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Factors influencing number of post-harvest practices adopted by smallholder vegetable farmers in Mashonaland East Province of Zimbabwe

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Abstract

Smallholder vegetable production plays a pivotal role in generation of household income, enhancing household food security and nutrition, hence, improving livelihoods in Zimbabwe's communal areas. Despite this, smallholder vegetable farmers suffer huge postharvest losses leading to significant reductions in profits, food quality and market competiveness. This study examined factors that influence adoption of postharvest practices of washing, grading, cooling, packaging and drying for value addition. This study used cross sectional survey data (n = 385) from four districts of Mashonaland East Province of Zimbabwe. The results of the Poisson count regression model (PCRM) revealed that the following variables were significant in influencing number of postharvest practices adopted by smallholder vegetable farmers: gender, education, household size, age, farming experience, distance to market, market information, group membership, credit and hired labour. The study recommends concerted efforts through public private partnerships (PPP) to provide active extension about postharvest education. This will promote adoption of simple, uncomplicated and innovate low cost technologies particularly by women. Such kind of training should be complemented by providing market information on crops such as rape, covo and tomatoes. Furthermore, agribusiness companies should assist in designing postharvest technologies that mirror adoption patterns of smallholder farmers.

Keywords: Postharvest Practices; Smallholder Vegetable Farmers; Postharvest Losses; Poisson Count Regression Model

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1. Introduction

According to Abass et al. (2014) an estimated over 70% of sub-Saharan Africa (SSA) population depend directly on agriculture as a primary source of income and food. As such, any measures which are geared towards enhancing agricultural production and productivity are very vital in eradicating extreme poverty and hunger in the continent. Despite this scenario in SSA agricultural productivity and per capita value of agriculture output is lowest in the world (FARA, 2006). Furthermore, the situation of low agricultural productivity is worsened by high postharvest losses which are experienced in SSA (World Bank, 2011). Smallholder vegetable farmers in developing countries encounter high incidences of postharvest losses from farm to retail stage. In addition, it has been noted that not much improvement has been attained in trying to reduce percentage losses in postharvest in most developing countries (Kitinoja et al., 2011). In Sub-Saharan Africa, various studies have estimated that smallholder vegetable farmers loss approximately 30% to 40 % of their produce before they reach the final consumer (Korsten, 2006; Weinberger et al., 2008; Coulomb, 2008; Tschirley, 2011; Kereth et al., 2013). These statistics indicate a very grim picture as far as the issue of postharvest losses in vegetables is concerned.

Smallholder vegetable production is very vital in generation of household income in Mashonaland East Province of Zimbabwe in particular as well as the entire country in general. Smallholder horticulture production also plays a pivotal role in enhancing household food security and nutrition, hence improving livelihoods (Njaya, 2014). This is because Mashonaland East Province is regarded as the hub of smallholder farmers' vegetable production and they supply Mbare Musika in the capital city of Harare. Despite this, smallholder vegetable farmers suffer huge postharvest losses leading to significant reductions in profits, food quality and market competiveness (Ali, 2012; Njaya, 2014). Minimising postharvest losses encountered by smallholder farmers is regarded as one key strategy which can reduce area needed for production, improve food supply and lead to conservation of natural resources (Kader, 2003). Changes in consumer markets, marketing of vegetable products through rapid urbanisation has reignited the importance of improving postharvest management of smallholder vegetable farmers so as to improve their income (Ali, 2012). Postharvest technology is defined as the "*handling, sorting, storage, transportation, marketing, and management of biological products from the moment of harvest until final consumption*" (Studman, 2001 page 109). Adoption of postharvest practices by smallholder vegetable farmers provides adequate opportunities for farmers to increase their profitability through raising local value added products, increasing bargaining power, enhancing market access and promoting greater competition among middlemen (Khatana et al., 1997; Mittal, 2007).The main objective of this study was to examine factors influencing number of postharvest practices adopted by smallholder vegetable farmers in four districts of Mashonaland east Province of Zimbabwe. Findings from this study will enable formulation of policies which enable improved productivity and profitability of smallholder vegetable farmers through enhanced postharvest management strategies.

2. Methodology

2.1. Study areas

The study was conducted in four districts of Mashonaland East Province of Zimbabwe. The province is divided into nine (9) administrative districts as shown in Figure 1 below. The four districts in which the study was carried out are Mutoko, Goromonzi, Murehwa and Seke districts. The selection of these districts was based on the intensity of smallholder farmers' vegetable production. These districts is where there is intensive production of vegetables by smallholder farmers for wholesale marketing in towns. Most of the vegetables produced in these districts are marketed on a daily basis at the Mbare Musika in Harare the capital city of the country. The main horticultural produce are tomatoes, onions and leafy vegetables.

