDA3: Atacora Ouest	Boukoumbe et Natitingou	8	90
PDA4: Borgou Sud, Donga et Collines	Bassila, Copargo, Ouake, Parakou, Perere, Tchaourou	29	287
Ensemble		81	809

Source: Field Survey (2019).

yields has a knock-on effect on the yields of cereal crops benefiting from the back effect of cotton fertilization. The same results were obtained by Coulibaly (Anang et al., 2020) who revealed the after-effect of previous crops on the agronomic and economic performance of vegetables.

MATERIALS AND METHODS

Study area

This study was conducted in the Departments of Alibori, Atacora, Donga, Borgou and the hills and covers approximately 97,654 km² (85% of the national territory) of which approximately 60% is arable land. The climate in the area is Sudanian, with a rainy and dry season. However, farmers are confronted with the unpredictable changes in the climate.

It is observed as a significant drop in the level of rivers. The area is known not only for cotton cultivation but also for certain cash crops such as maize, rice and sorghum. With the development of cotton production in the country, there is an increasing use of chemical fertilisers on farm. The use of chemical fertilisers is further extended to other crops including maize. Some local maize varieties gave way to improved varieties that benefited from the after-effects of cotton. In particular, maize, the second most important cash crop in Alibori, is gradually becoming part of the diet of the area's populations. In addition to cotton, and in order of importance in the crop rotation system, the main crops are maize, sorghum, rice, groundnuts, and cowpeas. In most of the zone, root crops and tubers are average, and yam production is declining significantly due to insufficient rainfall, the scarcity of fertile land, and the increase in cash crops.

Furthermore, agricultural advisory services have undergone many changes over time in Benin. In the 1980s, the country has experienced the development of public services using the "train and visit" method. This period was derailed by structural adjustment programs and the withdrawal of the government in the late 1980s. This disengagement could only be compensated for by the emergence of new actors (producers' organizations, NGOs, private sector, etc.) who developed different agricultural advisory services in the field through various approaches (participatory approach at the village level, the farmers-to-farmers approach etc.). As a result, the Beninese government is once again stepping into the fray, while bringing noticeable ideas on agricultural advisory support and extension provisions. However, as part of the government's action plan, reforms in the agricultural sector over the past three years have changed the institutional structure of the country's agricultural advisory system (Moumouni, 2019). The Strategic Plan for the Development of the Agricultural Sector, including the National

Strategy for the Agricultural Advisory (SNCA), is an instrument entrusted to the twelve (12) Departmental Directorates of Agriculture, Livestock and Fisheries (DDAEP) with technical assistance provided by the Agency for Agricultural Territorial Development (ATDA) (MAEP, 2017). However, the chances of farmers obtaining agricultural services in the various agricultural development poles (PDAs) are still low as the national average is estimated at nearly 23% (Adégbola et al., 2018).

Sampling

Multistage sampling was used to select the respondents of this study (Table 1). The first stage consisted of the selection of the study area (cotton-growing zone of North Benin) based on a purposive sampling. Cotton is Benin's main exportation crop and contributes about 8% to the Gross Domestic Product (GDP). Given its economic importance, the cotton sector is the best-organized sector that benefits from the support of successive governments. Thus, to support cotton production, this region benefits from the implementation of several agricultural advisory programs by both the public and private sectors. Also, in recent years, this zone has been experiencing the emergence of food crops that were once the preserve of the southern zone. The main crops in the zone are export crops, particularly cotton and food crops. The cotton growing zone of North Benin covered four department including Atacora, Donga, Borgou, and Alibori.

The second stage consisted of typifying the study area into two sub-zones based on the level of cotton production, which is a general basis for the provision of agricultural advisory services in the northern Benin. This typology was made based on the national average of cotton production. Thus, a distinction is made between:

1. Area with a high level of cotton production including municipalities with a production level above the national average.
2. Area with a low level of production comprising the municipalities with a level of production below or equal to the national average.

The selection of villages in each municipality was made by considering the level of production and access to agricultural advisory services. Discussions with DDAEP agents and ATDA agricultural advisors at municipality level made it possible to have a list of the villages that produce the most cotton and are therefore likely to benefit more from agricultural advisory services. It should be noted that the agricultural advice for other speculations, particularly those that are the subject of this study, was also used as criteria in the identification of villages. Based on the list of villages, the level of maize and cotton production was used to select the survey villages.

Data were collected in 16 municipalities in which 81 villages were

selected and distributed across four Agricultural Development Pole (PDA). These villages were selected randomly based on predefined criteria (production level and access to agricultural advice). In each village, structured interviews were conducted with farmers. In this regard, the socio-economic characteristics of the latter, information related to the crop production system, access and appreciation of farmers to agricultural advice, etc. The final step was the selection of households to be surveyed. Random sampling was used to select farmers with access to the agricultural advisory service and those without access. A total of 809 of producers of which 167 receiving agricultural advisory and 642 not receiving were selected.

