Determinants of Farmers' Participation Decision on Local Seed Multiplication in Amhara Region, Ethiopia: A Double Hurdle Approach

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Abstract: ***This study is intended to identify the determinants of farmers' participation in local seed multiplication and to assess the level of farmers' participation in wheat and potato seed multiplication in Amhara region, Ethiopia. Primary data was collected from 120 randomly selected respondents. The survey data was analyzed using double-hurdle model. Results of the determinants and intensity of farmers' participation in both wheat and potato seed multiplication indicated that distance to the main road, access to input supply, participation in field days and wealth status in terms of livestock size impacted the first binary decision of whether or not to participate in local seed multiplication farming. On the other hand, farmers' decision on the proportion of land allocated to seed multiplication were found to have been significantly influenced by number of oxen owned, access to complementary input and participation in field days. Therefore, responsible government organizations need to give attention to strengthen and leverage government extension service to promote awareness creation of the existing seed multiplication technologies by arranging field day visit. Emphasis needs to be given to enhancing the access to basic inputs either through sale or distribution is necessary for meaningful participation of farmers in local seed multiplication***

Keywords: Double Hurdle, Potato, Seed multiplication, Tobit, Wheat

1. Introduction

1.1. Background

The seed system in Ethiopia consists of the formal seed sector, the informal (farmers') seed system, as well as the occasional emergency seed programs, which are often operated by some NGOs and relief agencies (Dawit et al, 2008).After almost three decades of operation, the formal seed sector could not adequately satisfy the seed demand of the vast majority of the nation's farmers who are small holders and subsistence farmers. Currently, the share of the formal seed system is estimated to be about 10-20%, while the rest 80-90% is covered by the informal system (Zewdie et al., 2008).

Even though informal seed systems prove very valuable to supply large quantities of seed, they appear to have neglected some quality aspects (Lipper et al., 2005). Despite their long time existence, their effectiveness and eventually sustainability may be threatened by rapid changes in the agro-ecological or socio-economical conditions. Therefore, integration of both systems may yield the most effective and most sustainable way to secure the supply of optimum quality seeds of all crops to all farmers (Louwaars, 1994). This may involve development of either the formal or local seed systems.

Having in mind the importance of integrating the formal seed sector to that of the informal seed sector, in recent years' research, extension and development programs in Ethiopia have adopted Farmer-Based Seed Production and Marketing Scheme (FBSPMS), participatory approaches that unify the efforts of various stakeholders concerned with agricultural development with the aim of overcoming formal research-extension linkage weaknesses and improve localized seed availability on a sustainable basis begun to surface.

The Amhara National Regional State has also designed and implemented programs that have been expected to increase improved seed /supply. Based on this fact farmers' based seed multiplication and marketing scheme is focused on 35 potential districts of the region. This trend is believed to have been contributing to the overall realization of agricultural development objective of the region by increasing the supply of seed of different crops as well as by increasing the income of participant farmers. However, the growth in participation of farmers and amount of seed produced and supplied by seed producing farmers was below the level it can satisfy the seed demand of the region. There is paucity of information with regard to such a scenario of low performance of producers as to recommend appropriate policy options. Therefore, this study was initiated to identify factors which determine farmers' participation in seed multiplication and to examine the extent of adoption of seed multiplication for bread wheat seed producer farmers in Womberm district and for potato seed multiplier farmers in GuagsaShekudad district of Amhara National Regional State.

2. Methodology

Both purposive and two stage-sampling techniques were used to draw sample respondents. The study districts were purposively selected based on their experience in seed multiplication schemes and potentiality for the respective crops. A total of 120 respondents were selected by employing the probability proportional to size sampling technique. The primary data were collected from sampled households through structured questionnaire. The data were collected from February - March 2010.

2.1 Methods of Data Analysis

2.1.1 Econometric model specification

To overcome the weakness of the Tobit model the flexible forms of the Tobit model, known as the "double hurdle" model is usually preferred. So, for this study, a double hurdle model was used to determine those factors, which influence farmers' participation decision in seed multiplication and to examine the extent (intensity) of seed multiplication. The estimation of the double hurdle requires the joint use of the probit and the truncated regression model, in which the decision to participate and level of participation in seed multiplication are determined by two separate stochastic processes (Genanew and Alemu, 2010).
The formal model of the double- hurdle is given as follows

$D_i = \alpha Z_i + V_i$(Participation decision equation)
D_i=1, if $D_i *> 0$ and 0 if $D_i * < 0$

Where, $D_i *$ is a latent variable that takes the value 1 if the famer participates in seed multiplication and zero otherwise, Z is a vector of household characteristics and α is a vector of parameter.

