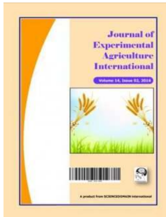

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Determinants of Adoption of Technologies for Cashew Production in Nampula, Mozambique

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Authors' contributions

This work was carried out in collaboration among all authors. Author AN designed the study, wrote the protocol, collected data, performed the statistical analysis and wrote the first draft of manuscript. Author HT managed the analyses of the study, performed statistical analysis and reviewed the manuscript. Author AU managed the literature search and critically reviewed the manuscript. Author SM managed the analyses of the study. All the authors read and approved the final manuscript.

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ABSTRACT

This study analyzed determinants of adoption and intensity of use of Technologies for Cashew Production (TCP) in Nampula, Mozambique. We used cross-sectional data collected from 258 farmers' household in 2016. A double-hurdle model was employed to assess the determinants of adoption and intensity of planting grafted seedlings and use of fungicide. The results showed that 27% of the households planted grafted seedlings with an intensity of seven seedlings annually, and 46% of famers used fungicide at 38% of intensity. Empirical results revealed that the major determinants of adoption of TCP are formal education, price of cashew nut and access to extension services. While the intensity of use is influenced by age of the household head and availability of family labor. Training in cashew was important factor for adoption and intensity of use of grafted seedlings. Adoption was higher in the district of Angoche and lower in Erati for both

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assessed technologies. Enhancing extension services and ensuring better cashew nut price policy are important measures for increasing adoption of grafted seedlings and fungicide application.

Keywords: Intensity of adoption; grafted seedlings; fungicide; double-hurdle model.

1. INTRODUCTION

Cashew is the third major export crop generating foreign currency and job in Mozambique, after sugar cane and cotton [1]. According to [2], in 2006 the global excess demand of cashew nut was estimated at 430, 000 metric tons of raw nuts, valued at US$270 Million, growing at an average of 6.5% annually. Between 2005 and 2009, the average contribution of cashew nut to the national agricultural exports was 12% [3].

In the late 1960s and early 1970s, Mozambique was one of the major producers and exporters of cashew nut in the world [3]. The highest production was achieved in 1972/73 with the commercial amount of 216 thousand tons of raw cashew nut, 50.8% of the world production [3]. Nevertheless, after 1975, the cashew production decreased drastically due to the civil war, inconsistent policies, oldness of cashews and incidence of diseases (powdery mildew and anthracnose) [4,5,3,6]. In the last decade, the highest production was achieved in 2011, with 113 thousand tons [7]. In 1998, the government introduced, through the Institute for Cashew Promotion (INCAJU), three programs for increasing production and productivity [4], namely: i) phytosanitary program; ii) integrated cashew management and iii) promote the processing of small and medium cashew industry [8].

INCAJU multiplies and distributes grafted seedlings to farmers, who pay a subsidized price. In 2017, smallholder farmers purchased a grafted seedling at US$0.08, and farmer's associations payed US$ 0.17, while the commercial farmers are charged US$0.34 per seedling [8]. On the other hand, the application of fungicide is conducted by private service providers, who get approval and support from INCAJU. Farmers do not pay the cost of chemicals, because it is 100% subsidized by the government. They pay only price for the spraying service. For 2017, the spraying cost was set at US$0.76 per cashew tree in the Northern and Central regions, including Nampula, and US$1.02 in the Southern region[1] [8].

In 2011/12, the use of grafted seedlings in Nampula was 5.13%, with intensity of seven seedlings annually, and 12% of households used fungicides [9]. These figures suggest that the majority of farmers are not yet using these technologies as part of cashew management. Therefore, this study aims at identifying factors influencing adoption and intensity of use of grafted seedlings and fungicide in Nampula, Mozambique. This information can be used for improving the current approaches on promoting the use of Technologies for Cashew Production (TCP).

2. METHODOLOGY

2.1 Description of the Study Area

The study was carried out in the Nampula province, one of the 11 provinces in Mozambique. It is located in the coastal Northeastern of the country, with a total of 79,010 km^2, bordered to the East by the Indian Ocean. According to the 2007 Census, the population is estimated at more than 4 million inhabitants, representing more than 19% of the national population, making it the most populated. There is a total of 829,642 agricultural holdings, representing 22%, the highest among the 11 provinces. However, among the 829,642 holdings, 828,788 are small scale holdings [10].