Theoretical framework and estimation of the impact of the farm advisory service on productivity

This study is based on the random utility maximization theory often used to model technology adoption decisions. The theory explains decision making as resulting from the level of satisfaction obtained. It suggests that farmers choose among several alternatives, the one that provides the greatest utility. We thus assume that a farmer decides to access agricultural advisory services based on the usefulness he or she derives from them. Let U_{i1} , be the utility that the access to advisory services provides to a farmer and U_{i0} the utility of a farmer without advisory services. Farmers choose to receive farm advice if the utility provided by access to advisory services (U_{i1}) is greater than the utility the farmer as if he or she does not receive advisory services (U_{i0}), that is $U_{i1} > U_{i0}$. However, since utility is not observable, it is only the benefit of access determined by observable and unobservable characteristics that can be observed. In this case, access to advisory services is then determined by the following equation:

$$CA_i = \alpha X_i + \varepsilon_i \text{ With } CA_i = \begin{cases} 1 \text{ si } CA_i^* > 0 \\ 0 \text{ si non} \end{cases} \quad (1)$$

CA_i is the binary variable representing access to the advisory services, α is the vector of parameters to be estimated; X is the set of socio-economic characteristics and institutional factors that influence access to advisory services and ε_i is the error term. The impact of advisory services on productivity can be expressed as follows:

$$Y_i = \varphi Z_i + \delta CA_i^* + \vartheta_i \quad (2)$$

Y_i is the variable representing productivity, CA_i^* , access to agricultural advice, Z_i , other variables that influence agricultural productivity, φ and δ are the parameters to be estimated and ϑ_i is the error term. The parameter δ would allow a direct assessment of the effect of the agricultural advisory on productivity if access to advisory services is random, which is not the case.

Indeed, the variable advisory services is not random and is correlated with the characteristics of farmers as well as the characteristics of their farms (MAEP, 2018). This can lead to selection bias since farmers, given their usefulness and various constraints (access to productive resources); can decide whether or not to receive advisory services. As a result, farmers who receive advisory services may be different from their peers who do not. Moreover, the issue of endogeneity may arise because the advisory service may be geared towards a specific category of farmers (e.g. cotton farmers). Besides, Danso-Abbeam et al. (2018) noted that selection biases can arise from observable and non-observable characteristics. To overcome selection biases and endogeneity problems, regression with endogenous treatment effect was used.

In addition to selection bias, endogeneity is another problem associated with impact assessment. As in Anang et al. (2020), regression with endogenous treatment effect was used in this

study. The approach has the advantage of correcting both observable and non-observable biases resulting from the non-random assignment of farmers to advisory services and thus allows unbiased estimation of the effect of the advisory services (Anang et al., 2020) on productivity.

Besides the average effect of the farm advisory on participants' productivity, the model also allows the estimation of other parameters of the linear regression that includes an endogenous binary variable. The model also controls for the non-observable variables that influence both access to advisory services and farm productivity. According to Awotide et al. (2015), the endogenous treatment effect regression model permits a specific correlation between non-observable variables affecting treatment and those affecting the potential output.

The regression with endogenous treatment effect model is conducted in two steps (the productivity equation and the endogenous latent variable equation which is access to the farm advisory services) and is as follows:

$$Y_i = \varphi Z_i + \delta CA_i^* + \vartheta_i \quad (3)$$

$$CA_i^* = \alpha X_i + \varepsilon_i \begin{cases} 1, CA_i^* > 0 \\ 0, \text{ si non} \end{cases} \quad (4)$$

With CA_i^* the latent access variable measuring the probability to access agricultural advisory services, CA_i is the endogenous variable of access to advisory services which takes the value 1 for farmers with access and 0 for those without access. Z_i and X_i are the explanatory variables for the productivity equations and advisory services respectively, φ and α being the parameters to be estimated. Like Anang et al. (2020), the maximum likelihood method was used to estimate the model parameters.

Productivity is a relative concept whose application and the meaning differ according to the sectors, regions and factors of production considered. In this study, the yield of each crop measured in Kg per hectare is considered an indicator of agricultural productivity. Regarding the explanatory variables, in the literature on the impact of agricultural extension program on agricultural productivity five group of factors are identified as drivers of agricultural productivity (Awotide et al., 2015; Emmanuel et al., 2016; Baloch and Thapa, 2018; MAEP, 2018; Teka et al., 2019). These factors are socioeconomics characteristics, physical capital, social capital, institutional factor and adoption of agricultural technologies. Socioeconomics characteristics included in the model are age, sex, number of year in agricultural production, household labour, year of schooling and farm income. Apart from age and experience, the other variables are hypothesised to have a positive effect on agricultural productivity. Age and number of years in production are associated with knowledge and skills accumulation. However, older and more experienced farmers may be tied to traditional agriculture and therefore be reluctant to adopt modern technologies. The sign of these variables is therefore ambiguous. In Benin as in most developing countries, male farmers have more access to productive resource, information and institutional factors than female farmers. Then it is expected that male farmer would have a better agricultural productivity than female. Year of schooling improve farmers ability to use modern technologies and then influence positively productivity. Proxy of labour availability, the household size provides the possibility to overcome labour constraints and to conduct farming operations on time. An increase in the farm income would also allow producers to have cash to easily acquire farm inputs; it therefore supposed to positively affect productivity.

