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Factors Affecting the Adoption of Recommended Fertilizer Doses by Wheat Farmers in the Casablanca-Settat Region of Morocco

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Abstract

Despite the economic advantages of introducing new agricultural technologies into the production system, their rate of adoption in Morocco remains relatively low. The objective of this article is to study the factors that hinder the adoption of these new technologies. We address the case of the recommended fertilizer doses (RFD). The study employs a probit model with a stratified random sampling approach.The data were collected from 297 farmers in the Casablanca-Settat region using a face-to-face interview method and analyzed through R software. The results of the study show that the main barriers are related to access to information and bank credit, government incentive, production orientation, distance to the market as well as age, and level of education.

Keywords

Adoption, obstacle, new technology, fertilizer recommendation, probit.

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Introduction

Agriculture is considered one of the key sectors of the Moroccan economy, it contributes about 17.3% of the national Gross Domestic Product (GDP) and employs 39% of the population (Harbouze et al., 2019). In Morocco, the majority of the rural population depends directly or indirectly on agriculture for their livelihoods and is likely to be three times poorer than people living in urban areas (Ghanem, 2015). The importance of this sector is transmitted in the efforts that Morocco has been making since its independence (Toumi, 2008). Special interest has been given to cereals because of their place in the country's agricultural system. Indeed, wheat is considered the most important cereal crop in Morocco. This crop contributes significantly to the livelihoods of the farming community. The average consumption of wheat in the country is estimated at 255 kg/year/capita (Bishaw et al., 2019), which makes the Moroccan citizen one of the highest consumers of wheat in the world, knowing that the world average is around 152 kg/year/capita.

However, the analysis of the situation of cereals in Morocco indicates that there is a big gap between the expected and actual production achieved by farmers. Indeed, to improve the productivity of cereals among farmers in the Casablanca-Settat region, the National Institute for Agronomic Research (INRA) has developed a set of innovative practices to introduce them into the production system.

Thus, several technologies have been introduced into the agricultural production system such as the introduction of new seed varieties, the introduction of new seeding systems, in particular direct seeding (Yatribi, 2020), the application of recommended doses of seeds, basic fertilizer and cover fertilizer, adoption of the recommended date for sowing, weeding, application of phytosanitary products and for harvesting and finally agricultural mechanization (Alaoui, 2005). Recommendations for these techniques are summarized in the following Table 1:

Production technique	Recommendation for new technology
Tillage	Zero tillage and/or direct seeding
Date of sowing	Between 01 November and November 20
The sowing dose	160 kg/ha (+/- 5 kg)
The sowing method	Sowing with seeder
The recommended fertilizer dose (RFD)	150 kg/ha (+/- 10 kg/ha)
The cover fertilizer	200 kg/ha (+/- 20 kg/ha)
Crop rotation	Rotation with food legumes
Herbicide treatment	1 time
Fungicide treatment	1 time
Harvest date	Between May 30 and June 30

Source: Compiled by the authors according to the researchers of the National Institute for Agronomic Research (INRA)

Table 1: Recommendations for new wheat production.

In this study, we are interested in the recommended fertilizer dose (RFD). This choice is made because of the place occupied by basic fertilizer in the technical management of wheat, the importance of the turnover generated by the fertilizer market in Morocco, and finally, the low levels of adoption achieved. Previous studies estimate that the level of adoption of RFD is the lowest of all the components of the technology package. These results were confirmed by those obtained in the present study. In addition, basic fertilizers are a very important element in the production of wheat. Its efficient use is therefore crucial for improving wheat yield in quantity and quality (Eddine et al., 2022).

In fact, usually, farmers use fertilizer doses based solely on their own experience. They apply more than 150 kg/Ha. If the farmer applies 150 Kg/ha (with 10 kg/ha more/less) of the RFD he's qualified as an adopter. The farmer must apply the exact recommended dose no more no less. The main reason for adopting this new technology is to improve the yield production of cereals and to decrease the cost of inputs.

The advantages of new agricultural production technologies have been proven by theoretical studies, empirical studies, and field experiments. A multitude of studies has been conducted in this sense. All these studies agree on the fact that the adoption of new agricultural production technologies is a necessity to ensure the continuity of farms. The analysis of this work reveals that the adoption of new technologies depends on several determinants, such as the socio-demographic characteristics of the farmer, the structural characteristics of the farm, and institutional factors (Bouzid et al., 2020).

The socio-economic characteristics of farmers could influence their decision to adopt new agricultural production technologies. Among these characteristics, we cite the farmer's age (Adesina and Zinnah, 1993; Sunny et al., 2022), human capital (Chirwa, 2005), gender (Atibioke et al., 2012; Chirwa, 2005), farming experience (Maniriho et al., 2022), family size (Challa and Tilahun, 2014), participation in non-farm activities (Chirwa, 2005), home-farm or home-market distance (Hailu et al., 2014) and social capital acquired via social networks (Bandiera and Rasul, 2006).

On the other hand, commercialization can be considered a determining factor in the decision to adopt innovation in agriculture (Bouzid et al., 2020; Diagne, 2020). Research on the problem of adoption of new agricultural technologies has revealed the existence of several other factors such as access to credit and extension services (Akudugu et al., 2012; Geta et al., 2013), off-farm income, farm size, types of crops grown, the destination of production, access to subsidy, and the cost of purchasing and installing the technology. The main studies are summarized in Table 2.

Previous studies have mainly focused on technical efficiency, fertilizer management techniques, fertilizer application comparisons, fertilization strategies for higher yields, and the effects of fertilizer diffusion (Choudhury et al., 2013; Rahman and Zhang, 2018).

Indeed, studies that have been conducted on agricultural innovations have shown that they allow farms to increase their efficiency and achieve economies of scale (Pépin, 2020). However, despite these advantages, their dissemination and adoption by Moroccan farmers are still problematic. Especially for the production of cereals in areas where conditions are not favorable.

Thus, although several studies have focused on the factors of adoption of new technologies in different regions of the globe, there are few studies conducted in Morocco that have mainly focused on the adoption of new technologies and the factors associated with the process of adoption. Thus, this study tries to identify the factors affecting the adoption of the recommended fertilizer doses (RFD) in an important region such as Casablanca-settat.