Nampula covers mostly two of ten agro-ecological regions (R7 and R8) of Mozambique [11]. R7 has altitude between 200 and 1000 meters. The topography is flat to wavy and the soil fertility is moderate to good. The annual precipitation is between 1000 to 1400 mm. In R8 the altitude varies between 0 and 200 meters and the topography is generally flat to soft wavy. The annual precipitation is 800 to 1200 mm. Both regions present during the year temperatures around 25^o C [11]. Nampula is the major

[1] *The full spraying cost including the chemicals is US$1.55 per tree in the Northern and Central regions and US$2.37 in the Southern.*

producer of cashew in Mozambique, with a share of about 40% of the national production [3]. There are three major cashew regions within Nampula (North, Center and South).

2.2 Theoretical Framework

Adoption describes the decision to use a new technology, practice or method by individual or groups [12]. It can be viewed as individual or aggregated. Adoption at the individual level reflects the decision of a farmer to integrate a new technology into his/her production system. The aggregation or group adoption implies the diffusion of a new technology within a region [12]. The focus of this study is the individual or household adoption. [13] defined innovation as an idea, practice or object, perceived by an individual as new. It does not matter whether the idea is new as measured by time or discovery. The newness of the idea perceived by individual makes it an innovation. However, adoption is not a permanent condition [14]. A farmer can decide to discontinue the use of a certain technology.

Feder et al. [12] argues that for divisible technologies, such as improved varieties or chemicals, it is possible to assess the degree of use or intensity within a household. Intensity can be measured as the number of hectares under an improved variety or the amount of inputs applied per hectare. In this study, intensity of adoption is the number of grafted seedlings planted annually and proportion of sprayed cashews.

The adoption of agricultural technology is expected to increase the farmers' productivity and income. This means that farmers will select those technologies that maximize their perceived utility. Therefore, when a farmer is confronted with two alternatives, he/she will compare their utilities. If U_{i0} is the utility of farmer *i* derived from the use of traditional technology, and U_{i1} is the utility from the adoption of new technology, it follows:

$$\begin{aligned} U_{i0} &= \beta_{i0}X_{i0} + \varepsilon_{i0} \\ U_{i1} &= \beta_{i1}X_{i1} + \varepsilon_{i1} \end{aligned} \quad (1)$$

Where X is the farm specific function, β the parameter and ε the disturbance term.

The farmer *i* is likely to adopt the new technology if $U_{i1} > U_{i0}$ [15].

2.3 Empirical Model

The literature suggests a variety of models for farmers' determinants of technology adoption. Many researchers employed the dichotomous regressions to model determinants of adoption, using Logit or Probit models [12,16,17]. However, these models explain only whether the farmer uses or not the technology and not the degree of use [18]. Therefore, in many cases, adoption cannot be explained adequately by the use of a dichotomous qualitative variable [12].

For assessing intensity of adoption, Tobit model [19] has been widely employed. Different authors applied the Tobit model for studying intensity of adoption of agricultural technologies, for example [20,21,14,22]. The major drawback of the Tobit model is to assume that the decision to adopt and that of how much to adopt is made jointly. This suggests that factors influencing the two decisions are the same. However, the decision to adopt and the decision on the amount to adopt can be made separately [17]. In order to allow a separate evaluation between adoption and intensity of use of TCP, we used the double-hurdle model. This model was first proposed by [23] and it assumes that the adoption decision and the intensity of adoption are determined independently. Recently, double-hurdle model has been extensively applied to assess intensity of adoption, for instance [24,25,17,18,26-29]. In this model, the adoption decision may be estimated by the Probit or Logit model [27], where all observations in the sample will be used. This estimation is followed by the Trucanted regression on the continuous positive values [27]. The double-hurdle model has an adoption (D) equation:

$$\begin{aligned} &D_i = 1 \text{ if } D_i^* > 0 \\ &D_i = 0 \text{ Otherwise} \\ &D_i^* = \alpha' Z_i + \varepsilon_i, \end{aligned} \quad (2)$$

Where D^* is a latent variable that takes 1 if the farmer adopts the TCP, and zero otherwise. Z is a vector of the household characteristics and α is the vector of parameters.