Social capital which assimilates to farmers' organisation membership is also linked to farm productivity improvement. Farmers' organisation is promoted by extension program and contributes to the dissemination of information about productive

Table 2. Variables introduced in the regression model.

Variable	Description	Expected sign
Outcome variable		
Yield	Quantitative variable expressing maize or cotton yield in Kg/ha	
Independent variable		
Socioeconomics characteristics		
Age	Quantitative variable expressing the age of the holding manager	+/-
Sex	Binary variable taking the value 1 if the operator is male and 0 otherwise	+
Year of schooling	Quantitative variable expressing the number of years of schooling of the farmer	+
Experience	Quantitative variable expressing the number of years of the farmer's crop production	+/-
Household size	Quantitative variable expressing the size of the farm household	+
Farm income	Quantitative variable expressing the share of farm income in total income	+
Technologies adoption		
Improved seeds	Binary variable taking the value 1 if the farmer uses improved seed and 0 otherwise	+
Quantity of chemical fertilizer	Quantitative variable expressing the amount of fertilizer used in kg/ha	+
Type of operation	Binary variable taking the value 1 if it is a cotton holding and 0 otherwise.	+
Improving plants	Binary variable which takes the value 1 if the farmer uses pigeon pea or fallows in Mucuna and 0 otherwise	+
Short cycle variety	Binary variable taking the value 1 if the farmer uses short-cycle varieties and 0 otherwise	+
Staggered sowing	Binary variable taking the value 1 if the farmer practices staggered sowing and 0 otherwise	+
Social capital		
Cooperative membership	Binary variable taking the value 1 if the operator is a member of a farmer organisation and 0 otherwise.	+
Institutional factors		
Access to farm advisory services	Binary variable taking the value 1 if the operator has contacts with the extension services and 0 otherwise	+
Access to agricultural credits	Binary variable taking the value 1 if the farmer has access to farm credit and 0 otherwise	+
Distance to market	Quantitative variable expressing the distance in km from the nearest periodic market to the producer's house.	-
Distance to the town	Quantitative variable expressing the distance in km between the farmer's village and the chief town of the commune	-

Source: Field survey (2019).

technologies. Membership of farmers' organisation can therefore enhance farmers' probability to use improved technologies and agricultural productivity.

Institutional factors concern access to credit, access to extension services, distance to local market and distance to town. Access to credit and extension services is expected to enhance agricultural productivity. Related to adoption of agricultural technologies, extension services contribute to agricultural productivity through the adoption of improved agricultural technologies (improved seed, fertilizers and pesticide). They provide farmers with information and training which enhance their knowledge and ability to use these technologies essential to productivity enhancement. Extension agents also facilitate farmers' access to financial service which in turn contributes to technologies adoption. It is also important to note that physical factor is not considered in this study. The different explanatory variables with the hypothesised sign are presented in Table 2.

Data collection and analysis

The data used in this research relate to the 2018-2019 crop year. The data were collected using a structured questionnaire administered to each farmer. It should be noted that before data collection, a pre-test of the questionnaire was conducted and allowed for the refinement of the final questionnaire used in this study. The data collected concerning socio-economic and demographic characteristics, as well as institutional factors. Other key variable considered is technology adoption. Besides, the data collected were analysed using descriptive statistics, inferential statistics, correlation analysis and econometric regression. Descriptive statistics (percentage, frequency distributions and mean) were used to analyse the socio-economic and demographic characteristics of farmers and other characteristics related to their operations. It allows the description of the different variables used in this study. Inferential statistics (Student's t-test and chi-square

test) were also used to test the differences observed between farmers who received and did not receive farm advisory services.

RESULTS

Farmers' characteristics in relation to their status of access to the farm advisory service

Overall, farmers had a low yield of maize and cotton with little improvement among those who have access to advisory services (Table 2). Most of the respondents producing maize (73%) were men while about 7% of the women were cotton growers. The average age of farmers was 44 years and few (27% for maize farmers and 15% for cotton farmers) had formal education. It is therefore imperative to find other mechanisms to improve farmers' knowledge and literacy, such as informal education programs, farmer field schools, etc. On the other hand, farmers generally belong to associations.