Authors	Form of technology/ practice adopted	Crop	Sample size	Location	Model	Results
(Uddin et al., 2016)	Conservation agriculture practice	Different types of crops	300 farmers	Five districts in Bangladesh	Logit model	The educational level of the household head, farm size, farm income, extension contact, and farming experience were found as significant factors.
(Nazu et al., 2021)	Improved management practices	Wheat	320 farmers	North of Bangladesh	Tobit model	Adoption rate is influenced by their educational level, farming experience, amount of labor (family and hired both) used, amount of land under wheat cultivation, extension services, organizational membership, training, and market distance from the farm.
(Akudugu et al., 2012)	Modern agricultural production technologies	No specification	300 farmers	Bawku West District of Ghana	Logit model	Results showed that farm size, expected benefits from technology adoption, and access to credit and extension services are significant factors.
(Diiro and Sam, 2015)	Improved maize seed	Maize	1218 maize farming households	Uganda	Semiparametric estimator	Nonfarm income has a positive and significant effect on the adoption of improved maize seed.
(Challa and Tilahun, 2014)	Modern technologies	No specification	145 households	Gulliso district in Ethiopia	Logit model	Household heads' education level, farm size, credit accessibility, perception of farmers about the cost of the inputs, and off-farm income positively and significantly affected the farm households' adoption decision; while family size affected their decision negatively and significantly.
(Geta et al., 2013)	Soil fertility management practice	Maize	385 farmers	Southern Ethiopia	Multinomial Logit model	The size of the farm, access to credit, availability of extension services, and training pertaining to soil fertility management were important factors affecting the decision to use a particular soil fertility management practice.
(Hagos and Zemedu, 2015)	Rice improved varieties	Rice	151 households	Fogera District of Ethiopia	Probit model	Households labor availability, education level of the household head, land holding, distance to the nearest village market, proximity to the main market, distance to access agricultural extension, access to the source of rice seeds, access to new cultivars of rice and off-farm income affects significantly the participation in improved varieties.
(Atibioke et al., 2012)	Grain storage technologies	Different types of crops	120 farmers	Ilorin West LGA of Kwara State in Nigeria	Logit model	Sex, level of education, and occupation are significantly related to the adoption of grain storage technologies.
Zhou et al., 2010)	Fertilizer use	Maize	349 farmers	Chaobai watershed in Northern China	OLS	Results show that irrigation, gains in crop yield, and higher earning goals are positively correlated with fertilizer use intensity, while farm size, manure application, soil fertility, and the distance to fertilizer markets are negatively correlated.
(Reza and Hossain, 2013)	Fertilizer Use	Rice	90 farmers	Rajshahi District in Bangladesh	Probit and Tobit Models	Type of land, irrigation facility, and access to credit had a positive and significant influence on fertilizer use but extension service is significantly and negatively related to fertilizer adoption. There were no significant relationships between adoption and education, distance from the market, and farm income.
(Adesina, 1996)	Chemical fertilizers	Rice	120 farmers	Côte d'Ivoire	Tobit model	Results show that the cultivation of lowlands, use of mechanization, farm size, land pressure, and availability of non-farm income positively influence farmers' use of fertilizers. On the opposite, the distance of the field to the village, the distance of the village to the major market, and if the cultivator is a female have a negative effect.
(Nigussie et al., 2017)	Sustainable andmanagement technologies	No specification	300 farm households and 1010 farm plots	North-western Ethiopia	Multivariate Probit and Poisson regression models	Results indicated that farmers' adoption of SLM measures depends on the gender of the household head, the availability of labor, and some plot characteristics, including soil fertility, soil depth, watershed position, and tenure.
(Caffey and Kazmierczak, 1994)	Flow-through or RAS technology	Crab production	61 producers	Louisiana in USA	Multinominal Logit model	The adoption of flow-through was significantly related to a producer's involvement in a full-time soft-shelled crab operation that relied solely on family labor and employment outside the seafood industry.
(Atry et al., 2009)	Integrated pest management (IPM) techniques	Wheat	72 wheat growers	Varamin County in Iran	Stepwise multiple regression analysis	The results showed that the level of knowledge is the key obstacle to the adoption level of sustainable IPM practices.
(Ntshangase et al., 2018)	No-till conservation agriculture	Maize	185 farmers	Sisonke District in South Africa	Logistic model	Findings show that an increase in extension visits, age, education, and farmers' positive perceptions significantly increased the likelihood of a farmer adopting no-till CA, and an increase in land size was negatively related to no-till CA adoption.

Source: Own compilation

Table 2: Studies on the factors affecting the adoption of new technologies. (To be continued).

Authors	Form of technology/ practice adopted	Crop	Sample size	Location	Model	Results
(Bhuiyan and others, 1987)	Improved seed-fertilizer-irrigation technology	No specification	100 part-tenant farmers	Mymensingh district of Bangladesh	Chi_square and t-test statistics	Adoption of improved production technology tended to be the highest on owned land followed by cash-rented land, crop-share rented land with input cost-sharing and crop-share rented land without input cost-sharing.
(Chuchird et al., 2017)	Water wheel (WW), water pump (WP), and weir (WR) irrigation technologies.	Rice	207 farmers	Chaiyaphum province in Thailand	Probit model	The results revealed that the land holding size, farm income, and water use association membership factors were highly positively associated with the WW adoption but negatively correlated with WP and WR. Also, age was positively associated with WR but negatively correlated with WP.
(Huang and Karimanzira, 2018)	Soil testing and fertilizer recommendation facilities (STFRF)	Different types of crops	176 farmers	North of Bangladesh	Logit model	Results show that being young farmers with less farming experience, being small-scale farmers, having higher education, having more farming income, and having more knowledge about these facilities and the fees of these facilities were found to have a significant effect on the adoption. On the opposite, gender, land ownership, and secondary income were found to be insignificant for the adoption.
(Alauddin and Tisdell, 1988)	High Yielding Varieties (HYV)	No specification	58 farmers	Bangladesh	OLS	Irrigation emerges as the key determinant of HYV adoption followed by farm size and education.
(Sunny et al., 2022)	Recommended fertilizer doses	Boro rice	405 farmers	Dinajpur district of Bangladesh	Probit model	Age, land typology, soil water retention, knowledge, and availability of cow dung significantly influenced farmers' decisions to apply fertilizers.