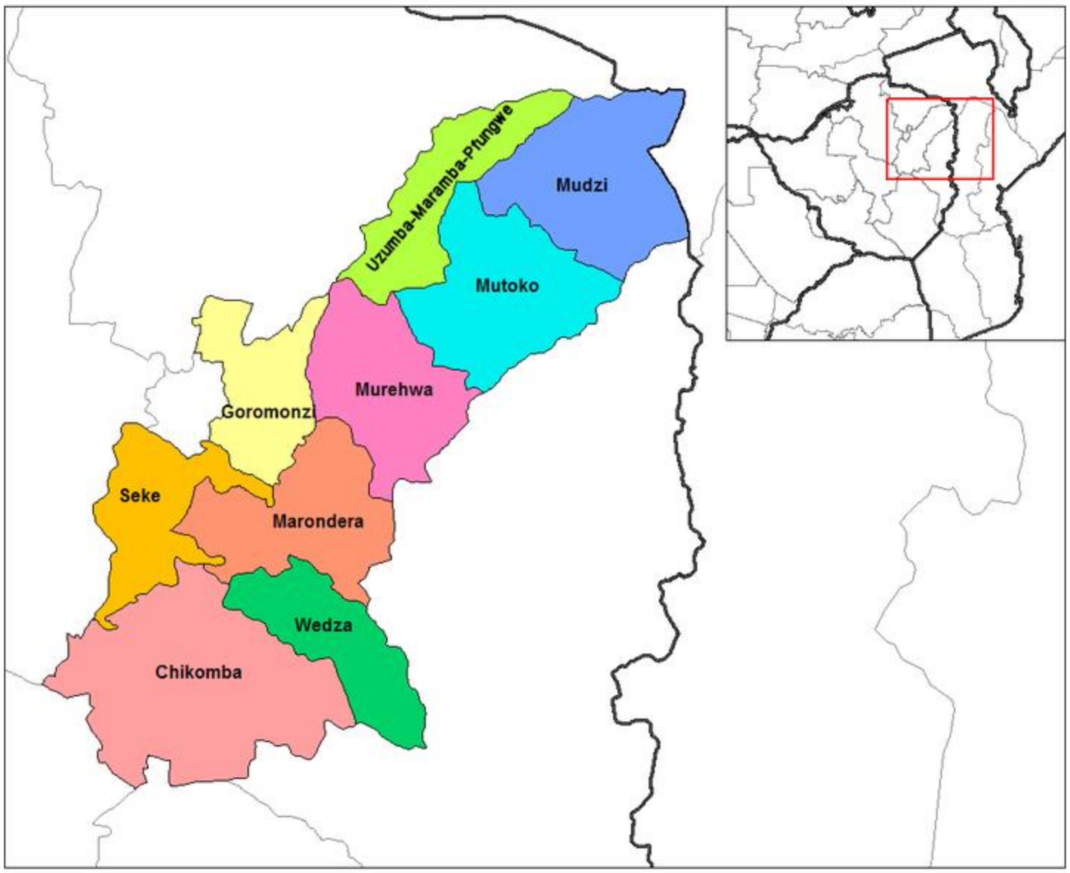

Figure1. Mashonaland East Province and location of the study areas

2.2. Data source and sampling procedures

A structured questionnaire was administered to a total sample size of 385 smallholder vegetable farmers in all four districts. Face-to-face interviews were conducted with farmers in the study areas with the assistance of Agricultural extension officers which were trained as enumerators. Data collection was conducted from August-October 2016. A multistage sampling procedure was used to select specific locations for the study, moving from the district level to specific wards and later to specific villages and households. This technique was considered the most appropriate for this study because sampling frames where not available at district level. The first stage comprised of purposive selection of four districts (Mutoko, Goromonzi, Murehwa and Seke) out of the 9 districts in the study area. The selection of these districts was based on the intensity of smallholder farmers' vegetable production. The second stage was the selection of three wards in each district where communities are engaged in vegetable production to give a total of 12 wards. The selection of these wards was guided by information obtained from agricultural extension workers and Non-Governmental Organizations (NGOs) that were operating in the districts. Furthermore, accessibility of the area was another criteria which was considered in identifying these wards. The third stage involved use of cluster sampling to select three villages (clusters) in each of the three wards. Finally, at the village level simple random sampling was applied to select households based on the sampling frame provided by the village head.

2.3. Method of analysis

Collected data was coded and entered into Statistical Package for Social Scientists (SPSS) version 23 as well as Stata 15/SE software for analysis. Descriptive statistics and the Poisson count regression model (PCRM) were used to analyse data that was collected from smallholder vegetable farmers. The empirical model was used to identify factors affecting adoption of postharvest practices for value addition in the smallholder farmers' vegetable value chain. Frequency of use of various postharvest practices—that is, count of postharvest practices adopted by smallholder vegetable farmers was the dependent variable. Socio-economic factors (that include age, education), institutional arrangements and technical factors were determinants.