$y_i^* = \beta x_i + u_i$ (Level of participation equation)
$y_i = y_i^*$ if $y_i^* > 0$ and $D_i^* > 0$
$y_i = 0$ otherwise

Where, yi* and y_i are latent and the observed levels of participation in seed multiplication respectively, x_i is a vector of variables influencing how much households participate in seed multiplication and β is a vector of parameters to be estimated.
If both decisions are made by the individual farmer independently, the error terms are assumed to be independently and normally distributed as:

v_i~ N (0, 1) and u_i~ N (0, σ²),

The result of Cragg's double-hurdle model (Cragg, 1971), was also compared with the alternative Tobit model (Tobin, 1958), for each seed type separately.

The Tobit model, originally developed by Tobin, may be expressed in the following way:
$y_i* = \beta x_i + u_i$, u_i N (0, σ2)

Where β is a vector of unknown coefficients, X is a vector of independent variables

2.1.2 Test for model appropriateness: Tobit versus Double-hurdle model

Whether a Tobit or a double hurdle model is more appropriate can be determined by estimating the Tobit and the double hurdle models separately and then conducting a likelihood ratio test.

The likelihood ratio test statistics Γ can be computed (Greene 2000) as:

$$\Gamma = -2\left[\ln L_{Tobit} - \left(\ln L_{Probit} + \ln L_{Truncated}\right)\right] \sim \chi_k^2$$

For good measure, Akakie's Information Criterion (Akakie, 1974) is also included as a model selection criterion. The Akakie's information criteria (AIC), serving as a measure of goodness of fit and model selection is generally defined, for individual models, by:

$$AIC = 2K - 2\ln(L)$$

Where, k = number of parameters in the model, L= the likelihood function

The Breusch-Pagan test for constant variance was used for heteroscedasticity test in order to avoid false rejection of hypothesis and unrealistic confidence intervals. Variance inflation factor (VIF) and Contingency Coefficients (CC) were also used to test for collinearity among continuous independent variables and for dummy or discrete variables respectively (Gujarati, 1995).

3. Determinants of Farmers' Participation in Seed Multiplication: Empirical Evidence from the Field

The traditional approach to deal with data that have too many zeros, yielding a censored dependent variable has been to use the standard Tobit model, originally formulated by Tobin (1958). The Tobit model has a number of potential shortcomings due to the restrictive assumptions it makes. Cragg (1971), modifies the Tobit model to overcome the restrictive assumption inherent in it, namely, he suggests the "double-hurdle" model to tackle the problem of too many zeros in the survey data. In the double-hurdle model, both hurdles have equations associated with them, incorporating the effects of farmers' characteristics and circumstances. A few studies have applied double-hurdle models in which the decision of whether or not to use improved technology and the decision of how much to use this improved technology could be affected by different set of factors (Genanew and Alemu, 2010).

Hailemariamet al. (2006) conducted a study using Cragg's double hurdle model to determine factors influencing the rate and intensity of adoption of poultry technology by assuming that the two decisions processes were separate. Results of the studies indicate that there were different sets of factors behind the decision to adopt and the decision about to which extent to do so. In the same way

Bekele et al. (2008) uses the augmented double-hurdle model for technology adoption under seed access constraints and the economic impacts of improved pigeon pea varieties in Tanzania. The study identifies the crucial role of seed access (local supply), extension, education, participatory decision-making, capital and household assets in determining adoption decision of farmers. Likewise, Berhanu and Swinton (2003), Tadesse (2008) and Komarek (2010) applied this model for their respective studies.

The double-hurdle model has the implicit advantage of being flexible to accommodate either sequential or simultaneous decision making of households and provides for the possibility of using same or different determinants in each one of the two decision equation hurdles. The Tobit model is also important when the data is censored and seed multiplication process can be explained by one hurdle and over the same set of determinants. The present study capitalizes on the said merits of the preceding two models, which most other models lack.