For example, 62% of maize farmers were members of a farmers' organization. This rate is relatively higher among farmers who have access to farm advisory services. Membership in associations can facilitate access to extension services. Regarding the number of people in charge of the farm, the number is higher on cotton farms (on average 10 people) than on maize farms (on average 8 people). Irrespective of the crop considered, the more the farm manager has access to advisory service, the greater the number of people in charge. Farms with limited access to labour tend to cultivate small areas of land and are less exposed to advisory services. As a result, these farms have limited access to loans for the expansion of the farm. As one would expect a priori, cotton farmers generally sowing large areas have more access to credit than those producing maize (13.65% for cotton farms versus 7.17% for maize farms). The more these farms maintain contact with extension, the more likely they are to access credit.

Moreover, the main source of income for the farms surveyed was agriculture, which contributed about 90% of the total farm income. However, respondents had an average Total Livestock Units (Cattle) is seven. It is important to mention that cotton farmers in majority make use of cattle for animal traction. While most farms were close to a market (3 to 4 km), they are generally far from the municipal town (more than 20 km on average). Surprisingly, the more remote the cotton farm is, the more the farmer has access to advisory services. The opposite trend is observed on maize-producing farms. Moreover, 61% of the maize-producing farmers with access to advisory services also cultivate cotton. This shows evidence of the functional and agronomic relationships that exist between cotton production and the production of food crops in the context of random access to agricultural inputs. This assertion is confirmed by the adoption of organic fertilisers and the quantity of chemical fertilisers used by the respondents. Indeed, the quantity

of chemical fertilisers used by maize farms that had access to farm advisory services was greater than those that did not.

On average, there was a difference of 100 kg between corn farms with access to advisory services and their peers without access. On the other hand, it was observed that cotton farmers with access to advisory services used slightly less chemical fertiliser than those without access. This confirms, to some extent, the idea that access to and rationality of inputs were positively correlated with access to advisory services. Yet, the adoption of agricultural technologies and innovations is still very low regardless of the status of access to advisory services and crops grown. This result does not lend itself to easy interpretation and may suggest the likelihood of asymmetries or the speed of information flow related to these technologies. The relatively higher level of education among farmers with access to farm advisory services may also imply a positive influence of education on access to adoption and extension. Table 3 shows descriptive statistics of the respondents' farm characteristics.

Impact of the farm advisory service on maize and cotton productivity

The results of estimating the effect of the advisory services on maize and cotton yields are presented in Table 4. From this table, it can be seen from Wald's statistic that the models are globally significant at the 1% significance level. Independence tests of the advisory access and farm productivity equations associated with each model indicate that within each model, the two equations are related, as shown by the statistical significance of the likelihood ratio tests at the 5% and 10% thresholds respectively. The negative sign of rho reveals that the unobserved variables that improve maize and cotton yields are correlated with those that limit farmers' access to advisory services.

DISCUSSION

Improving the productivity of maize and cotton: the role of agricultural advisory services

The results of this research show that maize and cotton yields are highly dependent on agricultural advisory services. This indicates the prominent role played by extension services on small farms in Benin. These results are consistent with those of Emmanuel et al. (2016) and Baloch and Thapa (2018) who showed the positive effect of advisory services on agricultural productivity. Indeed, Feder et al. (2004) had identified two main constraints to crop productivity, namely low technology and weak farm management. The role of extension agents in the

Table 3. Descriptive statistics of the respondents' farm characteristics.