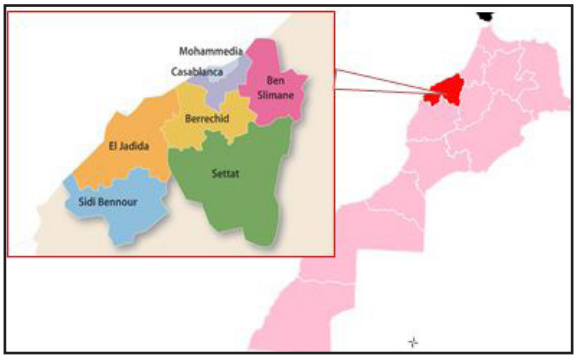
Source: Own compilation

Table 2: Studies on the factors affecting the adoption of new technologies (continuation).

Materials and methods

Study areas and data

The Casablanca-Settat region is considered one of the main cereal regions in Morocco, it is located in the center-west of the kingdom and has 6.862 million inhabitants (HCP, 2014), i.e. a density of 353 inhabitants per km and an area of 2.7% of the national territory.



Source: Ministry of equipment and water in Morocco (2022), www.equipement.gov.ma

Figure 1: Study area.

The region belongs to semi-arid areas with an annual average rainfall ranging from 333 mm to 398 mm depending on the province (Essalek et al., 2019). Most of its cultivable land is dedicated to a wheat-based cereal/legume food cropping system. During the 1960s and 1970s, it was called "the granary of Morocco in cereals ".

In order to collect data from a representative sample, we adopted a stratified random sampling design. The first step is to collect information on the number of farmers producing cereals and on the total area devoted to wheat in the two areas of the Casablanca-Settat region. In the second, the required subsample sizes were determined. Our basic sample is composed of 297 farmers. The questionnaire was administered individually to the farmers from two governorates (Settat and Benslimane) by a team of well-trained interviewers. Hence, the study was conducted in 2018 under the direction and coordination of researchers/engineers from the regional center for agricultural research in Settat (INRA) based on estimated rates of adoption levels in the two areas of the Casablanca-Settat region. The Sample size determination under Stratified Sampling Technique is as follows:

$$n = \frac{\sum_{j=1}^{k} N_j * P_j(1-P_j)}{N * \left(\frac{l}{Z\alpha/_2}\right) + \frac{1}{N} * \left(\sum_{j=1}^{k} N_j * P_j(1-P_j)\right)} \quad (1)$$

where,

l = 2.5: precision level

N = 65746: Total wheat growers in the study area

N_j = population in governorate j

P = 5%: The maximum adoption level we want to capture

Z0.95 = 1.96

The sample size: n = 297

With this sample size we can achieve all of the combinations of precision and adoption levels with 95% confidence, and 2.5% precision for capturing adoption levels of up to 5% in all study areas.

Empirical framework

The analysis of the adoption of new cereal production technologies, as is the case of the recommended doses of fertilizers (RFD), considers that the farmers adopting this technology are agents who make decisions in their interest (Ghimire et al., 2015). The adoption of the agricultural technology in question is therefore only the result of an optimization made by heterogeneous farmers (Foster and Rosenzweig, 2010). According to Ghimire et al. (2015), this optimization is done when farmers are supposed to maximize their utility function under many constraints. The difference between the utility of adopting the recommended fertilizer doses U_{iAdop} and the utility of not adopting this technology $U_{iNonadop}$ is denoted U_i^*. Farmer i will choose to adopt the new technology when the utility acquired by adopting is greater than that by not adopting it:

$$U_i^* = U_{iAdop} - U_{iNonadop} > 0 \quad (2)$$

This decision can be modeled as follows:

$$U_i^* = X_i'\alpha + \varepsilon_i \quad (3)$$

With $U_i = \{1 \text{ if } U_i^* > 0 \; 0 \; Else$

Where, U_i^* is the latent variable that expresses the probability that a farmer decides to adopt the new technology. This probability takes the value "1" in case of adoption and "0" in case of non-adoption. The term X_i' represents the explanatory variables of the adoption decision or those that express factors that hinder this adoption, as is the case of our study, α is a vector of parameters to be estimated, and ε_i is the term of error assumed to be independent and is normally distributed as follows: $\varepsilon_i\ N(0.1)$.

By definition, the Probit model defines the probability associated with the decision to adopt the RFD technology $(U_i = 1)$ as the value of the distribution function of the standard normal distribution $N(0.1)$ considered at point $x_i\ \alpha$.

The individual marginal effect of an explanatory variable on the probability of adopting the RFD technology is, by definition, the variation in the probability of adoption following the increase in this variable by an additional unit (Keita, 2015). This translates mathematically into the derivative of the expression of the probability function $P(y_i = 1/X_i)$ with respect to x_{ik}.

Where $P(y_i = 1/X_i)$ is the probability of adopting the RFD conditional on the characteristics of x_{ik}, α is a vector of k+1 parameters.

Declaration of variables

The bibliographical analysis that we carried out above enabled us to group the obstacles that hinder the adoption of new agricultural production technologies into three main categories. Thus, we distinguish obstacles linked to the technology itself, internal obstacles linked to the operation and the farmer, and other obstacles which are external and which are linked to institutional factors. The following Table 3 illustrates the variables which will be introduced into the model and which represent all the obstacles in question.

Description of the variable	Code of the variable	Nature of the variable
Adoption of RFD	ADOPENGRAIS	Boolean (1: Yes; 0: No)
Obstacles related to technology		
Purchase price of fertilizers in MAD/q	COST	Quantitative
The problem of commercialization	Rejection due to lack of data	
Availability of fertilizers at the right time	TECH_DISPONIBILITE	Boolean (1: Yes; 0: No)

Source: Own processing

Table 3: The variables of the Probit model. (To be continued).

Description of the variable	Code of the variable	Nature of the variable
Internal obstacles linked to the farm and the farmer		
The age of the farmer in years	AGE	Quantitative
Work rate on the farm in %	PERC_TOTAL_WORK_FARM	Quantitative
size in ha	FARM_SIZE	Quantitative
Gender	GENDER	Boolean (1: Yes; 0: No)
Farming experience	Rejection due to multi-collinearity	
The level of education in years of schooling	EDU	Quantitative
Membership of a cooperative	MEMBER_COOPERATIVE	Boolean (1: Yes; 0: No)
The orientation of the farm's production	PROD_SEED_MARKET	Boolean (1: market; 0: Self-consumption)
The type of land	TYPE_FONCIER	Boolean (1: Individual ownership; 0: rented or in association)
External obstacles linked to institutional factors		
Political incentives	GOV_INCITATION	Boolean (1: Yes; 0: No)
Access to credit	CREDIT_EASY	Boolean (1: Yes; 0: No)
Proximity to market in Km	DIST_MARKET	Quantitative
Participation in field days	FIELD_DAY	Boolean (1: Yes; 0: No)
Visit by extension agents	VISIT_EXTENSION	Boolean (1: Yes; 0: No)

Source: Own processing

Table 3: The variables of the Probit model. (Continuation).