The dependent variable of the model (y) is the count number of postharvest practices adopted by farmers that is, y = 0, 1, 2, 3, . . . , N. Since we are interested in explaining the likelihood that the farmer will adopt more postharvest practices the Poisson model is used. The Poisson probability density function is represented in equation 1:

$$f(Y_i|X_i) = P(Y_i = y_i) = \frac{e^{\lambda}\lambda^{y}}{Y!} y = 0,1,2,3 \ldots \ldots \quad 1$$

Where;

y_i is the number of postharvest practices adopted by a farmer

X_i are determinants of postharvest practices adoption

The expected mean parameter λ of this probability function is defined as illustrated in equation 2:

$$E[Y_i|X_i] = \lambda_i = \exp(x_i'\beta) \ldots \ldots \quad 2$$

Where;

$\exp(x_i'\beta)$ is the incidence rate ratio (IRR) for a one-unit change in X_i with all other variables held constant

Equation (2) represents the Poisson regression model for count data wherein the β parameters can be estimated using the maximum likelihood procedure. This procedure is carried out by maximizing the log-likelihood function (Equation 3):

$$\ln(\beta) = ln\left[\frac{e^{\lambda}\lambda^{y}}{Y!}\right] = -\lambda + Y_i \ln(\lambda) - \ln(Y_i!) = -\exp(x_i'\beta) + Y_i(x_i'\beta) - \ln(Y_i!) \quad \text{..............................} \quad 3$$

The Poisson model assumes the mean and variance of the dependent variable to be equal; that is, $E(Y_i) = var(Y_i) = \lambda$. However, this assumption may not be realistic. The variance of y_i can be smaller (larger) than its expected mean which indicates under-dispersion (over-dispersion) in the count data. This will result in the over-estimation (underestimation) of standard errors, thereby giving biased and inconsistent estimates of the Poisson regression parameters. In most cases, the count data have greater variance than their mean. The negative binomial can accommodate the over-dispersion problem by modelling the variance as a function of the mean. The variance function for the negative binomial model (NBM) is specified as (Equation 4):

$$var(y_i) = \lambda_i + \alpha\lambda_i^2 \quad \text{.....................................} \quad 4$$

Where;

α is the dispersion parameter to be estimated.

The NBM will be the same as the Poisson regression if α equals zero. The estimation of the NBM involves the maximization of the following log-likelihood function expressed as (Equation 5):

$$\ln L(\alpha,\beta) = \sum_{i=0}^{n}\left\{\sum_{j=0}^{y_i=1} \ln(j+\alpha^{-1}) - \ln(Y_i!) - (Y_i+\alpha^{-1})\ln\left[1+\alpha\exp(x_i'\beta)\right] + Y_i ln\alpha + Y_i(x_i'\beta)\right\} \text{..........} 5$$

If the dispersion parameter α is known and the variance function is correctly specified, then the maximum-likelihood estimator for the NBM is robust to distributional misspecification (Cameron et al., 1988). On the other hand, if ά is unknown, the quasi-generalized pseudo maximum likelihood estimation can be made using a consistent estimator (Greene, 2005).

3. Results and discussion

3.1. Socio-economic characteristics of farmers

Table 1 summarized the descriptive statistics of the farmers' socio-economic characteristics in the study area. The table shows that the majority of households in the study area were male-headed (68.1%) and having at least attained some primary education, with all the household heads in the four districts having attained some primary education.

Table 1. Socio-economic characteristics of survey respondents

Variables	**District**								**All**	
	Seke		**Goromonzi**		**Murehwa**		**Mutoko**			
Observation (N)	**102**		**105**		**103**		**75**		**385**	
Gender of household head (%)										
Males	70.6%		56.2%		68.9%		80.0%		68.1%	
Females	29.4%		43.8%		31.1%		20.0%		31.9%	
Marital status (%)										
Married	76.5%		73.3%		75.7%		82.7%		76.6%	
Single	3.9%		2.9%		2.9%		0.0%		2.6%	
Divorced	2.0%		3.8%		4.9%		2.7%		3.4%	
Widowed	17.6%		20.0%		16.5%		14.7%		17.4%	
Education level (%)										
Primary education	41.2%		45.7%		47.6%		24.0%		40.8%	
Secondary education	56.9%		51.4%		52.4%		74.7%		57.7%	
Tertiary education	2.0%		2.9%		0.0%		1.3%		1.6%	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Age	50.31	11.94	54.20	15.61	48.91	12.93	44.69	9.42	49.90	13.25
Household size	5.78	2.14	5.07	3.35	5.50	1.90	6.32	1.65	5.62	2.43
Years in vegetable farming	19.85	12.35	25.74	16.21	14.35	10.42	10.69	6.53	18.16	13.38