Variable	Maize (N=642)				Cotton (N=381)			
	Access to advisory service		Statistical test	All together	Access advisory service		Statistical test	All together
	No	Yes			No	Yes		
Maize yield (Kg/ha)	1072.81 (19.29)	1363.79 (44.01)	-6.40***	1127.2 (18.26)	1368.30 (26.84)	1396.63 (44.99)	-0.56	1376.55 (23.09)
Sex (% female)	6.90	5.83	0.176	6.70	7.41	6.31	0.145	7.09
Age	44.92 (0.61)	43.53 (1.08)	1.01	44.65 (0.54)	44.26 (0.75)	44.67 (1.17)	-0.29	44.38
Education	26.82	28.33	1.1	26.81	12.59	21.62	4.97**	15.22
Farm size	7.29 (0.18)	8.41 (0.42)	-2.65***	7.50 (0.17)	8.73 (0.31)	9.44 (0.52)	-1.21***	9.94 (0.27)
Cotton farm size (%)	32.76	60.83	32.64***	38.01	-	-	-	-
Total Livestock Unit (Cattle)	3.64 (0.59)	4.81 (1.21)	0.393	3.86 (0.532)	7.28 (0.77)	7.81 (1.52)	-0.341	7.44 (0.71)
Farm income (%)	8.63 (0.08)	8.72 (0.14)	-0.46	8.65 (0.073)	8.86 (0.095)	8.89 (0.14)	-0.187	8.87 (0.079)
Cooperative membership	34.10	73.33	61.89***	41.43	77.04	81.98	1.14	78.48
Access to credit	6.32	10.83	2.99*	7.17	10.37	21.62	8.45***	13.65
Quantity of chemical fertiliser used (kg)	155.58 (89.50)	206.35 (40.70)	1.97**	185.25 (65.27)	228.46 (6.70)	211.89 (8.62)	1.40	223.63 (0.18)
Distance between the village and the nearest market (km)	3.45 (0.19)	3.25 (0.41)	0.51	3.41 (0.17)	3.21 (0.27)	2.78 (0.44)	0.85	3.08 (0.23)
Distance between the village and the municipal town (km)	29.10 (1.2)	20.91 (1.56)	3.13***	27.57 (1.03)	19.43 (0.79)	22.36 (1.75)	-2.02**	20.29 (1.17)
Use of organic fertiliser	8.24	12.5	2.15	9.03	7.04	12.61	3.09*	8.66
Use of tractor	4.50	5	0.04	4.67	9.63	8.11	0.22	9.19
Use of improved crop varieties	5.17	6.67	0.42	5.45	91.37	91.82	0.455	91.51
Use of cover crops	0.96	2.50	1.89	1.25	2.22	2.70	0.079	2.36
Use of short-cycle varieties	6.32	7.50	0.22	6.54	2.96	3.60	0.106	3.15
Staggered sowing	8.81	6.67	0.583	8.41	7.04	3.60	1.64	6.04

Source: Field survey (2019).

dissemination and adoption of agricultural technologies in rural areas is well established. In Benin, the advisory services, in addition to being a channel for the introduction of technologies in rural areas, contribute to the improvement of farmers' knowledge and skills on these technologies such as improved seeds, fertilizers, phytosanitary products, etc. Besides, the extension services are also a channel for the introduction of technologies in rural areas. Already some 20 years ago, it was shown that the farm advisory service accelerates the rate of adoption of new technologies and provides a mechanism through which information on these

innovations can be passed on to farmers (Labarthe and Laurent, 2011). Lee (2017) revealed that the different information disseminated by the agricultural advisory improves the capacity to adopt new technologies and inputs. Moreover, the same authors had argued that advisory services contribute to building farmers' capacity to use technologies, Good Agricultural Practices (GAP), the establishment of demonstration plots or on-farm experiments. Advisory services thus constitute an essential component in the socio-economic development of developing countries (Bonye et al., 2012).

Improving maize and cotton productivity: the role of institutional factors

In addition to advisory services, institutional factors and the adoption of agricultural technologies and inputs also affect maize and cotton yields. At the institutional level, membership in a farmers' organisation and access to agricultural loans have a positive effect on yield. Maize farmers with membership in farmers' organisation have a better yield compared to those without. Indeed, cooperative membership enables access to agricultural information. As the results revealed, maize

Table 4. Impact of farm advisory on maize and cotton yield estimated using the endogenous treatment effect model.

Variable	Maize	Cotton
Age	-2.706**	1.892
Sex	-57.88	-
Education	50.66**	-119.1
Household size	-2.258	-9.807**
Cooperative membership	135.0***	-
Use of machinery/tractor	217.4***	43.90
Use of organic fertilizers	-2.430	10.23
Farm income (% from total income)	-17.39	-10.75
Use of improved varieties	-123.3*	-
Quantity of chemical fertilizer	0.006**	1.370***
Use of cover crops	275.9**	272.04
Use of short-cycle varieties	-94.60	-
Staggered sowing	-33.99	-61.52
Access to credits	43.83	179.0***
Total Livestock Units (Cattle)	-	5.662***
Distance between the village and the nearest market	5.015	7.448
Access to advisory service	552.9***	668.0***
Constant	1.307***	875.9***
Agricultural advisory		
Age	-0.0151***	-0.0047
Sex	-0.482***	-0.471***
Education	0.0704	0.240**
Cooperative membership	0.567***	-
Cotton farm size (%)	0.347	-
Distance between the village and the municipal town of its commune (in km)	-0.0083***	0.0034
Athrho	-0.493**	-0.973***
Lnsigma	6.090***	6.214***
Rho	-0.456	-0.75
sigma	441.26	499.45
Lambda	-199.0	-374.59
Observations	642	381
Wald chi ² (16_13)	138.65***	90.83***
Log-likelihood	-2705.2	-3061.68
LR test	4.19**	2.93*

***, ** and *: Coefficients thus indicated are significant at 1, 5 and 10% respectively.

Source: Field survey (2019).