The intensity of adoption (Y) is represented by:

$$\begin{aligned} &Y_i = Y_i^* \text{ if } Y_i^* > 0 \text{ and } D_i^* = 1; \\ &Y_i = 0, \text{ Otherwise} \\ &Y_i = \beta' X_i + v_i \end{aligned} \quad (3)$$

Where Y_i is the observed number of grafted seedlings planted or proportion of the sprayed cashews. X_i is a vector of household characteristic and β is the vector of parameters.

The error terms ε_i and v_i are assumed to be independent. The log-likelihood function for the double hurdle model is:

$$LogL = \sum_0 ln\left[1 - \Phi(\alpha Z_i^{'})\left(\frac{\beta X_i^{'}}{\sigma}\right)\right] + \sum_+ ln\left[\Phi(\alpha Z_i^{'})\frac{1}{\sigma}\phi\left(\frac{Y_i - \beta X_i^{'}}{\sigma}\right)\right] \quad (4)$$

Where Φ and ϕ are the standard normal cumulative distribution function and density function, respectively. Under the assumption of independence between ε_i and v_i, the double-hurdle model is equivalent to a combination of Probit model and Truncated regression.

2.4 Data Collection

We used cross-sectional data collected in September 2016, using a structured questionnaire at the household level. A multistage sampling technique was employed [30]. The first stage involved the selection of three districts. Each district was purposively selected within each of the three-cashew region in Nampula. This aimed at including districts that produce cashew and benefit from activities of cashew technology promotion. The selected districts were Angoche (South), Monapo (Central) and Erati (North). The second stage involved the village selection within the districts, and three villages were randomly selected in each district. This procedure consisted of assigning a number to each cashew village in the district and select randomly three numbers, and then determine the village name the number belongs to [30]. Finally, 30 farmers' households were randomly selected in each village, following the technique proposed by [30], making a total of 270 households to be interviewed. Nevertheless, we were able to locate and interview only 258 households.

2.5 Description of Dependent Variables

In this study, two models are estimated, one for the seedling planting and another for fungicide application. The dependent variable for adoption is dichotomous. Adopter is the farmer who planted grafted seedling or applied fungicide in 2014/15. On the other hand, the intensity of use indicates the number of grafted seedlings planted in 2014/15 or the percentage of the sprayed cashews in 2014/15 out of the total owned.

2.6 Description of Explanatory Variables and Hypotheses

Adoption literature provides long list of factors that may influence adoption of agricultural technologies. For example, farmer's decision to use agricultural technologies are hypothesized to be influenced by a combination effect of various factors such as household characteristics, socio-economic and physical environment [24,18,31]. The explanatory variables included in this study were mainly based on [12,18,31,32]. We also considered specific characteristics of the farming system in the study area [2]. The variables hypothesized to influence the adoption of TCP were grouped as: i) personal and household characteristics, ii) economic and market access and iii) institutional and geographical factors.

2.6.1 Personal and household characteristics variables

Age of the household head determines whether a farmer is younger or elderly. Older farmers are assumed to have gained knowledge and experience and assess more the attributes of a technology than younger farmers [26, 32]. [33] argue that old farmers are more risk averse and decrease interest in long term investment, while younger farmers are willing to try new technologies. Education was measured as years of formal schooling attended. It is expected to have positive effect on the adoption [24, 31, 26] because it increases farmer's ability to obtain relevant information for assessing technologies [14]. Farming experience was measured as years of farming cashew. It increases the practical skills, hence increasing the probability of adoption [31]. Gender is binary variable (male=1). It is expected to have positive effect on the adoption. Generally, males have more access to information, education and resources, which increase their adoption probability [26]. Training represents number of days of training in cashew in 2014/15. It is expected to have positive effect because training improves farmers' skills and knowledge.

