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Effects of selected drivers of information and communication on awareness and perception of tomato post-harvest loss-reduction technologies in Kaduna, Nigeria

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Abstract

The Nigerian government's policy on agriculture has supported productivity enhancements among smallholder farmers, yet tomato production is constrained by post-harvest losses leading to over 45 % (750,000 metric tons) loss. Various initiatives are constantly being introduced to make technologies and practices available to reduce these losses. This study was carried out to determine the level of awareness and perception of four technologies. A total of 420 tomato farmers were selected in Kaduna State, Nigeria. Awareness and perception were modelled using the Multivariate Probit Model. The results showed that one or more of the independent variables including cooperative affiliation (p<0.001, for awareness of Reusable Plastic Crate {RP} technique), frequency of extension visit (p<0.001, for awareness of RP), and farm area cultivated (p<0.05, for awareness of Refrigerated Truck {RT}/ Machine Drying {MD}) were significant. For perception, some of the independent variables explored and found significant included multiple sources of information for CS/RT, losses through transit/storage (P<0.01) and the number of technologies adopted (P<0.001) for cheapness; credit access (P<0.001) and farm area (P<0.001) for availability; marital status (P<0.01) and losses through storage (P<0.021) for labour saving perceptions. The awareness and perception of the tomato PHL reduction technologies do not provide common determinants. The study concluded that the communication channels such as Farmer to Farmer, Radio and extension agents (57.9%, 9.3%, 33% for RP, respectively), among others, influenced awareness of the new technologies among farmers. The study recommends the need to drive farmers' awareness using suitable advocacy channels. A better understanding of constraints that influence farmers' perceptions is important while designing and rolling out technologies.

Keywords: *Adoption; Awareness; Multivariate; Post-harvest losses; Probit Model; perception; Technologies*

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Introduction

Food losses have attained increased attention in recent times globally with an estimate of about 1.3 billion tons being lost each year (Gustavsson *et al.*, 2014). Postharvest losses (PHLs) account for significant amounts of global food loss (De Lucia and Assennato, 2006; Kitinoja *et al.*, 2011; Parfit *et* *al.,* 2010). In 2021, agriculture contributed around 23.36 % to Nigeria's GDP (Statistica, 2022), yet over 45 % (750,000 metric tons) of tomatoes produced in Nigeria is lost through post-harvest activities, and the country still relies on imports (FAOSTAT, 2016; and Ashinya *et al.,* 2021). Although inadequate infrastructure and socio-economic constraints are suggested to limit the adoption of proven post-harvest technologies that would have curbed losses, lack of uniform information on the extent of PHLs, major sources of PHLs and methods for assessment of PHLs further constrain the situation.

Tomato (*Solanum Lycopersicum*) is a major vegetable crop that has achieved tremendous popularity over the last century (Wener, 2000). It is an important vegetable crop in Nigeria accounting for 18% of the daily consumed vegetables, and also the leading producer in Sub-Saharan Africa (Ugonna *et al.,* 2015). Despite this global and regional status in tomato production, the country still imports tomatoes in form of pastes costing over US$ 170 million, to meet its demands (Edeh, 2017). Nigeria is constrained by tomato PHLs, mostly for rain-fed farming, pests and disease incidence and many other factors (Adenuga *et al.,* 2013; Arah *et al.,* 2015).

Adoption and use of post-harvest technologies could play a dominant role in PHL reduction, not only for tomato crops but also for other crops (Kebeney *et al*., 2015). Farmers will adopt technologies they have pre-existing knowledge of or information about, and information access could also lead to the dis-adoption of the technologies. Farmers get access to information about technology from regular contact with extension agencies, which tends to have a positive relationship with deciding to adopt certain technologies or practices (Tesfaye *et al*., 2001; Habtemariam, (2004). Nguezet *et al.,* (2013) found for example that farmers with better access to extension services have a higher rate of adopting the NERICA rice varieties.