SD= Standard Deviation

This could be attributed to the country's high literacy rate which is estimated at 96% (Zimstat, 2012b). Mutoko district had the highest proportion of farmers with post primary education (74.7%) followed by Seke (56.9%). However, a small proportion of vegetable farmers in Mashonaland East Province had attained some tertiary education (1.6%). Murehwa district did not even have any farmers who reported to have attained any tertiary education. According to Musasa et al. (2015) literacy level of smallholder farmers and middlemen is very important as it allows for better flow of product information and knowledge within the value chain. Therefore, more efforts still need to be done to provide tertiary education to vegetable farmers. The majority of interviewed vegetable farmers were married (76.6%). Mutoko district had most of the households heads being married (82.7%) followed by Seke district (76.5%) and the least was Goromonzi district (73.3%).

The average age of farmers varied among the surveyed districts, ranging from a mean of 45 years in Mutoko district to 54 years in Goromonzi district. The mean age of all districts combined was 50 years. Therefore, Mutoko district had youngest farmers with average age of 44.69 years, while Goromonzi district reported the highest average age of 54.20 years, thus making farmers in this district to be relatively old. The high concentration of young vegetable farmers in Mutoko district might be attributed to irrigation schemes which tend to be lucrative and profitable hence they attract young farmers. The average household size comprised about 6 individuals and on average the respondents had about 13 years of vegetable farming experience. The mean household size varied among the survey districts, Mutoko having the highest average household size than all other surveyed districts. The average household size obtained from the study is slightly higher than the average size of household obtained during the last census in 2012 which was 4.1 (Zimstat, 2012a). Hence, this might be attributed to the average rate of natural increase in the province over the years since the last census was conducted, 5 years ago.

3.2. Major vegetables produced by district

Table 2 below reveals that the three dominant vegetables which were cultivated in the survey area were: rape, covo and tomatoes, which were grown by 51.2%, 45.2% and 37.1% of the farmers across all the four districts respectively. Again, rape, covo and tomatoes were the three most predominant vegetables grown in Seke, Goromonzi and Murehwa districts. However, Mutoko exhibited a different trend, the three dominant vegetables were carrots, butternuts and cucumber which were being produced by 90.7%, 41.3% and 20 % of the farmers respectively. The different trend exhibited by Mutoko farmers can be explained by farmers in Chitora irrigation scheme mainly focusing on vegetables which fetch higher price on Mbare Musika the informal market were farmers trade most of their vegetable output. All the vegetables that were being produced were destined for the domestic market and there were none that were being exported.

3.3. Main causes of vegetable postharvest losses

Figure 2 below summarises information on main causes of postharvest losses obtained from vegetable production during the 2016 cropping season. The results indicate that the main causes of postharvest losses for rape, covo and tomatoes, the three dominant crops that were produced in Seke, Goromonzi and Murehwa districts are pests and diseases. According to the result (Figure 2) majority of farmers (about 90 %) responded that pests and diseases were the major cause of high levels of postharvest losses in tomatoes. Factors such as decay and rough handling were mentioned as the second and third major causes of postharvest losses respectively by farmers in rape, covo and tomato production. The reason for high volumes of vegetables which decay (rot) can be ascribed to non-availability of buyers, and poor or no storage facilities in the study area.

Table 2. Most cultivated vegetables in the four districts

Crop	% of smallholder farmers growing vegetable				
	Seke	**Goromonzi**	**Murehwa**	**Mutoko**	**Average % across all districts**
Rape	67.6	51.4	68.0	5.3	51.2
Tomatoes	40.2	61.0	35.9	1.3	37.1
Cabbage	2.9	1.0	1.0	0	1.3
Potatoes	5.9	1.9	4.9	0	3.4
Onions	23.5	9.6	18.4	0	13.8
Covo	75.5	50.5	34.0	12.0	45.2
Carrots	6.9	0	1	90.7	19.7
Butternut	0	3.8	5.8	41.3	10.6
Sweet potato	7.8	20.0	12.6	0	10.9
Cucumber	2.0	2.9	4.9	20.0	6.5
Green beans	0	0	0	18.7	3.6