2.6.2 Economic and market access variables

Access to credit is binary and refers to whether the household received credit in 2014/15. Farmers who accessed credit may overcome financial constraints and purchase inputs [14]. Several authors found access to credit influencing positively adoption, including [16, 18, 27]. Family labor was measured in man equivalent. It is expected to have positive effect on adoption. Land holding is an indicator of wealth and social status [14, 18]. Therefore,

[2] These variables are the output price, gender interaction with access to important resources and district index.

farmers with large land are more likely to adopt technologies. It is measured in hectares. Output price is an indicator for market access, and represents the relative profitability of a technology [18]. It is expressed in US Dollar per kilogram. We hypothesized that price of cashew nut will have positive effect on adoption. The interactions between gender and land and between gender and family labor were defined to account for access to resources by gender. [34] studied the effect of gender on adoption of maize varieties in Ghana and concluded that there is no significant association between gender and adoption of agricultural technologies, unless access to resources is correlated with gender. Therefore, gender on adoption should be analyzed jointly with access to important resources.

2.6.3 Institutional and geographical variables

Access to extension services refers to whether the household was assisted by the cashew extension officer in 2014/15. The extension assistance to farmers increases their understanding of technology attributes and ensure their correct implementation. Given the observed differences on socio-economic characteristics and development of cashew production among the districts, we included in the model the district index for Angoche and Erati. Monapo was used as benchmark.

3. RESULTS AND DISCUSSION

3.1 Descriptive Statistics

Farmers' households were assessed with the objective of identifying factors determining adoption of TCP in three districts of Nampula in Mozambique. About 27% of the surveyed households planted grafted seedlings in 2014/15, with an intensity of seven seedlings annually. On the other hand, 47% of the assessed households applied fungicide to cashews against powdery mildew, with an intensity of 38% of the total owned cashews. [35], investigating factors influencing adoption of cashew technologies in Tanzania, learned that 25% of the respondents adopted improved cashew planting materials. [36] found that 30% of households planted grafted seedlings and 79.5% used sulfur for disease control in four districts of the Southeast Tanzania. [37] while studying cashew disseminated technologies in Mkinga district of Tanzania observed that 39% out 80 respondents planted improved cashew varieties. Nevertheless, the adoption and intensity of use in our study area are still low, especially because farmers are getting the technologies at a subsidized price.

Table 1 presents the mean comparison of continuous explanatory variables by adoption group. Farmers who planted grafted seedlings and applied fungicide have higher education, higher family labor, larger land and perceived higher output price in 2014/15. Moreover, farmers who planted grafted seedlings had longer experience and training in farming cashew.

The results of Chi2 test for dummy explanatory variables showed significant difference of frequency between adopters and non-adopters in terms of access to extension and gender for both technologies, and access to credit for seedling planting (Table 2).

Table 1. Descriptive statistics of continuous variables by farmers' group

Variable	Seedling planting			Fungicide application		
	Adopters (70)	Non-adopters (188)	t-test	Adopters (120)	Non-adopters (138)	t-test
Age	45.64	43.78	1.02	44.36	44.22	0.08
Education	4.56	3.38	2.91***	4.32	3.17	3.21***
Experience	20.66	17.64	1.88*	18.95	18.04	0.64
Training in cashew	2.90	0.41	4.25***	1.34	0.86	0.89
Family labor	2.72	2.37	2.27**	2.66	2.29	2.73***
Total land	4.83	3.42	2.89***	4.37	3.31	2.44**
Output price	33.94	29.72	3.27***	34.22	27.95	5.66***
Gender*land	4.71	3.24	2.96***	4.26	3.11	2.58**
Gender*labor	2.69	2.26	2.59**	2.61	2.17	3.00***

*Notes: *, ** and *** denote statistically significant at 10%, 5% and 1% level, respectively.*
Source: Own survey, 2016

Table 2. Descriptive statistics of dummy variables by farmers' group

Variable	Character	Seedling planting			Fungicide application		
		Adopters (70)	**Non-adopters (188)**	**χ^2-Value**	**Adopters (120)**	**Non-adopters (138)**	**χ^2-Value**
Access to credit	Yes	6	4	5.68**	7	3	2.31
	No	64	184		113	135	
Access to extension	Yes	62	117	16.65***	101	78	23.09***
	No	8	71		19	60	
Gender	Male	69	175	2.99*	117	127	3.74*
	Female	1	13		3	11	
Angoche	Yes	44	38	42.78***	67	15	59.85***
	No	26	150		53	123	
Monapo	Yes	15	68	5.08**	32	51	3.11*
	No	55	120		88	87	
Erati	Yes	11	82	17.23***	21	72	33.47***
	No	59	106		99	66	