In Kaduna State, the main driver of information and creating awareness for farmers is the extension services. In Nigeria, agricultural extension services have been dominated by Agricultural Development Programs (ADPs) based in each of the 36 states and the Federal Capital Territory since the mid-1970s (Ahmed and Adisa, 2017). However, due to the low quality of service provision through ADPs, in the last 25 years, extension services have been provided by a variety of public, commercial, and voluntary agencies with diverse objectives (NAERLS and FDAE, 2017). The Nigerian extension service, inclusive of Kaduna State, faces numerous challenges such as poor capacity, and knowledge of local personnel, weak agricultural research extension linkages, inadequate input supply, limitation of knowledge about agricultural policies and regulations and limited success stories from farmers or adopters (Ajala *et al.,* 2013; Issa and Adiyu, 2020).

The specific objective of this study, therefore, was to analyse the effects of selected drivers of information and communication on awareness and perception of tomato post-harvest loss-reduction technologies.

Materials and Methods

Study Area

Kaduna State in Nigeria was selected for this study and the choice of this area is anchored on tomato as a key and important crop produced in the area while also being the highest producing state in the country, at 3.6 million metric tonnes annually (National Bureau of Statistics, 2012). The location was also selected based on a study carried out by The Global Alliance for Improved Nutrition (GAIN) GEMS4, (2016) which mapped out the tomato production states with data on the production level, number of farmers and clusters, and level of wastages. The mapping was implemented through enumerators' visits to major tomato-producing locations in twelve states, all in northern Nigeria, where farmers were interviewed, and cluster locations were captured via a global positioning system (GPS). Kaduna State is in the North-West Zone of Nigeria, according to the six geo-political zonal classifications of the country, with Sudan-Savannah vegetative cover comprising of grasses, short trees, and little shrubs. Four Local Government Areas (LGAs) - Soba, Kudan, Zaria, and Makarfi were selected by random sampling (LGAs with less than 4 farming clusters were excluded from the sampling scheme. The target population of the study was tomato farmers in Nigeria, while the accessible population were tomato farmers in Kaduna State in Nigeria.

Sampling procedure and sample size

Respondents for the study were selected using a multistage sampling technique. The initial step was the purposive selection of Kaduna State location which was based on its volume of tomato production output which stands highest in the country. Then the first stage of sampling was the selection of four Local Government Areas (LGAs) by simple random sampling within the state. The second stage of sampling was the selection of three clusters (villages) within each selected LGA, again by simple random sampling. A cluster (aggregation of rural farmers) is a settlement around low-lying land that is subject to seasonal flooding or waterlogging along the riverbanks, streams, or depressions with favourable agro-environment and ecological conditions, especially for dry-season farming. (Cluster groups often are the creation of national or regional governments and donor agencies, to organise rural farmers into settlements for purpose of target market and outreach service delivery). Equal sampling allocation was done at the cluster level to select 35 farmers (farming households) from each selected cluster, at random; and this constituted the third stage of the sampling process. (Equal sampling allocation was done at the cluster level as the cluster populations were nearly uniform.) Hence, the sample in this study is deemed as an adequate representation of the tomato farmers' population in Kaduna State for valid extrapolation of the result obtained to the entire State.

Mapping of the clusters, farm settlements and villages for the study was done with the help of community leaders, Extension Agents, and local guides in selected LGAs, to select the required number of villages. Sometimes farmers rotate crops due to market and economic forces (for example, if there was a glut in tomatoes, a farmer could move to rice farming the next season or vice versa). Tomato farmer's association(s) and/or cooperative society leaders were visited and interviewed, and through their membership registers a frame of farmers engaged majorly in tomato farming was constructed for the selected clusters and from which the sample of farmers or farming households were selected. The Global Positioning System (GPS) set was used to record the coordinates of the interview point or homestead of each farmer for reference purposes and ease of location (Figure 1).

According to data from surveys done by GEMS4 (2016), there are 82,000 (approximately) tomato farmers in Kaduna State, spread across 47 clusters (communities) in 11 Local Government Areas (LGAs), with approximately 1,745 farmer households per cluster on average. To get the sample size, the Yamane formula (1973**)** was used with a confidence interval of 95% and an estimated error of 5%.

$$n = \frac{N}{1+Ne^2}$$

Where n=sample size

N=population of the study; *(N=81,920)*

e=margin of error (0.05)

(n = 399 minimum)

A 3-stage sampling procedure was applied to obtain a valid and representative spread, comprising a sample of 4 LGAs, and 3 clusters per LGA (that's a total of 12 clusters in the sample.)