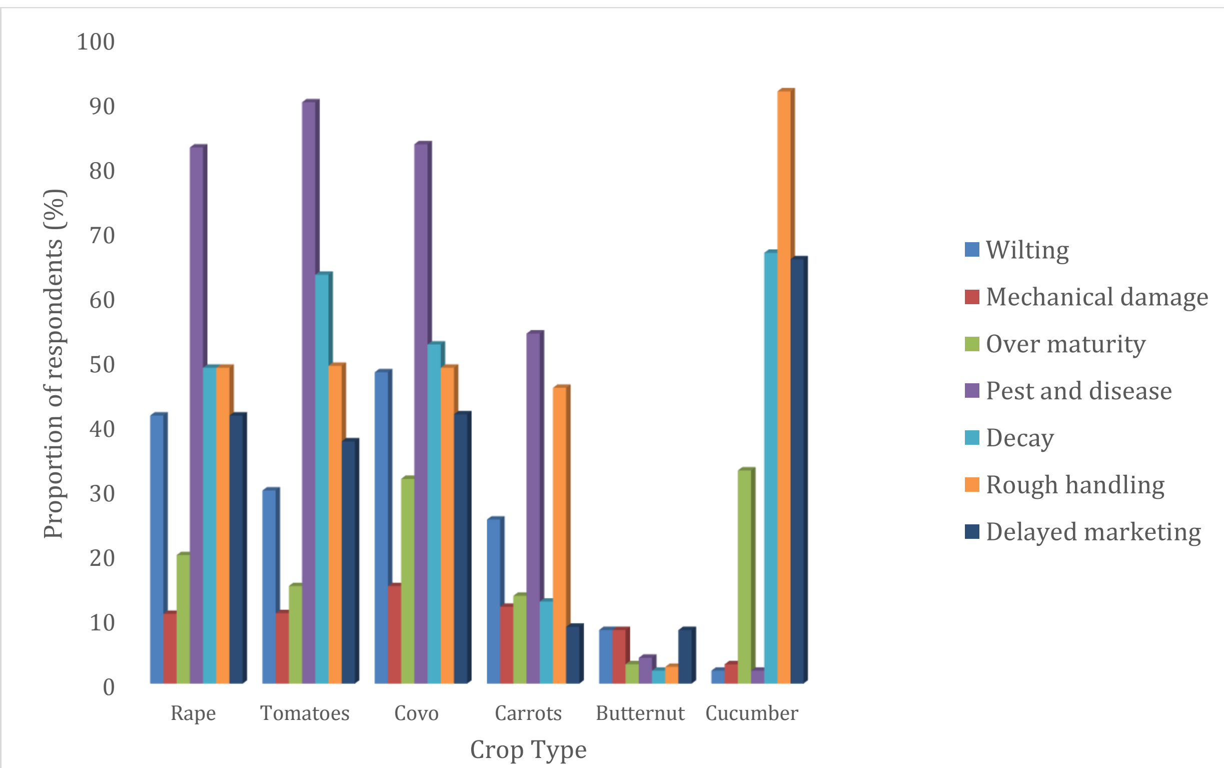

Figure 1. Main causes of vegetable postharvest losses

Table 3. Coefficient estimates and marginal effects of the PCRM for rape, covo and tomatoes

e			Covo						Tomatoes					
Marginal effects			Poisson estimates			Marginal effects			Poisson estimates			Marginal effects		
dy/dx	Std. Err.	P>|z|	Coef.	Std. Err.	P>|z|	dy/dx	Std. Err.	P>|z|	Coef.	Std. Err.	P>|z|	dy/dx	Std. Err.	P>|z|
0.0674	0.0442	0.127	1.1765	0.7093	0.097*	0.0514	0.0361	0.154	1.3942	0.5977	0.020**	0.0120	1.8932	0.995
0.0007	0.0481	0.988	1.6770	0.8228	0.042**	0.0733	0.0416	0.078*	0.0410	0.6542	0.950	0.0003	0.0560	0.995
0.0344	0.0134	0.010**	0.2486	0.1432	0.083*	0.0108	0.0085	0.201	-0.0610	0.1382	0.659	-0.0005	0.0828	0.995
0.0049	0.0025	0.050*	-0.0081	0.0304	0.790	-0.0003	0.0013	0.786	-0.0138	0.0276	0.616	-0.0001	0.0188	0.995
- 0.0022	0.0020	0.266	0.0672	0.0310	0.030**	0.0029	0.0018	0.109	0.0102	0.0222	0.645	0.0001	0.0139	0.995
- 0.0096	0.0156	0.536	-0.0785	0.2225	0.724	-0.0034	0.0092	0.711	-0.0534	0.0626	0.394	-0.0004	0.0725	0.995
0.0004	0.0008	0.592	-0.0074	0.0098	0.454	-0.0003	0.0004	0.446	-0.0277	0.0119	0.020**	-0.0002	0.0377	0.995
0.1428	0.0711	0.045**	-0.1909	0.7489	0.799	-0.0083	0.0330	0.800	-16.9971	2090.38	0.994	-0.1462	5.0893	0.977
- 0.0376	0.0216	0.082*	-0.1728	0.2558	0.499	-0.0075	0.0125	0.547	0.0451	0.2509	0.857	0.0004	0.0613	0.995
- 0.1194	0.0681	0.080*	-2.1481	1.2261	0.080*	-0.0940	0.0483	0.052*	1.8630	1.1802	0.114	0.0160	2.5297	0.995
- 0.2048	0.0884	0.021**	-1.0492	0.7845	0.181	-0.0459	0.0416	0.270	-0.2047	0.4805	0.6700	-0.0017	0.2779	0.995
0.0370	0.0453	0.415	-1.0946	0.8067	0.175	-0.0479	0.0411	0.245	-1.0844	0.8983	0.227	-0.0093	1.4724	0.995
			3.2681	3.7367	0.382				17.3837	2090.384	0.993			
			106						106					
			43.32						46.27					
			0.0009						0.0000					
			0.5098						0.4896					
			- 37.1241						-34.5465					