farmers without farmer organisation membership have lower probability of receiving advisory services. For Danso-Abbeam et al. (2018), farmer organisations have been recognised in recent years as a cost-effective means of disseminating information and technology to farmers. Thus, farmers' organisations have become the one of the main advisory services providers in rural areas. They thus constitute a melting pot that promotes farmers' access to production inputs, information on agricultural technologies, training and experimentation on technologies and technical production itineraries, and thus promote good agricultural productivity. Takam-Fongang et al. (2019) have also discussed the positive role of grouping in improving agricultural productivity. In

addition, access to financial services has a positive effect on cotton yield. Cotton production, like any economic activity, requires financial resources to meet the various costs related to the purchase of inputs and labour. Awotide et al. (2015) had argued that access to credit has an indirect effect on productivity through its influence on the adoption of agricultural technologies, labour and the improvement of capital needed for agricultural investments.

Improving maize and cotton productivity: The role agricultural inputs and technological change

Concerning inputs and technology adoption, the results

show that an increase in the quantity of chemical fertiliser utilised also increase the yield of maize and cotton. This finding contends with the of Emmanuel et al. (2016) which found a positive effect of chemical fertiliser use on rice yield. In the meantime, covers crops as part of the sustainable land management practices also improve the fertility of the soil, thus the crop yield. Similarly, the use of machinery on farm in particular tractors, significantly improves maize yield. As mentioned by Rehman-Ud-din and Khattak (2018), the use of tractors significantly improve the crop yield of wheat and maize. This could be explained by the fact that the use of tractors promotes deep ploughing, better soil and seedbed preparation, reduced weed incidence and better use of inputs including chemical fertilisers and manure (Rehman-Ud-din and Khattak, 2018). Devendra and Shreemat (2017) argue that mechanisation is an efficiency-enhancing option in agricultural production that can contribute to improved agricultural production, productivity and profitability through increased labour and land productivity.

In contrast to Takam-Fongang et al. (2019) who showed the positive effect of using improved varieties on maize productivity, the results show that farmers using improved maize varieties encountered lower yield compared to those using traditional varieties. This result is surprising as it was expected that the use of improved crops varieties would result in an improved yield. However, a similar result was found by Wu et al. (2010) who observed a decrease in yields of improved varieties over time. Thomas-Sharma et al. (2016) associate this decrease in the yield of improved varieties with varietal degeneration related to pathogen accumulation over time. In addition to this, the climatic and soil conditions prevail in the environment. Indeed, Takam-Fongang et al. (2019) stipulates that improved varieties are adapted to specific soil characteristics and climatic conditions. These characteristics or climatic conditions change over time and can therefore lead to a decrease in the potential of these varieties.

Socio-economic factors affecting maize and cotton productivity

Socio-economic characteristics also influence agricultural productivity. Indeed, young maize farmers have a better yield compared to older farmers. This result is consistent with those of Takam-Fongang et al. (2019) who showed the negative effect of age on maize yield. Indeed, the age of farmers is associated with experience and accumulation of knowledge on crop production over time. However, the low productivity of older farmers is believed to be related to their attachment to conventional low-productive production practices. Alam et al. (2016), older farmers are more reluctant to use new technologies and

therefore tend to maintain their usual farming practices.

In short, older farmers are resistant to technological innovations that would increase agricultural productivity. Younger farmers, on the other hand, have little experience and therefore consult extension agents for access to information on technical production routes as well as new production technologies Baloch and Thapa (2018). Furthermore, farmers over time and with the weight of age may become inefficient in carrying out agricultural work and thus be less productive.

The level of education plays a key role in improving maize yields. Results show that maize yield is higher among highly educated farmers. Thus, formal education improves the level of knowledge of farmers on the use of agricultural technologies and the application of technical production routes taught by extension services. It improves the management capacity of farmers and promotes a better allocation of resources. These findings corroborate those of Asadullah and Rahman (2009) and Ferreira (2018) who have shown that education positively affects agricultural productivity in Bangladesh and Malawi. Also, Anang et al. (2020) showed the effect of education on access to advisory services and adoption of technologies that are influential factors in agricultural productivity. They argued that both adopters and respondents with access to farm advisory services have a relatively higher level of education than non-adopters and those with no contact with advisory services.

Household size negatively affects cotton yield. The negative effect of household size on productivity has been observed by Awotide et al. (2015). For these authors; the larger the size of the household the higher the probability of being poor; which limits the availability of financial resources for agricultural production and consequently a reduction in productivity.

The results also reveal that cotton farmers with more cattle have a better yield. Cattle ownership is a source of prosperity and agricultural savings in rural areas. It can contribute to the reduction of credit constraints during the crop year. In addition, farmers with cattle can use the manure to fertilise fields and thus improve soil fertility levels and thus obtain higher yields. Anang et al. (2020) observed the positive effect of herd ownership on yield and income in Ghana.