4. Result and Discussions

4.1. General Description of the Respondent

Sample respondents were composed of both male and female household heads. It was found that among the total sample respondents 95% of the sample households are headed by males in all of the survey sites and 93% were married. The percentage of male-headed households of seed producers was higher than that of female-headed households. This could be attributed to various reasons including shortage of labor and limited access to information and required inputs. From the total non-seed producers, 16.6% of it is illiterate, whereas only 6.6% of seed producers were found to have been in this category.

The average size of owned cultivated land for wheat seed producer farmers in Womberma district was 2.09 ha, while that of non-producer farmers was 2.01 ha. Likewise, in Shekudad district average size of owned cultivated land for potato seed producer farmers was 1.016 ha, while that of non-producer farmers was 0.94 ha. Statistically, there was no significant difference between seed producers and non-seed producers with respect to the size of cultivated land holding. However, the allocations of land for seed multiplication were greater at Womberma district as compared to Shekudad district. This could be due to the fact that, wheat seed multiplications call for isolation distance with other planted crops, which favors large plot owner households. For instance, framers who are interested in multiplication of wheat seed needed to allocate a minimum of 0.5 hectare of land.

4.2. Adoption and preference of wheat varieties

From 1980 up to 2010, the Ethiopian Institute of Agricultural Research (EIAR) and the regional research organizations in collaboration with other International research centers verified, demonstrated and popularize more than 25 bread wheat varieties for moisture–stress, water- logged and optimum environment areas (Variety registry book, 2010) (see Appendix Table 3) . In the last few years, different improved varieties of wheat and potato were introduced into the farming system of the study district with the help of Regional Agricultural Research Institutes and MoARD. Nevertheless, it is only two wheat varieties predominantly under production during the study year.

Farmers who have been involved in wheat seed multiplication farming, there is a narrow genetic diversity of wheat varieties and farmers opt to plant only two wheat varieties namely Kubsa (HAR -1685) and Galama (HAR-604) bread wheat varieties from year to year. From the total respondents 95% of them planted Kubsa (HAR - 1685) varieties and only negligible amount of the respondents, which is 5%, allocated land for Galama (HAR-604) bread wheat varieties during the survey times. The possible reason for this high adoption of this two wheat varieties attributed partly due to the high productivity and the abundant availability of seeds of this two wheat varieties were regional and federal seed enterprises were willing to intensively multiple only these two varieties. Shockingly, this both wheat varieties are highly susceptible to stem (stripe) rust problems.

4.3. Econometric Results

4.3.1. Determinants of Farmers' Participation in and Intensity of Wheat Seed Multiplication

The results of the joint maximum likelihood estimation of the double-hurdle model are shown in Table 1 and Appendix Table 4 for the probability of participation in wheat seed multiplication (D) and to what extent (intensity of involvement in wheat seed multiplication) (Y). A Tobit model containing the same set of variables is also presented in Appendix Table 4. The results from the two models were comparable and show the robustness of the model specification. All the statistically significant variables had the same directional effects in both models. Tests of model selection were performed using log likelihood test and AIC. Thus, the tests jointly support use of results of the sequential decision model to assess determinants of farmer's participation in wheat seed multiplication. The implication of this result is that probability of participation and level of participation are not based on the same decision making process.

According to the results of the double-hurdle model, access to complementary inputs and attending or participation in field day visits were found to have been cross-cutting determinants in the two decisions stages indicating the importance of complementary inputs and field days in promoting wheat seed multiplication for wider adoption by small-holders.

Access to complementary inputs (such as fertilizer and chemical) has a significantly positive effect on the probability of adoption decision (at 1% significance level) and extent of adoption of wheat seed multiplication (at 10% significance level). Those farmers who have access to complementary inputs increased the likelihood of participation in and the expected proportion of land allocation for wheat seed multiplication by 64% and 27.36%, respectively. A possible explanation for this is that seed multiplying farmers use more complementary inputs compared to non-seed producer farmers. So, this result indicates that for wheat seed multiplication to be successful, the availability of complementary inputs at the right quantity and time is quite indispensable.

As hypothesized attending field days on improved seed technologies was positively influencing the adoption decision as well as intensity of the adoption of wheat seed multiplication at 1% and 5% level of significance in that order. The result implies that participation in field days increases the probability of farmers' decision to participate in wheat seed multiplication and the proportion of land committed to wheat seed multiplication by 67.6% and 44.85%, respectively.