probability levels respectively

Problems related to rough handling as a cause for postharvest losses in cucumber production was stated by about 91% of the respondents. Post-harvest loss and quality deterioration of vegetables in the study area occurred due to lack of chemicals to control pests and diseases, decay, rough handling emanating from poor harvesting and handling techniques as well as delayed marketing. In addition, market flooding resulting from producing similar type of vegetables at the same time affected the market value.

3.4. Poisson count regression model results

Analysis of factors influencing number of postharvest techniques adopted by smallholder vegetable farmers was done using the Poisson count regression model (PCRM).The results of the Poisson count regression model (PCRM) for rape, covo and tomatoes are shown in Table 3 below. One assumption of the Poisson count regression model is that the mean and variance of the dependent variable are equal. Therefore, this gives rise for the need for a hypothesis test for over-dispersion using the Negative binomial model (NBM) to determine the most appropriate model to use (Mariano et al., 2012). However, in this instance both the PCRM and the NBM have the same likelihood ratio, hence the hypothesis that alpha is equal to zero is not rejected. Thus the estimated coefficients of the PCRM and the NBM are the same. Hence, only the results of the PCRM are discussed since it suits the data best. Furthermore, the likelihood ratio value shows that the model, as a whole, is highly significant (1% level). For rape production 7 out of 12 variables where statistically significant, at 10% level. Also for covo production 5 out of 12 variables where statistically significant, and lastly for tomato 2 out of 12 variables where statistically significant, at 10% level.

Gender of household head was found to significantly influence number of postharvest practices adopted by farmers across all the three vegetables mainly grown in the study area. It was positive and statistically significant at 10% level for both rape and covo production, while it was positive and significant at 5% level for tomato production. The marginal effect results suggest that female headed households will adopt one unit more postharvest practices than their male counterparts. The probable explanation for this is that postharvest practices mainly adopted in the study area such as washing, drying and grading are associated with female activities. For example drying entails slicing, washing, boiling of the vegetables and eventually drying them on an open surface. Gender roles in the study area dictates that such kind of activities are mainly undertaken by women. For that reason males were more likely to refrain from participating in such kind of basic postharvest activities. As such females adopted these low cost and uncomplicated postharvest practices such as grading, washing, drying etc. in Mashonaland East Province. Similar comparable findings were established by Abdul-Hanan et al. (2014) that there tend to be a positive relationship between gender and adoption of techniques. Females tend to embrace adoption of uncomplicated techniques whilst their male counterparts prefer adoption of complicated techniques.

Educational level proved to be one of the factors that positively influence adoption of postharvest techniques by smallholder covo farmers. The estimated marginal effect of education shows that the probability of engaging in postharvest practices for value addition increases by 0.073 in covo production for a 1 year increase in formal schooling. Hence, as expected farmers with high literacy levels had better information about postharvest practices in the study area compared to those who were less educated. The implied message is that as education level increases farmers are likely to embrace the importance of engaging in postharvest practices for value addition. It is envisaged that engaging in these practices is likely to increase income of covo in the output market. In most cases, it was old farmers who had attained minimal basic primary education and they would rely mainly on their traditional knowledge on postharvest management and marketing of their vegetables. Such kind of farmers where likely to find it very difficult to deal with unscrupulous middlemen in the output market as well as having proper strategies to deal with postharvest losses. Similar comparable studies reached the same findings that smallholder vegetable farmers with high education levels have better postharvest management strategies and interpret market information better (Ali, 2012; Musasa et al., 2015). Further, the results concur with several studies which argue that more educated farmers have greater probability of adopting techniques compared to their less educated counterparts (Doss & Morris, 2001; Foltz, 2003).