Results and discussion

Descriptive statistics

Descriptive statistics of the variables, carried out by R software, are presented in Table 4 according to the decision to adopt agricultural technology. Results revealed that among the 297 farmers surveyed, only 18.18% (n=54) adopted the recommended fertilizer doses. The average age of adopters is 44 years against 51 years for non-adopters. These adopters farmers are characterized by a level of schooling that is close to 8 years, exceeding farmers who do not adopt the RFD by more than 5 years of schooling. The difference in terms of age and years of education is significant at the 1% level according to the results of the Student test that we carried out.

Our results indicate that 57.5% (31) of the adopters produce cereals for marketing purposes, while only 29.22% (71) of the non-adopters go to market their final products. Moreover, the descriptive statistics that we established showed that there is no great difference between the two groups of farmers concerning the nature of land ownership. About 70% of the land is 'individual property'. On the other hand, adopters own slightly larger farms than non-adopters (18.27 hectares (Ha) among adopters versus 15.17 Ha among non-adopters). This difference is not too significant because the standard deviation is high in both groups of farmers. In addition, farmers in both groups spend between 87% and 91% of their working time on their farms.

The results indicated that 46.30% (25) of adopters attended a trial and demonstration day on new technologies as part of a research project, while only 23.05% (56) of non-adopters did so. Another result that seems interesting is related to the availability of technology. The results show that more than 80% (259) of respondents declared that fertilizers are available at various points of sale. In addition, 29.63% (16) of adopters received a government incentive for the adoption of new agricultural technologies including the RFD, on the other hand, only 11% (27) of non-adopters declared having received it. Moreover, statistics indicate that about 52% (28) of farmers who adopted RFD reported being visited at least once by an extension agent, yet only 13% (33) of non-adopters received such a visit. Both differences are statistically significant at the 1% level.

Furthermore, reading these results leads us to focus on the question of social groups in peasant communities. The results indicated that 22.22% (12) of adopters are members of an agricultural cooperative or association. Whereas, only 9% (23)

	mean/ frequency		Significance	
	Adopters (n = 54)	Non-adopters (n = 243)	Student	Khi2
Adopengrais	18.18	81.82		
fertilizer_quantity (kg)	149.26	204.81	30.93***	
age (years)	44.02	50.71	3.73***	
genre (1= male)	98.15	100.00		4.51**
education (years)	8.05	5.23	-3.98***	
prod_seed_market (1= yes)	57.42	29.22		15.57***
type_foncier (1= (individual propriety)	68.52	70.78		0.11
field_day (1= yes)	46.30	23.05		12.04**
tech_disponibilite (1= yes)	81.48	88.48		1.94
gov_incitation (1= yes)	29.63	11.11		12.24***
visit_extension (1= yes)	51.85	13.58		39.65***
member_cooperative (1= yes)	22.22	9.47		6.91***
credit_easy (1= yes)	27.78	6.17		22.71***
dist_market (km)	5.10	7.81	3.43**	
farm_size (ha)	18.27	15.17	-0.74	
perc_total_work_farm (%)	91.85	87.721	-1.45	
primary_income (1= agri)	87.04	92.59		1.77
cost (mad/100kg)	279.20	275.278	0.48	

Note: Signif. codes: 0 '***', 0.001 '**', 0.01 '*', 0.05 '.', 0.1 ' ' 1
Source: Own calculation

Table 4: Descriptive statistics.

of non-adopters integrate such an organizational structure. This difference is statistically significant. Additionally, our estimates indicate that 27.78% (15) of adopters have easy access to bank credit, compared to only 6% (15) of non-adopters. A difference is also significant at the 1% level according to the Khi2 test.

Model results and discussion

The results obtained, by the binary Probit model, affirm that most of the variables used in the model had the expected signs. The model developed has a high explanatory power (Hu et al., 2006), as indicated by McFadden's Pseudo R-squared (R^2=0.38). The Wald statistic indicates that the model has significant explanatory power (X2= 106.3, P(> X2) = 1.1e-16). The final model retained in this study will not take into account the variables: gender, type of land, availability of technology, and farm size due to the presence of multicollinearity. Thus, our final model is presented in the Table 5.

Variables	Coefficients		Marginals	
	Value	SE	AME	SE
Age	-0.02**	0.009	-0.004	0.002
Edu	0.06**	0.023	0.11	0.005
prod_seed_market	0.39.	0.231	0.068	0.040
field_day	0.73**	0.236	0.127	0.039
gov_incitation	0.68*	0.292	0.118	0.050
visit_extension	0.70**	0.249	0.121	0.041
member_cooperative	0.29	0.316	0.051	0.054
credit_easy	1.00**	0.354	0.173	0.060
dist_market	-0.06*	0.027	-0.011	0.005
perc_total_work_farm	0.008	0.006	0.001	0.001
primary_income	-0.71.	0.381	-0.123	0.065
Cost	-0.001	0.003	0.0002	0.005
Constant	-0.37	1.180		

Note: Signif. codes: 0 '***', 0.001 '**', 0.01 '*', 0.05 '.', 0.1 ' ' 1 / SE = Standard error
Source: Own calculations

Table 5: The Probit model results.

The results provided by the Probit model, carried out by R software, indicate that the age of farmers has a negative and significant impact at the level

of 1% on the decision to adopt the RFD. Thus, the more the age of a farmer increases, the more his probability of adopting the RFD decreases. This means that young farmers tend to use new technologies in the service of agricultural activity, and older farmers are less adept at new agricultural technologies. Also, the calculation of the marginal effects shows that increasing the age of the farmer by one year will reduce the probability of adopting the technology in question by 0.4%. These results are consistent with those of Irungu et al. (2015) that young people are technologically receptive compared to older people. These results also agree with those of Kalantari-Dahaghi (2010) who showed that young farmers are more receptive to accepting new technologies than older farmers (El Intidami and Benamar, 2020). Other studies, such as that of Roussy et al. (2015), confirm our result and indicate that age is a brake on the adoption of agricultural innovation.