4.3.2. Determinants of farmers' participation in and intensity of potato seed multiplication

To select the model that best identifies the determinants of farmers' participation in and intensity of potato seed multiplication, a series of model specification tests were carried out using the joint decision criteria of log likelihood test and Akaike's Information Criteria (AIC). Both tests reject the use of results of the simultaneous decision, i.e. Tobit model. This is an indication of the existence of two separate decision-making stages in which individuals make independent decisions regarding the participation in and intensity of potato seed multiplication.

The result of marginal effects of the parameter estimates for double hurdle model for the determinants of adoption and intensity of potato seed multiplication are displayed in Table 2. For cross-referencing, the maximum likelihood estimates for the Tobit model are also given in Annex Table 5.

Table 2: Marginal effects of the determinants of farmers' participation in potato seed multiplication

Variables	Double – hurdle model: Decision to Participate (probit, D): Coefficient	Robust Std. Err	Marginal effects	Level of participation (Truncated regression, Y: Coefficient	Robust Std. Err	Marginal effects
-cons	0.692	1.653		-0.9615	1.024	-57.988
HIREDLAB	0.369	0.4241	0.146	0.221	0.1289*	13.3
MANEQV	0.070	0.229	0.028	-0.017	0.052	-1.0284
AGEHH	-0.029	0.027	-0.012	-0.0031	0.0076	-0.1909
EDUCATIH	0.071	0.0859	0.028	0.0109	0.0168	0.66010
CULTVATE	0.0478	0.493	0.019	0.397	0.236*	23.94
OFFARMIN	-0.0002	0.0001	-0.00001	-0.00001	0.00005	-0.0085
TIMSUPPI	0.430	0.655	0.169	-0.309	0.2928	-18.64
TRASEDM	0.949	0.462**	0.363	0.603	0.4595	36.36
MRKTINFO	0.274	0.419	0.108	0.371	0.2116*	22.38
FIELDDAY	1.728	0.557***	0.599	-0.253	0.195	-15.27
CREDITUS	-0.203	0.443	-0.08	0.1578	0.1588	9.522
DISNEARM	-0.013	0.0079*	-0.005	-0.001	0.0031	-0.0627
EXTENSIO	-0.316	0.5443	-0.125	0.457	0.3905	27.605
TLU	0.171	0.085**	0.068	0.0112	0.0114	0.68085
Weighted variable	C			C		

*, ** and *** significant at 10%, 5% and 1%
Robust Std. Err = Robust Standard Error
Source: own computation

Table 1: Marginal effects of the determinants of farmers' participation in wheat seed multiplication

Variables	Double – hurdle model: Decision to Participate (probit, D): Coefficient	Robust Std. Err	Marginal effects	Level of participation (Truncated Regression, Y): Coefficient	Robust Std. Err	Marginal effects
-cons	-3.863	1.305***		0.7337	1.123	1.9889
YEARFARE	0.082	0.061	0.033	-0.0105	0.044	-0.5533
MANEQV	0.043	0.187	0.0173	0.2005	0.194	2.546
CULTVATE	0.17	0.296	0.067	0.0060	0.203	9.9
HIREDLAB	2.18	0.658***	0.698	0.5858	0.433	3.8
NOOX	0.226	0.179	0.090	0.1886	0.084 **	12.44
TIMSUPPI	1.98	0.562***	0.64	0.5343	0.304 *	27.36
TRASEDM	0.83	0.522	0.322	-0.575	0.682	-25.9
MRKTINFO	-0.429	0.606	-0.169	0.0304	0.338	19.8
FIELDDAY	2.15	0.725***	0.676	0.7068	0.349 **	44.85
DSMAINRO	-2.068	0.747***	-0.823	-0.7781	0.837	-0.2449
Weighted variable	C			C		

*, ** and *** significant at 10%, 5% and 1%
Robust Std. Err = Robust Standard Error
Source: Own computation

The results of the marginal effect analysis indicate that having access to training increases the probability of farmers' participation in potato seed multiplication by 36%. According to the results of the double-hurdle model, relative to farmers who have not attended field days, the reference group in the present analysis, farmers' who attend field days on previous year are about 60% more likely to participate in potato seed multiplication. This is because of the fact that attending field days will enable farmers to get more information and improve their understanding about the available packages.