As expected *household size* increase the number of postharvest practices adopted by vegetable farmers. Household size coefficient was positive and statistically significant at 1% and at 5% level for rape and covo production respectively. This is because for the majority of smallholder farmers in Mashonaland East Province family labour was the major source of labour since they lacked resources to employ hired labour. As such, large family sizes in the area were able to avail labour for postharvest value addition practices such as grading, washing and packaging. Furthermore, large household sizes were also able to offer additional labour to farmers during times when there was high competition for labour with other farming activities such as planting, weeding and harvesting of other crops in the study area. This is because the dominant postharvest practices adopted in the study area such as washing, grading and drying were labour intensive. These findings are consistent with several previous studies which suggest that household size plays a significant role in production and marketing of vegetables by smallholder farmers (Ali, 2012; Bindu & Chigusiwa, 2013; Sebatta et al., 2015). As such it minimises costs that might be incurred through hiring labour for undertaking rigorous value addition activities.

Results of the survey shows that *age* was positively associated with adoption of postharvest practices at 5% significance level for rape production. The rationale is that as the farmer gain more experience with increasing age, they may become more aware of the importance of adopting postharvest practices in rape production. While on the other hand, young farmers might be lacking experience and appreciation of the importance of the primary postharvest techniques in rape production. Previous findings by Ramirez and Shultz, (2000) confirm the same that age and experience have a positive influence on adoption of technologies. In their study they found out that a 53-year-old farmer with 21 years of farming experience was three times likely to adopt integrated pest management technologies in Central America in comparison to a 38 year old farmer with only 10 years of farming experience. These findings tend to suggest that there is need to educate the youth about the importance of postharvest techniques. This might assist in improving smallholder farmers' production and marketing of vegetables in Mashonaland East Province of Zimbabwe.

The coefficient of *farming experience* was positive and statistically significant at 5% level for covo production. The positive coefficient for covo production imply that as farmers gain more experience they are more likely to adopt postharvest practices for value addition. Experienced farmers appreciated the importance of engaging in postharvest practices for value addition in the output market compared with farmers with less experience. These results are consistent with the findings of Gido et al. (2015) that farming experience positively influence farmers' decision making. This is based on acquired knowledge from extension services over the years as well as their own personal experiences. It could also be that experienced farmers might have acquired more resources over time. Hence, they might be having higher output of vegetables compared with less experienced farmers which will eventually compel them to engage in postharvest practices for value addition. Furthermore, similar comparable results were found by Mutayoba and Ngaruko, (2015) that farmers experience increase quality and quantity of vegetables produced. Additionally, experience gives farmers bargaining power as well as improve their marketing networks. Again, a similar study conducted by Al-Shadiadeh et al. (2012) showed that farming experience had positive and statistically significant effect on influencing farmers' decision to adopt postharvest practices in vegetable production. Results of this survey may provide evidence for the need to train farmers on postharvest handling techniques as well as production of higher value horticultural crops. To this end, trainings and extension advice can be designed targeting less experienced farmers for them to adopt postharvest techniques which can improve their vegetable production and marketing strategies.

Distance to the market negatively and significantly influences adoption of postharvest techniques by smallholder tomato farmers at 5% significance level. This means that as distance to the market increases, adoption of postharvest techniques by smallholder tomato farmers' decrease. The rationale of these findings is that smallholder tomato farmers in the study area get discouraged to adopt postharvest techniques as market distance increases. This is because most farmers in the absence of markets would target local informal markets where post-harvest value addition has minimum relevance. These findings are consistent with comparable earlier studies which suggest that longer distances negatively influences smallholder farmers' participation in markets and subsequently adoption of techniques (Jari & Fraser, 2009; Siziba et al., 2011; Mariano et al., 2012). Results of this present study tend to suggest that reducing distance to market might improve tomato production as well as adoption of postharvest techniques in the study area.

As expected *market information* was positive and statistically significant at 5% level for rape production. The result suggest that an increase in access to market information by rape farmers leads to increasing engagement in postharvest practices for value addition. A probable explanation in this present study is that access to market information may be revealing that basic post harvesting practices increase farmers profit for rape in their current marketing channels. Thus, the implied message from these findings is that selling partially value added rape offer significant profit returns in Mashonaland East Province hence it is worth venturing into such basic postharvest techniques. These findings are in line with similar comparable study by Ali, (2012) which established that availing of market information plays a significant role in influencing smallholder vegetable farmers' adoption of postharvest techniques.

In this study, the coefficient of *group membership* was negative and statistically significant at 5% level. This implies that group membership had a negative influence on adoption of postharvest practices for rape farmers than those farmers who were working individually. These findings are contrary to those of Abdul-Hanan et al. (2014) who argue that there is a positive influence on technology adoption by farmers who belong to farmer groups than those who do not. Similar sentiments are echoed by conventional wisdom in literature that farmers who are group members are more likely to be involved in value addition practices compared to their individual counter parts (Berem et al., 2010; Orinda, 2013). This is because groups may have better access to credit, equipment, training, technical advice and benefit from collective marketing which individual farmers lack hence promoting value addition. Furthermore, according to Markelova et al. (2009) in addition to filling in the gaps created by market imperfections, collective action can open up new marketing opportunities for smallholder farmers by introducing innovations to existing value chains or creating entry ways into new markets. Nonetheless, a negative coefficient found in this study is not surprising given the history of failure of farmer groups in Zimbabwe as stated by various scholars (Stringfellow et al., 1997; Masakure & Henson, 2005; Zivenge & Karavina, 2012). Moreover, social cohesion and networking may have revealed to them that value addition to rape is unprofitable compared to those farmers who work individually and use conventional wisdom in thinking that value addition is always profitable.