*Notes: *, ** and *** denote statistically significant at 10%, 5% and 1% level, respectively.*
Source: Own survey, 2016

3.2 Empirical Results

3.2.1 Determinants of adoption and intensity of use of grafted seedlings

The significant Wald chi-square value of 73.52 suggests that the explanatory variables jointly explain the decision to use grafted seedlings. The truncated regression model is also significant with test statistic for the likelihood of 91.66 (Table 3).

Age of the household head does not influence the decision to use grafted seedling. However, it had positive effect on the intensity of planting. This means that the older the farmer, greater is the number of seedlings they planted. [27] while studying socio-economic determinants of intensity adoption of cocoa innovations in Ghana concluded that older farmers will increase the intensity of a technology once they are convinced of its advantages. [38-40] defend that elderly farmers tend to intensify adoption of technologies as result of experience, higher capital accumulation and large family size. Large families are associated with higher family labor.

The probability of using grafted seedlings is positively influenced by education of the household head. [35] found that a unit increase in education led to 26% increase in the log-odds of adopting cashew technologies in Tanzania. [29], who studied the adoption of maize varieties in Nigeria, explains that higher education influences farmers' attitudes and thoughts, making them more rational and able to analyze the benefits of a technology.

Farming experience had negative sign and insignificant for adoption. However, experience-squared was significant with positive coefficient. This implies that as the experience increases, the probability of adoption decreases until 19 years, from which starts increasing exponentially. This finding was also observed by [31] when studying adoption of tef technologies in Ethiopia. For [29] experience provides farmers with knowledge that increases their rationality in use of new technologies.

Training influenced positively both adoption and intensity. [36], when studying the adoption of cashew farming in Tanzania, concluded that training is a very important factor for adoption, since farmers need to understand and practice technologies before adopting.

Family labor had positive effect on the intensity of adoption. This suggests that grafted seedlings are labor intensive [24,41]. Poor farmer's households rely on family labor for their farming operations [42]. This labor constraint can affect the crop productivity and return to the technology and discourage adoption. [35] observed similar effect of labor on cashew technologies.

Price of cashew nut had positive significant effect. [36] learned that when farm-gate prices of raw cashew nut are low, farmers avoided buying seedlings in Tanzania. As highlighted by [18], output price is the economic profitability easily perceived by farmers to their investment on technologies. Therefore, technologies which are felt to be profitable, have higher probability of being adopted.

Access to extension services had positive effect on adoption. Farmers who were visited by extension officers are about 13% more likely to adopt grafted seedlings than their counterparts. [35] found that access to extension services had 99% increase in the log-odds of adoption of cashew technologies in Tanzania. This effect was expected since extension services disseminate information, knowledge and practical skills for agricultural technologies. In Mozambique, many farmers have limited access to extension services, thus lowering their probability to adopt technologies. [4] observed that cashew farmers in the Northern Mozambique did not know the advantages of grafted seedlings, thus not willing to buy.

Farmers in different districts used grafted seedlings at different degrees. In Angoche they are about 14% more likely to adopt than in Monapo and planted about 9 seedlings more compared to Monapo. While farmers in Erati are 12% less likely to plant grafted seedlings compared to Monapo. Nevertheless, the farmers who planted seedlings in Erati, planted 12 seedlings more than their counterparts in Monapo.

Higher adoption in Angoche can be explained by availability of seedlings, since there is a nursery, which enables farmers to get seedlings on time. [36] argues that unavailability of technologies near the farmers affects the adoption, since it becomes more expensive and time-consuming for travelling to nearby villages. In Angoche, Monapo and Erati, 66%, 92% and 95%, respectively of households who did not plant grafted seedlings, reported as first reason unavailability of seedlings at the planting time. Higher planting intensity in Erati than in Monapo may suggest that farmers with better financial resources in this district are able to afford higher transportation cost and get seedlings from outside the district. And in order to make their investment more profitable, they tend to acquire larger quantities of seedlings.