With regard to access to advisory services, the results reveal that farmers' access to farm advisory services is positively correlated with sex, education level, and cotton farm ownership and association membership. On the other hand, age and the distance between the village and the municipal town limit producers' access to agricultural advisory services.

CONCLUSION AND RECOMMENDATIONS

The study used linear regression with endogenous

treatment effect to analyse the effect of advisory services on maize and cotton productivity in northern Benin. The results reveal that access to agricultural advisory services improves maize and cotton yields by 552.9 kg/ha and 668 kg/ha respectively. Moreover, advisory service appears to be a powerful tool for improving agricultural productivity. Facilitating farmers' access to such services is therefore essential for improving agricultural productivity and farmers' living conditions; access to advisory services is correlated with the characteristics of the farmers, institutional and technological factors at the level of the farming. Thus, to improve crop productivity, policymakers and practitioners at the grassroots level need to work towards improving not only farmers' access to advisory services but also the quality of the services offered. This will require strengthening the technical and material capacities of extension agents to provide effective but networked and gender-sensitive agricultural advisory services. Since the results have shown the limitations of improved varieties in improving yields, specialized centres must work to ensure the purity and certification of the seeds produced and then facilitates access to them by farmers.

CONFLICT OF INTEREST

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENTS

The enumerators are highly acknowledged for their participation in data collection. The authors wish to express their gratitude to the farmers from the study area for their contributions.

REFERENCES

- Adégbola YP, Amagnide GAY, Chabi Adjubo MA, Sossou C, Oluo BD, Maboudou Alidou G, Hinnou C, Oussou BT, Kouton-Bognon BY, Adéguélou K, Djidonou SJ, Arodokoun U, Sédégnan A (2018). Caractérisation et évaluation des milieux homogènes des Pôles de Développement Agricole du Bénin (paper version available at the institution library).
- Adekunle AA, Ellis-Jones J, Ajibefun I, Nyikal RA, Bangali S, Fatunbi O, Ange A (2012). Agricultural innovation in sub-Saharan Africa: experiences from multiple-stakeholder approaches. Forum for Agricultural Research in Africa (FARA), Accra, Ghana. <https://www.tapipedia.org/sites/default/files/mendeley/PDF/A.%20et%20al.%20-%202012%20-%20Agricultural%20Innovation%20in%20Sub-Saharan%20Africa%20Experiences%20from%20multi-stakeholder%20approaches.pdf>
- Agbangba EC, Adegbola P, Dagbenonbakin GB, Houssou P, Ogoouvé F, Agossou HK (2018). Analyse des besoins en équipements et matériels de production des spéculations des pôles de développement agricole du Bénin. *International Journal of Biological and Chemical Science* 12(6):2691-2702.
- Alam GM, Alam K, Mushtaq S (2016). Influence of institutional access and social capital on adaptation decision: Empirical evidence from hazard-prone rural households in Bangladesh. *Ecological Economics* 130:243-251. doi: 10.1016/j.ecolecon.2016.07.012.
- Anang BT, Bäckman S, Sipiläinen T (2020). Adoption and income effects of agricultural extension in northern Ghana. *Scientific African* 7, e00219. doi: 10.1016/j.sciaf.2019.e00219.
- Anderson JR (2008). *Agricultural Advisory Services*. <https://openknowledge.worldbank.org/handle/10986/9041>
- Asadullah MN, Rahman S (2009). Farm productivity and efficiency in rural Bangladesh: The role of education revisited. *Applied Economics* 41(1):17-33. doi: 10.1080/00036840601019125.
- Awotide BA, Abdoulaye T, Alene A, Manyong VM (2015). Impact of Access to Credit on Agricultural Productivity: Evidence from Smallholder Cassava Farmers in Nigeria. (No. 1008-2016-80242). doi: 10.22004/AG.ECON.210969.
- Baloch MA, Thapa GB (2018). The effect of agricultural extension services: Date farmers' case in Balochistan, Pakistan. *Journal of the Saudi Society of Agricultural Sciences* 17(3):282-289. doi:10.1016/j.jssas.2016.05.007.
- Bocher TF, Simtowe F (2017). Profit efficiency analysis among groundnut farmers from Malawi. *Journal of Development and Agricultural Economics* 9(10):278-288. doi:10.5897/JDAE2017.0774.
- Bonye SZ, Kpieta BA, Jasaw GS (2012). Promoting community-based extension agents as an alternative approach to formal agricultural extension service delivery in northern Ghana. *Asian Journal of Agriculture and Rural Development* 2(1):76-95. Available at: www.aessweb.com.
- Bradford LA, Johnson GL (1953). *Farm Management Analysis*. *Journal of Farm Economics* 35(4):635. doi:10.2307/1233382.
- Chia E, Petit M, Brossier J (2015). Théorie du comportement adaptatif et agriculture familiale. in *L'agriculture en famille: travailler, réinventer, transmettre*. EDP Sciences p. 81. doi: 10.1051/978-2-7598-1192-2.c006.
- Coulibaly K (2012). Analyse des facteurs de variabilité des performances agronomiques et économiques des cultures et de l'évolution de la fertilité des sols dans les systèmes agropastoraux en milieu soudanien du Burkina Faso: approche expérimentale chez et par les paysans. Université Polytechnique de Bobo Dioulasso.
- Danso-Abbeam G, Ehiakpor DS, Aidoo R (2018). Agricultural extension and its effects on farm productivity and income: Insight from Northern Ghana. *Agriculture and Food Security* 7(1):1-10. doi:10.1186/s40066-018-0225-x.
- Devendra G, Shreemat S (2017). *Agricultural and Rural Mechanisation in Nepal: Status, Issues and Options for Future*. <https://cgspace.cgiar.org/handle/10568/87968>
- Emmanuel D, Owusu-Sekyere E, Owusu V, Jordaan H (2016). Impact of agricultural extension service on adoption of chemical fertilizer: Implications for rice productivity and development in Ghana. *NJAS - Wageningen. Journal of Life Sciences* 79:41-49. doi: 10.1016/j.njas.2016.10.002.
- Feder G, Murgai R, Quizon JB (2004). The Acquisition and Diffusion of Knowledge: The Case of Pest Management Training in Farmer Field Schools, Indonesia. *Journal of Agricultural Economics* 55(2):221-243. doi: 10.1111/j.1477-9552.2004.tb00094.x.
- Ferreira T (2018). Does education enhance productivity in smallholder agriculture? Causal evidence from Malawi. <https://econpapers.repec.org/RePEc:sza:wpaper:wpapers298>.
- Fuglie KO, Rada NE (2013). Resources, Policies, and Agricultural Productivity in Sub-Saharan Africa. Available at: <https://ideas.repec.org/p/ags/uersrr/145368.html>.
- Gandonou E, Chogou S, Adegbidi A (2019). Impact du conseil agricole privé sur l'efficacité technique des petits producteurs d'ananas au Bénin. *Économie Rurale* 368(2):55-73. doi: <https://doi.org/10.4000/economierurale.6736>.
- Gebrehiwot KG (2015). The impact of agricultural extension on households' welfare in Ethiopia. *International Journal of Social Economics*. Emerald Group Publishing Ltd., pp. 733-748. doi: 10.1108/IJSE-05-2014-0088.
- Labarthe P, Laurent C (2011). *Économie des services et politiques*