With the equal sampling allocation at the cluster level, the sample taken per cluster was approximately 34 (399/12 clusters = 33.25); while the total in the sample was 408 (34 x 12 clusters) farmers. Therefore, the study comprised a theoretical sample of 408 farmers at the household level, however, 420 farming households (35 per cluster) were sampled and interviewed.

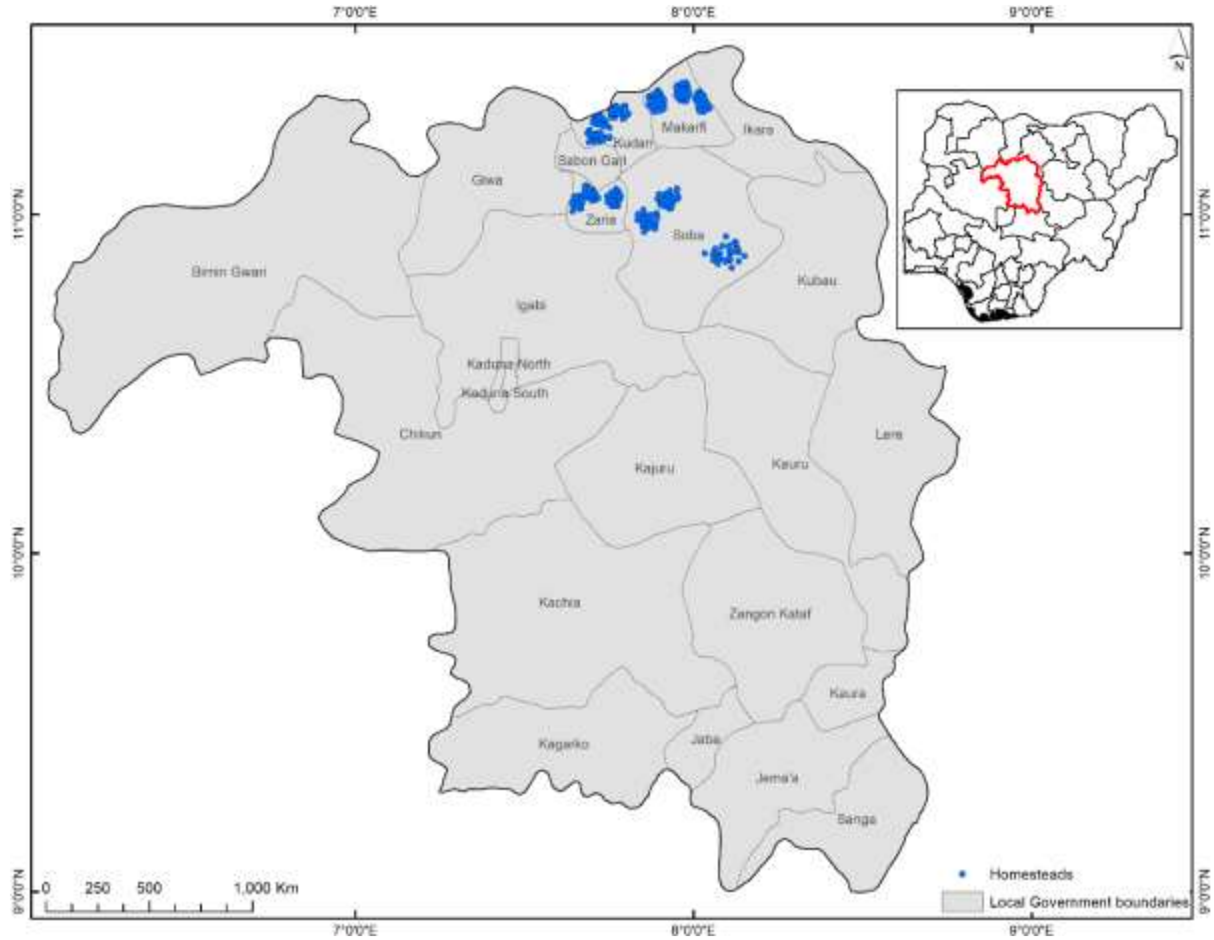

Figure 1. Map of Kaduna, Nigeria showing the study areas and respondent locations.