The model indicates that the level of education of the farmer influences positively and significantly, at the level of 1%, the decision to adopt the RFD. This means that a low level of literacy is a real obstacle to the adoption of RFD. One less year of schooling will result in a 1.1% probability of refusing the new technology. This result agrees with those of Hadjimanolis (1999), the latter explains that the major obstacles to innovation are linked to the education system and the skilled labor force (Segarra-Blasco et al., 2008). Thus, our result shows how the level of literacy is an important human capital that influences the adoption of technologies, especially among farmers in rural areas.

The rejection of agricultural technology by farmers in the Casablanca-Settat region is also explained by the orientation of production. Indeed, smallholder farmers who produce cereals only to meet their consumption needs tend not to adopt RFD technology. Thus, if a farmer switches from marketing as the main orientation of his cereal production to an orientation towards self-consumption, he is more likely to refuse the adoption of the RFD technology, with a probability of 6.8%. This result agrees with that of Tene et al. (2013). In this sense, Lefranc (2008) indicates that the real obstacle that hinders the adoption of new agricultural technologies lies in the difficulties encountered at the level of marketing.

Also, the results of our model revealed that financing is a barrier that hinders the adoption of new agricultural technologies. Indeed, the credit easy variable has a negative and significant impact on the decision not to adopt the RFD. Also, the inaccessibility to bank financing reduces the chances of adopting the technology in question by 17.3%. Our result agrees with those obtained by several researchers, in particular with de Janvry et al. (2015) for whom liquidity constraints constitute a major obstacle to the acquisition of agricultural technology. Bellon-Maurel and Huyghe (2016) consider that funding leads actors to act at different levels of the innovation process. It is a factor that facilitates the process of agricultural technology transfer and therefore innovation in general. For his part, Richefort (2008) stipulates that financial constraint is decisive in the choice of agricultural technology. On the other hand, our result is in disagreement with that of (Karlan et al., 2014) who explain that as soon as the farmer is insured, he would be able to find the financial means to acquire the technology.

Moreover, our model indicates that the distance from the nearest market has a significant impact on the rejection of new technology. Indeed, the more the distance between the farm and the market increases, the more the farmer tends to refuse the RFD technology. Our estimates show that an extra mile between the firm and the market will result in a 1.1% probability of rejection.

The results of our modeling indicate that farmers who consider agricultural activity as their main source of income are more likely not to adopt RFD. Moreover, the calculation of marginal effects indicates that switching to agriculture as the main activity will reduce the probability of adopting the RFD by 12.3%. The results obtained, which are statistically significant at the 10% level, agree with those of Amir et al. (2016) and Richefort and Fusillier (2010).

The low rate of adoption of the RFD is also explained, according to the model, by the absence of government incentives. Our results revealed that at the 5% level, this lack of political incentives negatively affects the adoption of the new RFD technology by 11.8%. This agrees with the results of the study that was conducted by Richefort (2008). The latter explains that government incentives can be in the form of subsidized pricing as they can take the form of an incentive for technical change through investment aid, advice, and guidance on the implementation of the technology in question (Richefort, 2008). It should be noted that, in our case, we mean by government

incentives, the satisfaction of farmers with the efforts made by government authorities in terms of communication, advice, guidance, and encouragement for farmers to adopt new production technologies in general and the RFD in particular.

Finally, the result of the Probit regression indicates that the farmers who did not attend the demonstration days and/or who were not visited by the extension agents do not adopt the RFD technology. Moreover, at the 1% threshold, the probability of not adopting the technology in question decreases by more than 12% among the farmers in question. This indicates that the lack or insufficiency of reliable information concerning the RFD constitutes a major obstacle to its adoption. This result shows how essential advisory and extension agents are in the process of agricultural technology transfer in general and in the adoption of new technologies in particular. The latter are known for their role as facilitators of access to agricultural information (El Boukhary and Benamar, 2020). The results obtained agree with those of the studies cited above. Studies on the adoption of new technologies consider that contact with agricultural advisory and extension agents reduces the uncertainty expressed by farmers about the performance of these agricultural innovations. They also serve as intermediaries between the field and the laboratory (Tene et al., 2013).

Conclusion

In this article, we have tried to determine the obstacles that hinder the adoption of RFD technology for cereal producers in the Casablanca-Settat region. Data was collected from 297 farmers. The Probit model developed for this purpose showed the impact of farmer-related barriers such as age and level of studies, others linked to the farm such as the orientation of production and the distance from the market, others of an institutional nature such as access to bank credit and government incentives and others related to access to information on new agricultural technology such as contact with agricultural advisory and extension agents and participation in field days. The latter are the main obstacles that hinder the adoption of the RFD according to the model. This result emphasizes the crucial role that access to information plays in the dissemination and adoption of new agricultural production technologies. This information is generally provided by researchers from agricultural research centers, agricultural researchers within the framework of research programs, and agricultural advisory and extension agents.

However, the current situation indicates that the services offered within the framework of agricultural advice suffer from several constraints, in particular those related to financing (El Bilali et al., 2013). Extension agents are limited: an extension agent covers an average of 24,000 hectares (ha) of land and reaches 1,930 farmers (El Bilali et al., 2013). This indicates that extension agents are limited in serving farmers, hence the need to adopt technological innovation even in advisory and extension work such as the use of digital platforms, the creation of phone applications for providing mobile-based extension services, setting up advertising campaigns in radio and television channels to promote these new technologies and disseminate them to a large community of farmers. This could be accomplished through the exchange of experiences with the European countries, especially in terms of digitalization, the use of new information technologies and forecasting based on the economic model used by the European commission. The latter suggests adopting amended fertilizer regulation which is possible by harmonizing definitions and quality standards for all types of fertilizing products that can be traded across the European Union.

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References

[1] Adesina, A. A. (1996) "Factors affecting the adoption of fertilizers by rice farmers in Cote d'Ivoire", *Nutrient Cycling in Agroecosystems*, Springer, Vol. 46, No. 1, pp. 29-39. ISSN 1573-0867. DOI 10.1007/BF00210222.

[2] Adesina, A. A. and Zinnah, M. M. (1993) "Technology characteristics, farmers' perceptions and adoption decisions: A Tobit model application in Sierra Leone", *Agricultural Economics*, Wiley Online Library, Vol. 9, No. 4, pp. 297-311. ISSN 1574-0862. DOI 10.1111/j.1574-0862.1993.tb00276.x.

[3] Akudugu, M. A., Guo, E. and Dadzie, S. K. (2012) "Adoption of modern agricultural production technologies by farm households in Ghana: what factors influence their decisions?", *Journal of Biology, Agriculture and Healthcare,* Vol 2, No.3. E-ISSN 2225-093X, ISSN 2224-3208.