- publiques de conseil agricole. *Cahiers Agricultures* 20(5):343-351. doi:10.1684/agr.2011.0508.
- Lee Y (2017). The Effects of Agricultural Extension Service and Education on Farm Productivity -Evidence from Mbale District in Uganda -. Available at: <https://papers.ssrn.com/abstract=2935980>.
- MAEP (2017). Plan Stratégique de Développement du Secteur Agricole. Cotonou.
- MAEP (2018). Rapport de performance du secteur agricole, gestion 2017.
- Paillard S, Treyer S, Dorin B (2010). Agrimonde. Scenarios et défis pour nourrir le monde en 2050. Versailles: Ed. Quae. Available at: http://publications.cirad.fr/une_notice.php?dk=558036.
- Rehman-Ud-din, Khattak NUR (2018). Impacts of farm mechanisation on wheat and maize crops' productivity in Peshawar valley. *Sarhad Journal of Agriculture* 34(3):516-525. doi: 10.17582/journal.sja/2018/34.3.516.525.
- Sissoko F, Coulibaly D, Cissé O, Dugué P (2015). Évaluation de l'arrière effet de la culture du coton sur la production céréalière en zone cotonnière du Mali. PAG.
- Takam-Fongang GM, Kamdem CB, Kane GQ (2019). Adoption and impact of improved maize varieties on maize yields: Evidence from central Cameroon. *Review of Development Economics* 23(1):172-188. doi: 10.1111/rode.12561.
- Teka AM, Lee SK, Watson D (2019). The impact of agricultural package programs on farm productivity in Tigray-Ethiopia: Panel data estimation. *Cogent Economics and Finance* 7(1):1631987. doi: 10.1080/23322039.2019.1631987.
- Thomas-Sharma S, Abdurahman A, Ali S, Andrade-Piedra JL, Bao S, Charkowski AO, Crook D, Kadian MS, Kromann P, Struik PC, Torrance L, Garrett KA, Forbes GA (2016). Seed degeneration in potato: the need for an integrated seed health strategy to mitigate the problem in developing countries. *Plant Pathology* 65(1):3-16. doi: 10.1111/ppa.12439.