5. Conclusion and Implications

In order to meet the differentiated and complex needs of the small-scale farmers' seed demand, farmer-based seed production and marketing scheme (FBSPMS), was implemented in Ethiopia in 1997. The Amhara National Regional State (ANRS) has also designed and implemented programs that have been expected to increase improved seed supply since the year 1997. The major component of the program was the farmer-based seed multiplication and distribution scheme. Considering the lack of well-organized information on the pace of the aforementioned activity in the regional state, this study is intended to identify the determinants of farmers' participation decision in local seed multiplication and to assess the level of participation of farm households in seed multiplication, especially on the farmers of Womberma and GuagsaShekudad district.

Analyses of determinants of farmer's participation in local seed multiplication farming identified the superiority of the two-step, double-hurdle model as compared to the one step, Tobit, model in describing farm households' involvement in both wheat and potato seed multiplication farming. The model considered farm households' involvement in seed multiplication as two separate stochastic processes, in which the decision to participate in seed multiplication and level of participation decision in seed multiplication farming were affected by different set of factors.

Results of the double-hurdle model pertaining to the determinants and intensity of wheat seed multiplication farming indicated that these two sequential decisions were influenced by different set and levels of determinant factors. To this effect, access to hired labor, distance to the main road, access to input supply and field day visit influenced the first binary decision of whether or not to participate in wheat seed multiplication farming. On the other hand, farmers' decision on the proportion of land allocated to wheat seed multiplication (intensity of adoption) is positively and significantly influenced by number of oxen owned, access to complementary input and field day visit. However, access to input supply and field day visit were the only common determinant factors that significantly influenced the two decisions.

Results of analysis of the determinants and intensity of potato seed multiplication farming showed that the first hurdle of whether or not to participate in potato seed multiplication was influenced by institutional arrangements including access to training related to seed multiplication technology, field day visit and distance to the nearest market and wealth status in terms of livestock size. The second hurdle was influenced by access to hired labor, size of cultivated land and access to market information. Among the determinants mentioned previously with the exception of distance to the nearest market, the remaining variables were positively and significantly related to the determinants of farmers' participation in potato seed multiplication. Generally, the two processes were influenced by different set of factors.

5.1. Policy Implications

In this study, it has been observed the reality that institutional variables like training, field day visit and access to input supply is an important factor for the success of adoption and intensification of seed multiplication technology. The result of this study has shown that, those farmers who did not attend field day visit on seed multiplication technology lack information and knowledge besides the skill to produce the required seed and they were reluctant to involve in seed multiplication technology. The implication for this is that there is a need to strengthen and leverage government extension service and rural institutions to promote awareness creation of the existing seed multiplication technologies by arranging field day visit. In addition to this, the agricultural research institutions should also expand their pre-extension and popularization trials on improved seed multiplication technology to the relatively remote districts areas as well.

Farmers who have been involved in wheat seed multiplication farming, there is a narrow genetic diversity of wheat varieties and farmers opt to plant only two wheat varieties namely Kubsa (HAR -1685) and Galama (HAR-604) bread wheat varieties. Appallingly, this both wheat varieties are highly susceptible to stem (stripe) rust problems. Therefore, broadening the genetic composition and increase option of the choice of improved high yielding and rust tolerant wheat varieties for farmers using the participatory varietal selection (PVS) methods might be a remedy for this problem.

This study has also shown that both participation decision and level of participation decision in seed multiplication technology were strongly related to access to complementary inputs. Therefore, efforts aimed at increasing the capacity of making agricultural productivity enhancing inputs available through policies that promote the development of farm inputs supplying institutions or accessible input sales/distribution points is necessary for meaningful participation of farmers in seed multiplication.

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Annexes

Annex Table 1: Descriptive statistics of selected continuous variables in the empirical model

Variable	Definition	Minimum	Maximum	Mean	Std. Deviation
AGEHH	Age of the respondent, measured in years.	21	66	45	10.71
EDUCATIH	Education level of the house hold, years of education	0	12	3.73	3.11
MANEQV	Household size, man - equivalent	0	6.3	2.53	1.38
OFFARMIN	Off-farm income , in Birr	10.00	7760	2040.2	1723.12
YEARFARE	Experience in improved wheat and potato production, in years	3	39	18.13	7.76
CULTVATE	Owned cultivated land size , in hectares	0.25	4.00	1.56	0.917
NOOX	Number of oxen the household owns	0	6	2.31	1.762
TLU	Tropical livestock unit, excluding oxen ownership	0.00	20.2	4.75	3.82
DSMAINRO	Distance from the main road, in walking hours	0.30	3.00	1.98	7.14
DISNEARM	Distance from market center, in walking hours	1.00	4	2.6	4.87