3.2.2 Determinants of adoption and intensity of use of fungicide

Table 4 presents the estimation results for adoption and intensity of use of fungicide. The results of the Probit model show that the Wald chi-square of 96.28 is significant at 1% level. This implies that the model is fitted and the variables included, collectively explain fungicide application. The truncated regression is also significant with Wald chi-square value of 48.73.

Age of household head influenced negatively the intensity of fungicide application. This suggests that younger farmers are more likely to intensify the use of fungicide. [43] found that adoption of genetically modified maize varieties in Indiana

Table 3. Determinants of adoption and intensity of planting grafted seedlings

Variable	Adoption (Probit)			Intensity (Truncated regression)		
	Coefficient	Robust Sta. error	AME[a]	Coefficient	Robust Sta. error	AME
Age	0.0031	0.0108	0.0008	0.5821**	0.2698	0.3598
Education	0.0728**	0.0337	0.0180	-0.0555	1.1888	-0.0343
Experience	-0.0379	0.0299	-0.0094	0.6822	0.9369	0.4217
Experience2	0.0010*	0.0005	0.0002	-0.0191	0.0164	-0.0118
Training in cashew	0.0435*	0.0230	0.0108	1.5978***	0.4831	0.9877
Access to credit	0.2213	0.4200	0.0549	6.3588	10.8770	3.9307
Family labor	-0.0050	0.0834	-0.0012	4.7163**	2.3289	2.9154
Total land	0.0541	0.0349	0.0134	0.8865	0.5491	0.5480
Output price	1.1965*	0.7219	0.2966	-1.7144	31.3938	-1.0597
Access to extension	0.5228**	0.2402	0.1296	0.7641	8.6836	0.4723
Angoche district	0.5523**	0.2479	0.1369	14.1409*	8.5425	8.7411
Erati district	-0.4893*	0.2508	-0.1213	20.1395*	11.5702	12.4491
Constant	-2.0903***	0.6038		-44.3072**	21.4023	0.3598
Wald chi2 (12)	73.52***			91.66***		
Log-Likelihood	-114.79			-278.61		
No. of observations	258			70		

*Notes: *, ** and *** denote statistically significant at 10%, 5% and 1% level, respectively.*
[a] Average Marginal Effects
Source: Own survey, 2016

Table 4. Determinants of adoption and intensity of use of fungicide

Variable	Adoption (Probit)			Intensity (Truncated regression)		
	Coefficient	**Robust Sta. error**	**AME[a]**	**Coefficient**	**Robust Sta. error**	**AME**
Age	-0.0041	0.0108	-0.0011	-0.4633*	0.2524	-0.4585
Education	0.0631*	0.0344	0.0174	-1.3456	0.8853	-1.3317
Experience	0.0074	0.0115	0.0020	-0.0756	0.2441	-0.0748
Access to credit	-0.1859	0.2765	-0.0513	-0.0938	3.9689	-0.0928
Family labor	0.1081	0.1307	0.0298	3.6603**	1.6739	3.6227
Total land	-0.1252	0.4170	-0.0345	-3.7869	10.9405	-3.7479
Output price	2.1611***	0.7252	0.5961	-10.7861	19.8408	-10.6751
Access to extension	0.5929***	0.2004	0.1636	12.6490	7.7383	12.5188
Angoche district	0.8619***	0.2520	0.2377	5.7637	6.2290	5.7044
Erati district	-0.6592***	0.2212	-0.1818	1.0002	8.2653	0.9899
Gender*labor	0.1719	0.2767	0.0474	0.3359	3.8697	0.3324
Gender*land	-0.0358	0.1309	-0.0099	-3.0068*	1.6763	-2.9758
Constant	-1.9138***	0.5535		97.4670***	13.7613	
Wald chi2 (12)	96.28***			48.73***		
Log-Likelihood	-127.23			-557.51		
No. of observations	258			120		

*Notes: *, ** and *** denote statistically significant at 10%, 5% and 1% level, respectively.*
[a] Average Marginal Effects
Source: Own survey, 2016

increases with age among young farmers as they gained experience and increase their human capital, then it declines with age close to retirement. [33] highlighted that young farmers are less risk averse and may easily adopt new technologies. [44] also observed age affecting negatively the intensity of adoption of improved rice varieties in Nigeria.