[4] Alaoui, S. (2005) "*Référentiel pour la conduite technique de la culture de blé dur (Triticum Durum)*". [Online]. Available: http://www.abhatoo.net.ma/content/view/pdf/15906 [Accessed: Feb. 15, 2023]. (In French).

[5] Alauddin, M. and Tisdell, C. (1988) "Patterns and determinants of adoption of high yielding varieties: farm-level evidence from Bangladesh", *The Pakistan Development Review*, Vol. 27, No. 2, pp. 183-210. ISSN 0030-9729. DOI 10.30541/v27i2pp.183-210.

[6] Amir, M., Peter, N. and Muluken, W. (2016) "The role of mobile phones in accessing agricultural information by smallholder farmers in Ethiopia", *RUFORUM Working Document Series*, Vol. 14, No. 1, pp. 395-402. ISSN 1607-9345.

[7] Atibioke, O., Ogunlade, I., Abiodun, A., Ogundele, B., Omodara, M. and Ade, A. (2012) "Effects of farmers' demographic factors on the adoption of grain storage technologies developed by Nigerian stored Products Research Institute (NSPRI): A case study of selected villages in Ilorin West LGA of Kwara State", *Research on Humanities and Social Sciences,* Vol. 2, No. 6, pp. 56-63. E-ISSN 2225-0484. ISSN 2224-576.

[8] Atry, S., Ahmad, R. and Elham, F. (2009) "Factors influencing the adoption of integrated pest management (IPM) by wheat growers in Varamin County, Iran", *African Journal of Agricultural Research*, Vol. 4, No. 5, pp. 491-497. ISSN 1991-637X.

[9] Bandiera, O. and Rasul, I. (2006) "Social networks and technology adoption in northern Mozambique", *The Economic Journal*, Vol. 116, No. 514, pp. 869-902. ISSN 0013-0133. DOI 10.1111/j.1468-0297.2006.01115.x.

[10] Bellon-Maurel, V. and Huyghe, C. (2016) "L'innovation technologique dans l'agriculture", *Géoéconomie*, No. 3, pp. 159-180. ISSN 1620-9869. DOI 10.3917/geoec.080.0159. (In French).

[11] Bhuiyan, M. and others. (1987) "Influence of Tenurial Status of Land on the Adoption of Improved Production technology in an area of bangladesh", *Bangladesh Journal of Agricultural Economics*, Vol. 10, No. 2, pp. 1-11. ISSN 0257-3539. DOI 10.22004/ag.econ.211973.

[12] Bishaw, Z., Yigezu, Y., Niane, A., Telleria, R. and Najjar, D. (2019) "*Political economy of the wheat sector in Morocco: seed systems, varietal adoption, and impacts*", Beirut, Lebanon: International Center for Agricultural Research in the Dry Areas. [Online]. Available: https://repo.mel.cgiar.org/handle/20.500.11766/8505 [Accessed: Feb. 15, 2023].

[13] Bouzid, A., Boudedja, K., Cheriet, F., Bouchetara, M. and Mellal, A. (2020)" Facteurs influençant l'adoption de l'innovation en agriculture en Algérie. Cas de deux cultures stratégiques: le blé dur et la pomme de terre" (Factors influencing the adoption of innovation in agriculture in Algeria. Case of two strategic crops: durum wheat and potato), *Cahiers Agricultures*, Vol. 29, pp. 1-10. ISSN 1166-7699. DOI 10.1051/cagri/2020013. (In French).

[14] Caffey, R. H. and Kazmierczak, R. F. (1994) "Factors influencing technology adoption in a Louisiana aquaculture system", *Journal of Agricultural and Applied Economics*, Vol. 26, No. 1, pp. 264-274. E-ISSN 2056-7405, ISSN 1074-0708. DOI 10.1017/S1074070800019350.

[15] Challa, M. and Tilahun, U. (2014) "Determinants and impacts of modern agricultural technology adoption in west Wollega: the case of Gulliso district", *Journal of Biology, Agriculture and Healthcare*, Vol. 4, No. 20, pp. 63-77. ISSN 2225-093X. DOI 10.1.1.842.9765&rep=rep1&type=pdf.

[16] Chirwa, E. W. (2005) "Adoption of fertiliser and hybrid seeds by smallholder maize farmers in Southern Malawi", *Development Southern Africa,* , Vol. 22, No. 1, pp. 1-12. ISSN 0376-835X. DOI 10.1080/03768350500044065.

[17] Choudhury, A., Chandra, H. and Arora, A. (2013) "Application of solid oxide fuel cell technology for power generation—A review", *Renewable and Sustainable Energy Reviews*, Vol. 20, pp. 430-442. ISSN 1364-0321. DOI 10.1016/j.rser.2012.11.031.

[18] Chuchird, R., Sasaki, N. and Abe, I. (2017) "Influencing factors of the adoption of agricultural irrigation technologies and the economic returns: A case study in Chaiyaphum Province, Thailand", *Sustainability*, Vol. 9, No. 9, p. 1524. ISSN 2071-1050. DOI 10.3390/su9091524.

[19] Diagne, A. (2020) "*Adoption et Impact Des Innovations Technologiques Agricoles Dans Les Filières Maïs et Arachide Au Sénégal*", PhD Thesis, Université Laval. [Online]. Available: http://hdl.handle.net/20.500.11794/67886 [Accessed: Feb. 15, 2023]. (In French).

[20] Diiro, G. M. and Sam, A. G. (2015) "Agricultural technology adoption and Nonfarm earnings in Uganda: a Semiparametric analysis", *The Journal of Developing Areas*, Vol. 49, No. 2, pp. 145-162. ISSN 1548-2278. DOI 10.1353/jda.2015.0013.

[21] Eddine, S. B., Douira, A. and Yousfi, E. B. (2022) "Effets des engrais azotés sur le rendement du blé et de l'orge sous stress biotique dû à la pourriture sèche du collet induite par le Fusarium culmorum", *Revue Marocaine Des Sciences Agronomiques et Vétérinaires*, Vol. 10, No. 1. ISSN 2550-4401. (In French).

[22] El Bilali, H., Driouech, N., Berjan, S., Capone, R., Abouabdillah, A., Ahouate, L., Azim, K. and Najid, A. (2013) "Agricultural extension system in Morocco: problems, resources, governance and reform", *Conference: 21st European Seminar on Extension Education (ESEE) – "Extension education worldwide: Trends, challenges and cases",* Antalya , Turkey. [Online]. Available: https://www.researchgate.net/publication/260890282_Agricultural_extension_system_in_Morocco_problems_resources_governance_and_reform [Accessed: Feb. 15, 2023].