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DSMAINRO	Distance from the main road, in walking hours	0.30	3.00	1.98	7.14
DISNEARM	Distance from market center, in walking hours	1.00	4	2.6	4.87

Annex Table 2: Socio-economic and institutional characteristics of respondents (dummy variables)

Variables	Womberma			Shekudad		
	Seed producer %	Non producer %	χ^2	Seed producer %	Non producer %	χ^2
Access to market information						
- Yes	53.3	26.7	4.44**	33.3	6.7	6.667***
- No	46.7	73.3		66.7	93.3	
Training participation						
- Yes	83.3	33.3	15.43***	93.3	20	32.85**
- No	16.7	66.7		6.7	80	
Attending field day visit						
-Yes	66.7	16.7	15.429***	63.3	26.7	8.15***
- No	33.3	83.3		36.7	73.3	
Access to timely input supply						
- Yes	53.3	13.3	10.8***	40	33.3	0.287
- No	46.7	86.7		60	66.7	
Access to hired labor						
- Yes	83.3	46.7	6.239**	66.7	36.7	5.046**
- No	16.7	53.3		33.3	63.3	
Access to credit						
- Yes	36.7	53.3	1.684	69	63.3	0.209
- No	63.3	46.7		31	36.7	
Access to extension service						
- Yes	86.7	60	5.45**	93.3	76.7	3.268*
- No	13.3	40		6.7	23.3	

Source: own computational result
***, **, * Significant at 1%, 5% and 10%

Annex Table 3: Bread wheat varieties currently under production in Ethiopia

No	Variety	Year of release	Plant height (cm)	Maturity(days)	Rainfall (mm)	Altitudes (m)	Yield(q/ha)
1	Dereselign	1974	90-106	100-125	>500	1650-2200	24-40
2	K6290-Bullk	1977	110-125	128-131	>500	1800-2200	30-50
3	K6295-4A	1980	100-115	128-131	>600	1900-2400	30-60
4	ET-13A2	1980	105-120	127-149	>600	2200-2900	30-60
5	Pavon-76	1982	90-100	120-135	>500	750-2500	30-60
6	Mitike (HAR-1709)	1993	110-125	125-135	>600	2000-2600	30-70
7	Wabe (HAR-710)	1994	90-100	120-140	>600	≤2200	40-60
8	Kubsa (HAR-1685)	1994	90-100	120-140	>600	2000-2600	50-70
9	Galama (HAR-604)	1995	100-125	120-155	>600	2200-2800	45-65
10	Abola (HAR-1522)	1997	75-110	128-131	>600	2200-2700	40-65
11	Magal (HAR-1595)	1997	60-100	113-124	>500	1800-2400	30-50
12	Tusie(HAR-1407)	1997	75-110	125-130	>600	2000-2500	40-65
13	Tura (HAR-1775)	1999	90-100	120-150	>600	2200-2800	40-55
14	Katar (HAR-1899)	1999	90-100	110-134	≥600	2000-2400	30-60
15	+ Shina (HAR 1868)	1999	95-105	100-120	>600	2800-2500	35-65
16	Simba (HAR-2536)	2000	90-100	100-150	>600	2000-2600	30-50
17	Hawi (HAR-2501)	2000	90-100	105-125	>500	1800-2200	15-40
18	Wetera (HAR-1920)	2000	90-100	120-150	≥600	2000-2400	20-45
19	++Meda-Walabu (HAR 1480)	2000	95-110	100-125	>600	2300-2800	35-45
20	++ Sof-Omer (HAR-1889)	2000	90-100	125-150	>600	2300-2800	35-45
21	Sirbo (HAR-2192)	2001	90-100	85-105	>600	2200-2800	30-45
22	KBG01	2001	80-90	80-100	>600	2000-2400	30-45
23	Bobitcho (HAR 3116)	2002	90-100	95-105	>600	1800-2800	40-50
24	Meraro	2004	90-100	110-120	>500	1800-2800	40-50
25	Digelu (HAR-3116)	2004	95-110	100-120	>600	2000-2600	35-45
26	ETBW (HAR-4921)	2007	70-90	90-120	>600	2000-2400	30-50
27	Picaflor #1	2010	-	-	>500	1800-2400	-
28	Danphe#1	2010	-	-	>600	2000-2600	-