As expected, formal education positively influenced the use of fungicide, but not its intensity. [35] observed similar effect of education on adoption of cashew production technologies in Tanzania. Higher education of farmers increases their ability to obtain and use information on technologies [32]. [27] found that primary and tertiary education influenced the adoption of cocoa technologies in Ghana.

Availability of family labor had positive and significant effect on the intensity of use. Cashew farmers sprayed about 4% more at each man equivalent increment. Although the use of fungicide does not require direct application of labor, other complementary activities does. These activities include weeding, pruning and collection of cashew nut, which in case of not being performed properly on time may affect the return on fungicide investment.

Output price had positive effect on the adoption of fungicide. This implies that farmers who received higher prices were more motivated to use fungicides. [45], who investigated the constraints of farmers in cashew production in Nigeria, defend that lower cashew nut price does not encourage farmers to invest in inputs, because it increases uncertainty on the expected return for the crop. [46], who studied factors for adoption of technology for cashew production in Brazil, also observed positive effect of cashew nut price on adoption.

Access to extension services determined positively the adoption of fungicide. Farmers who accessed extension services were 16% more likely to use fungicide than their counterparts. Extension officers provide relevant information on cashew spraying and connect farmers to service suppliers. [47] found extension services influencing positively adoption of improved onion varieties in Bangladesh and argue that new varieties or practices require more extension assistance than the traditional ones, thus, farmers who access extension services are more likely to adopt.

Farmers in Angoche were 24% more likely to use fungicide compared to farmers in Monapo. While farmers in Erati had 18% probability less to adopt than in Monapo. This can be explained by the existence of more human resources for the extension services and community cashew promotors in Angoche. From our observations, Erati is characterized by poor infrastructures and relative remoteness as compared to the two other districts, which can imply higher transportation cost, thus the middlemen willing to pay low farm-gate price.

Interaction between gender and land was statistically associated with intensity of fungicide application. The negative coefficient suggests that females with more land are more likely to intensify the use of fungicide. This confirms the hypothesis that resource allocation on gender can influence the adoption of technologies and that females are land constrained.

4. CONCLUSION

We identified factors determining the probability and intensity of adoption of TCP in Nampula, Mozambique. The decision to use the TCP and how much to use are influenced by different factors.

The adoption of grafted seedlings was determined by formal education, farming experience, training in cashew, price of cashew nut and access to extension services. While the intensity of planting was influenced by age, training in cashew and availability of family labor. Adoption and intensity of seedling planting was higher in the district of Angoche. This implies that cashew famers in Angoche have realized the importance of TCP for increasing productivity. Grafted seedling availability at farmers' village is among the major determinants for adoption. INCAJU should increase seedling availability at the village level by involving and supporting private seedling producers at the village level and enhance the existing cashew stakeholders. Another strategy should be to establish a public nursery [3] in Erati, which would also provide seedlings to the neighboring districts of Nacaroa and Chiure. The use of fungicide was influenced by education, price of cashew nut and access to extension services. While the intensity of use was associated with age, availability of family labor and interaction between gender and land holding. Similar to seedling planting, many farmers in Angoche and a few in Erati used fungicide.

Access to extension services was found to be one of the most powerful factor for adoption of TCP. Extension assistance increases awareness of farmers on agricultural technologies and their practical skills. Therefore, the government should strengthen the cashew extension in human capital and means of transportation and communication. In this regard, especial attention should be given to the districts of Erati and Monapo. When promoting TCP, farmers with higher education level should be used as lead farmers for influencing others to adopt. Minimum price policy should be adopted and its implementation must be monitored to ensure that farmers get the expected return to technology investment and encourage them to use new technologies. Age of the household and family labor availability were the common factors for intensifying the use of both technologies. Elderly farmers intensified more seedling planting, while the younger ones intensified the use of fungicide. Land ownership among women increases the intensity of fungicide plan application.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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