[23] El Intidami, M. E. B. and Benamar, F. (2020) "Approche économique de l'analyse des déterminants socioéconomiques de l'adoption des innovations et technologies en agriculture: Cas de la technologie d'irrigation localisée (TIL)", *Alternatives Managériales Economiques*, Vol. 2, No. 3, pp. 237-258. E-ISSN 2665-7511. DOI 10.48374/IMIST.PRSM/ame-v2i3.22173. (In French).

[24] Essalek, B., Bahou, A., Nahli, A. and Saloui, A. (2019) "Estimation de la temperature de surface des terres: cas de la ville de Casablanca (MAROC)", *Conference XXXIIème Colloque Internationale de l'AIC,* Thessaloniki - Greece 29 .5. - 1.6. 2019 [Online]. Available: https://www.researchgate.net/publication/333704558_ESTIMATION_DE_LA_TEMPERATURE_DE_SURFACE_DES_TERRES_CAS_DE_LA_VILLE_DE_CASABLANCA_MAROC [Accessed: Feb. 15, 2023]. (In French).

[25] Foster, A. D. and Rosenzweig, M. R. (2010) "Microeconomics of technology adoption", *Annual Review of Economics*, Vol. 2, No. 1, pp. 395–424. E-ISSN 1941-1391. DOI 10.1146/annurev.economics.102308.124433.

[26] Geta, E., Bogale, A., Kassa, B. and Elias, E. (2013) "Determinants of Farmers' Decision on Soil Fertility Management Options for Maize Production in Southern Ethiopia", *American Journal of Experimental Agriculture*, Vol. 3, No. 1, pp. 226-239. ISSN 2457-0591. DOI 10.9734/AJEA/2013/2299.

[27] Ghanem, H. (2015) "Agriculture and rural development for inclusive growth and food security in Morocco", Global Economy & Development at Brookings, Working Paper 82. ISSN 1939-9383.

[28] Ghimire, R., Wen-Chi, H. and Shrestha, R. B. (2015) "Factors affecting adoption of improved rice varieties among rural farm households in Central Nepal", *Rice Science*, Vol. 22, No. 1, pp. 35-43. ISSN 1672-6308. DOI 10.1016/j.rsci.2015.05.006.

[29] Hadjimanolis, A. (1999) "Barriers to innovation for SMEs in a small less developed country (Cyprus)", *Technovation*, Vol. 19, No. 9, pp. 561-570. ISSN 0166-4972. DOI 10.1016/S0166-4972(99)00034-6.

[30] Hagos, A. and Zemedu, L. (2015) "Determinants of improved rice varieties adoption in Fogera district of Ethiopia", S*cience, Technology and Arts Research Journal,* Vol. 4, No. 1, pp. 221-228. ISSN 2305-3372. DOI 10.4314/star.v4i1.35.

[31] Hailu, B. K., Abrha, B. K. and Weldegiorgis, K. A. (2014) "Adoption and impact of agricultural technologies on farm income: Evidence from Southern Tigray, Northern Ethiopia", *International Journal of Food and Agricultural Economics (IJFAEC)*, Vol. 2, No. 4, pp. 91-106. ISSN 2147-8988. DOI 10.22004/ag.econ.190816.

[32] Harbouze, R., Pellissier, J.-P., Rolland, J.-P. and Khechimi, W. (2019) "*Rapport de Synthèse Sur l'agriculture Au Maroc*", PhD Thesis, CIHEAM-IAMM. [Online]. Available: https://hal.science/hal-02137637 [Accessed: Feb. 15, 2023]. (In French).

[33] HCP (2014) "Note sur les premiers résultats du Recensement Général de la Population et de l'Habitat 2014", *Recensement général de la population et de l'habitat 2014 (RGPH2014).* [Online]. Available: https://rgph2014.hcp.ma/Note-sur-les-premiers-resultats-du-Recensement-General-de-la-Population-et-de-l-Habitat-2014_a369.html [Accessed: Jan. 27, 2022]. (In French).

[34] Huang, Z. and Karimanzira, T. T. P. (2018) "Investigating key factors influencing farming decisions based on soil testing and fertilizer recommendation facilities (STFRF)—A case study on rural Bangladesh", *Sustainability*, Vol. 10, No. 11, p. 4331. ISSN 2071-1050. DOI 10.3390/su10114331.

[35] Hu, B., Shao, J. and Palta, M. (2006) "Pseudo-R^2 in logistic regression model", *Statistica Sinica*, Vol. 16, No. 3, pp. 847-860. ISSN 1017-0405. [Online]. Available: http://www.jstor.org/stable/24307577 [Accessed: Feb. 15, 2023].

[36] Irungu, K., Mbugua, D. and Muia, J. (2015) "Information and Communication Technologies (ICTs) attract youth into profitable agriculture in Kenya", *East African Agricultural and Forestry Journal*, , Vol. 81, No. 1, pp. 24-33. ISSN 0012-8325. DOI 10.1080/00128325.2015.1040645.

[37] de Janvry, A., Sadoulet, E., Kyle, E. and Dar, M. (2015) "L'adoption des technologies agricoles: quelles leçons tirer des expérimentations de terrain?", *Revue d'economie Du Developpement*, Vol. 23, No. 4, pp. 129-153. ISSN 1245-4060. DOI 10.3917/edd.294.0129. (In French).

[38] Kalantari-Dahaghi, A. (2010) "Numerical simulation and modeling of enhanced gas recovery and CO_2 sequestration in shale gas reservoirs: A feasibility study", *SPE International Conference on CO_2 Capture, Storage, and Utilization,* New Orleans, Louisiana, USA, November 2010, paper no. SPE-139701-MS. ISBN 978-1-55563-317-2. DOI 10.2118/139701-MS.

[39] Karlan, D., Osei, R., Osei-Akoto, I. and Udry, C. (2014) "Agricultural decisions after relaxing credit and risk constraints", *The Quarterly Journal of Economics,* Vol. 129, No. 2, pp. 597-652. ISSN 0033-5533. DOI 10.1093/qje/qju002.

[40] Keita, M. (2015) "Introduction à l'Econométrie" (Introduction to Econometrics), MPRA Paper No. 66840, University Library of Munich, Germany. [Online]. Available: https://ideas.repec.org//p/pra/mprapa/66840.html [Accessed: Feb. 15, 2023].