+ Bread wheat variety released by Adet Research Center, ++ Bread wheat variety released by Sinana Research Center
Source: Variety registry book, 2010

Table 4: Maximum likelihood estimation of double-hurdle Vs Tobit model for wheat seed multiplication

Variables	Double-hurdle model				Tobit regression	
	Decision to Participate (probit)		Level of participation (Truncated regression)		Level of participation	
	Coefficient	Robust Std. Err	Coefficient	Robust Std. Err	Coefficient	Robust Std. Err
-cons	-3.863	1.305***	0.7337	1.123	-1.638	0.603***
YEARFARE	0.082	0.061	-0.0105	0.044	0.028	0.037
MANEQV	0.043	0.187	0.2005	0.194	0.098	0.161
CULTVATE	0.17	0.296	0.0060	0.203	0.0034	0.163
HIREDLAB	2.18	0.658***	0.5858	0.433	1.087	0.363***
NOOX	0.226	0.179	0.1886	0.084 **	0.167	0.09*
TIMSUPPI	1.98	0.562***	0.5343	0.304 *	1.034	0.313***
TRASEDM	0.83	0.522	-0.575	0.682	0.328	0.365
MRKTINFO	-0.429	0.606	0.0304	0.338	-0.057	0.315
FIELDDAY	2.15	0.725***	0.7068	0.349 **	0.769	0.288***
DSMAINRO	-2.068	0.747***	-0.7781	0.837	-1.332	0.465***
Weighted variable		C		C		C
Number of observation		60		30		60
Wald chi2 (10) / F10, 50		44.49		24.41		7.99
Prob> chi2		0.000***		0.00***		0.000***
Log likelihood		-17.94		-121.07		-244.66
AIC		57.89		266.15		513.33

*, ** and *** represent statistical significance of factors at 10, 5 and 1 per cent levels respectively. Robust Std. Err = Robust Standard Error
Source: Own computation of survey data.

Annex Table 5: Maximum likelihood estimation of double-hurdle Vs Tobit model for potato seed multiplication

Variables	Double-hurdle model				Tobit regression	
	Decision to Participate (probit)		Level of participation (Truncated regression)		Level of participation	
	Coefficient	Robust Std. Err	Coefficient	Robust Std. Err	Coefficient	Robust Std. Err
-cons	0.692	1.653	-0.9615	1.024	0.089	0.358
HIREDLAB	0.369	0.4241	0.221	0.1289*	0.150	0.0753*
MANEQV	0.070	0.229	-0.017	0.052	0.0067	0.0475
AGEHH	-0.029	0.027	-0.0031	0.0076	-0.008	0.0077
EDUCATIH	0.071	0.0859	0.0109	0.0168	0.0008	0.0139
CULTVATE	0.0478	0.493	0.397	0.236*	0.2458	0.17004
OFFARMIN	-0.0002	0.0001	-0.00001	0.00005	-0.00003	0.00003
TIMSUPPI	0.430	0.655	0.309	0.2928	0.036	0.1455
TRASEDM	0.949	0.462**	0.603	0.4595	0.3169	0.1254**
MRKTINFO	0.274	0.419	0.371	0.2116*	0.1138	0.0803
FIELDDAY	1.728	0.557***	0.253	0.195	0.1656	0.1091
CREDITUS	-0.203	0.443	0.1578	0.1588	-0.0498	0.1063
DISNEARM	-0.013	0.0079*	-0.001	0.0031	-0.0042	0.0022*
EXTENSIO	-0.316	0.5443	0.457	0.3905	-0.0242	0.1522
TLU	0.171	0.085**	0.0112	0.0114	0.0199	0.0251
Weighted variable		C		C		C
Number of observation		60		30		60
Wald chi2 (14) / F14, 46		39.92		32		2.03
Prob> chi2		0.000 ***		0.00***		0.03**
Log likelihood		-18.95		203.58		-211.46
AIC		67.9		-375.16		454.93

*, ** and *** represent statistical significance of factors at 10, 5 and 1 per cent levels respectively. Robust Std. Err = Robust Standard Error
Source: Own computation of survey data.