Access to credit was significant at 10% level of significance, for both rape and covo production. It showed a negative influence on adoption of postharvest techniques. This is inconsistent with the findings of Mariano et al., (2012) and Abdul-Hanan et al., (2014) who maintains that access to credit is an important factor in adoption of techniques by smallholder farmers. However, this result is not surprising because only a very small proportion of farmers in the study area were having access to credit. Moreover, the majority of them were located in Mutoko district mainly in the irrigation schemes. Besides, the majority of these smallholder farmers in irrigation schemes were producing vegetables such as carrots, butternuts and cucumbers which experience minimal postharvest losses. Hence, the results tend to suggest that there is an inclination to move away from conventional leafy vegetables such as covo and rape and switch towards high value crops with increasing access to credit. Pursuing this further, because credit comes at a cost such as interest rates, farmers may have realised that acquiring credit for postharvest practices of rape and covo may be unprofitable. As such they would rather acquire credit for high value field crops such as tobacco.

Hired labour had a negative coefficient and statistically significant at 1% level of probability for rape production. The negative coefficient of hired labour imply that smallholder farmers find it unprofitable to hire additional labour to engage in postharvest practices of rape. As such they just utilise available family labour as confirmed by a positive and statistically significant coefficient of household size. The marginal effects shows that as hired labour increases the possibility of adopting postharvest practices decrease by 0.20. A possible explanation could be that hired labour is channelled to other competing agricultural enterprises rather than rape postharvest practices. These findings are also consistent with those of Sebatta et al. (2015) that bigger household sizes supply the required labour for value addition activities, thus reducing the need for hired labour to undertake postharvest practices.

4. Conclusions and recommendations

Results of the study have shown that smallholder farmers in the study area, mainly cultivate three major vegetables which are rape, covo and tomatoes. With the exception of tomatoes, rape and covo do not fetch higher prices on the output market. In view of that, there is need for farmers to diversify their production to other high value vegetables which fetch higher prices on the output market. Furthermore, pests and diseases, followed by decay were identified as the main causes of postharvest losses across all major vegetables predominantly cultivated in the study area. Largely most of the underlying causes of huge postharvest losses are within the control of the farmer. As such, strategies which enhance postharvest management can result in substantial reduction in losses which can increase farmers' income without necessarily expanding land under cultivation. Hence, the need by government and NGOs to invest in training of farmers about identification and control of pests and diseases as well as proper crop rotation methods and other postharvest management strategies are recommended. The results of the PCRM revealed that the following variables were significant in influencing number of postharvest practices adopted by smallholder rape growers: gender, household size, age, market information, group membership, credit and hired labour. Similarly, the significant variables influencing number of postharvest practices adopted by smallholder covo growers were: gender, education, household size, farming experience and credit. In the same way, the two variables that were influencing number of postharvest practices adopted by smallholder tomato farmers were: gender and distance to market. Thus, concerted efforts through public private partnerships (PPP) to provide active extension about postharvest education is required. This will promote adoption of simple, uncomplicated and innovative low cost technologies particularly by women. Such kind of training should be complemented by providing market information on crops such as rape, covo and tomatoes. Furthermore, agribusiness companies should assist in designing postharvest technologies that mirror adoption patterns of smallholder farmers. Thus, they have to suit local conditions. Overall, such kind of policies will go a long way in reducing smallholder vegetable farmers' postharvest losses.

However, the study was limited by the following factors: budgetary constraints and time restrictions resulted in the study just being conducted in only one province of Zimbabwe. Hence, other scholars can also expand the research and investigate postharvest losses along the marketing value chain of fruits in other parts of the country such as Manicaland Province where there is also a high concentration of smallholder farmers engaged in horticulture production. In the same way, future studies that explore potential ways in which the country's horticulture sector can be resuscitated to produce for export markets are important. This is important given the fact that the sector experienced massive contraction towards its contribution to the country's Gross Domestic Product (GDP) following the fast track land reform programme. Additionally, there is need for studies that focus on methods that accurately estimate postharvest losses of smallholder horticulture farmers' in the country specifically and the entire continent at large. Review of literature thus far has shown that currently such kind of studies are scanty.

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