[41] Lefranc, L. M. (2008) "Conditions d'adoption et Impacts Des Innovations Technologiques Dans Le Cadre Du Bananier Plantain Au Sud Du Cameroun", PhD Thesis, Montpellier SupAgro. [Online]. Available: https://agritrop.cirad.fr/570082/ [Accessed: Feb. 15, 2023]. (In French).

[42] Maniriho, A., Musabanganji, E., Mulumeoderhwa, F., Manirakiza, D. and Lebailly, P. (2022) "Preferences of Small-Scale Farmers for Innovative Farming Techniques in Volcanic Highlands in Rwanda", *AGRIS On-Line Papers in Economics and Informatics*, Vol. 14, No. 2, pp. 73-83. ISSN 1804-1930. DOI 10.7160/aol.2022.140206.

[43] Nazu, S. B., Khan, M. A., Saha, S. M., Hossain, M. E. and Rashid, M. H.-A. (2021) "Adoption of improved wheat management practices: an empirical investigation on conservation and traditional technology in Bangladesh", *Journal of Agriculture and Food Research*, Vol. 4, p. 100143. ISSN 2666-1543. DOI 10.1016/j.jafr.2021.100143.

[44] Nigussie, Z., Tsunekawa, A., Haregeweyn, N., Adgo, E., Nohmi, M., Tsubo, M., Aklog, D., Meshesha, D. T. and Abele, S. (2017) "Factors influencing small-scale farmers' adoption of sustainable land management technologies in north-western Ethiopia", *Land Use Policy*, Vol. 67, pp. 57-64. ISSN 0264-8377. DOI 10.1016/j.landusepol.2017.05.024.

[45] Ntshangase, N. L., Muroyiwa, B. and Sibanda, M. (2018) "Farmers' perceptions and factors influencing the adoption of no-till conservation agriculture by small-scale farmers in Zashuke, KwaZulu-Natal Province", *Sustainability*, Vol. 10, No. 2, p. 555. ISSN 2071-1050. DOI 10.3390/su10020555.

[46] Pépin, P. (2020) "L'adaptation aux changements climatiques en agriculture: Identification des pratiques et des technologies permettant d'augmenter la résilience des productions végétales du Québec", mastery test, Université de Sherbrooke, Sherbrooke, Canada. [Online]. Available: http://hdl.handle.net/11143/17652 [Accessed: Feb. 15, 2023]. (In French).

[47] Rahman, K. A. and Zhang, D. (2018) "Effects of fertilizer broadcasting on the excessive use of inorganic fertilizers and environmental sustainability", *Sustainability*, Vol. 10, No. 3, p. 759. ISSN 2071-1050. DOI 10.3390/su10030759.

[48] Reza, S. and Hossain, E. (2013) "Factors Affecting Farmers' Decisions on Fertilizer Use: A Case Study of Rajshahi District in Bangladesh", *Bangladesh Journal of Political Economy,* Vol. 29, pp. 211-221. ISSN 2227-3182.

[49] Richefort, L. (2008) "Processus de Sélection Des Technologies d'irrigation Par Les agriculteurs: Entre Interactions Sociales et Choix Rationnels", PhD Thesis, Université de la Réunion. [Online]. Available: https://www.theses.fr/2008LARE0014 [Accessed: Feb. 15, 2023]. (In French).

[50] Richefort, L. and Fusillier, J.-L. (2010) "Imitation, rationalité et adoption de technologies d'irrigation améliorées à l'île de la Réunion", *Economie & Prevision,* No. 2, pp. 59-73. ISSN 0249-4744. DOI 10.3917/ecop.193.0059. (In French).

[51] Roussy, C., Ridier, A., Chaib, K., and others. (2015) "Adoption d'innovations par les agriculteurs: rôle des perceptions et des préférences", University work, 35 p. [Online]. Available: https://hal.science/hal-01209051 [Accessed: Feb. 15, 2023]. (In French).

[52] Segarra-Blasco, A., Garcia-Quevedo, J. and Teruel-Carrizosa, M. (2008) "Barriers to innovation and public policy in Catalonia", *International Entrepreneurship and Management Journal*, Vol. 4, pp. 431-451. ISSN 1555-1938. DOI 10.1007/s11365-008-0086-z.

[53] Sunny, F. A., Fu, L., Rahman, M. S., Karimanzira, T. T. P. and Zuhui, H. (2022) "What influences Bangladeshi Boro rice farmers' adoption decisions of recommended fertilizer doses: A case study on Dinajpur district", *PloS One*, Vol. 17, No. 6, p. e0269611. ISSN 1932-6203. DOI 10.1371/journal.pone.0269611.

[54] Tene, M., Laure, G., Temple, L. and Havard, M. (2013) "*Les déterminants de l'adoption d'innovations techniques sur maïs à l'ouest Cameroun, une contribution à la sécurisation alimentaire*", PAG. [Online]. Available: https://api.semanticscholar.org/CorpusID:147484563 [Accessed: Feb. 15, 2023]. (In French).

[55] Toumi, L. (2008) "*La nouvelle stratégie agricole au Maroc (Plan Vert): Les clés de la réussite*", Larbi TOUMI, Novembre. [Online]. Available: https://faolex.fao.org/docs/pdf/mor145892.pdf [Accessed: Feb. 15, 2023]. (In French).

[56] Uddin, M., Dhar, A. and Islam, M. (2016) "Adoption of conservation agriculture practice in Bangladesh: Impact on crop profitability and productivity", *Journal of the Bangladesh Agricultural University*, Vol. 14, No. 1, pp. 101-112. ISSN 2408-8684. DOI 10.3329/jbau.v14i1.30604.

[57] Yatribi, T. (2020) "Innovations technologiques, entrepreneuriat et agriculture: Enjeux, Atouts et contraintes pour l'agriculture marocaine", *Revue de l'Entrepreneuriat et de l'Innovation*, Vol. 3, No. 9. ISSN 2508-9463. DOI 10.34874/IMIST.PRSM/reinnova-v3i9.22112. (In French).

[58] Zhou, Y., Yang, H., Mosler, H.-J. and Abbaspour, K.C. (2010) "Factors affecting farmers' decisions on fertilizer use: A case study for the Chaobai watershed in Northern China", *Consilience*: *The Journal of Sustainable Development* No. 4, pp. 80-102. ISSN 1948-3074. DOI 10.7916/D8C24W3R.