Data Collection

Following the satisfaction that survey instruments were well-validated, tested and migrated to the appropriate collection apparatus (print format), it was then administered to the sampled tomato farmers with the aid of two field research assistants and some local guides. The respondents predominantly speak the Hausa language; therefore, the research assistants and guides were selected based on their local language proficiency. The research assistants received training to familiarize themselves with the survey instruments, and how to administer contingent valuation questions, to avoid structural, content and administration biases. The pre-testing was done on 15 respondent farmers outside the study area, and this helped to improve the questionnaire instruments and survey strategy to obtain quality results. On arrival at these villages, the village heads were consulted seeking their support in identifying these farmers and their households.

Validation of the questionnaire content was done by relevant supervisors and experts to scrutinize and assess the relevance of the questionnaire to the objectives of the research.

The questionnaire was administered through face-to-face interviews with the heads of farming households. The selected farmers were briefed about the purpose of the study, and permission was sought; the survey questionnaires were administered using the farmers' indigenous language and collected successfully. (There were no objections from farmers experienced as we had the permission of the village heads transmitted through familiar local guides.)

The survey collected information on various demographic, socioeconomic and farm characteristics (including farm-holding, landtenure, farm practices, farm inputs, labour-use, on-farm/off-farm income); postharvest loss-reduction technology attributes (including awareness, knowledge, adoption and limitations); extension-service exposure, access to cooperative and/or commercial credit; ownership of a range of household and farm assets; handling, transport and marketing of produce; livestock farming/holding; etc.

Data handling and analysis

After data collection using hard print questionnaires, the filled questionnaires were sorted and their data entered appropriately into Microsoft Excel spreadsheets followed by data checking and corrections for coding and entry errors. Data analysis was done using the Statistical Package for Social Sciences (SPSS version 22 software) for descriptive statistics, and Stata version 13 for econometric analysis. A Preliminary summary analysis was done using the frequency procedure to show the data overview and sent to supervisors for validation. Descriptive statistics were used to characterize the farmers, their farms, and their socioeconomic profiles where necessary. In addition, econometric models were used to determine factors influencing awareness and perception of the technologies under investigation. Four PHL-reducing technologies were investigated, namely Reusable plastic crates (RP), Cold Storage Chamber (CS), Refrigerated Truck (RT), Machine Drying (MD) and

Chemical Disinfectant (CD). The awareness of the technologies of each of the farmers was determined using the Multivariate Probit Model (MVP) with the hypothesis tested as follows:

***H*o**: No relationship exists between selected drivers of information and communication on the awareness and perception of tomato post-harvest loss-reduction technologies.

In the same vein perception of farmers on how effective, less costly, how easier to operate, and how less labour demand with other characteristics of modern technologies is compared to conventional/traditional storage methods. (Significant differences were evaluated at $p < 0.10$ or 10% alpha level of significance so as not the overlook potentially important effects.) The model is as presented below:

Multivariate Probit Model (MVP) for determining Factors Influencing Farmers' Awareness and Perception of the Technologies

The MVP is a binary response regression model used to estimate both the observed and unobserved influence on dependent variables of several independent variables simultaneously, which permits error terms to correlate freely (Wosene *et al*., 2018).

According to Belderbos *et al*., (2004), the MVP takes such correlations into account. If a correlation exists, the estimates of separate (probit) equations for the cooperation decisions are inefficient, therefore the model according to Greene (2012) was used.

An MVP model is useful for jointly estimating several correlated binary outcomes. In contrast, the ordinary probit model considers only one binary dependent variable (Kassie *et al*., 2015; Belderbos *et al*. 2004). The MVP model, therefore, helps to overcome problems or weaknesses associated with the univariate probit model (Dougherty, 2011; Cappellari and Jenkins, 2003). The general specification for the MVP (Green 2012; Lorenzo and Stephen 2003) is –

$$Y_{im} = \beta'_m X_{im} + \varepsilon_{im}, m = 1, \ldots, M$$

$$Y_{im} = 1 \; if \; y^*_{im} > 0 \; and \; 0 \; otherwise \quad \text{--}1$$

Where, $\varepsilon_{im}, m = 1, \ldots M$ are error terms distributed as multivariate normal, each with a mean of zero, and variance-covariance matrix V, where V has values of 1 on the leading diagonal and correlations $\rho_{jk} = \rho_{kj}$

$Y_{im}*$ is a dormant variable that relates to the type of practice. Y_{im} are manifest binary variables that specify whether a farmer used a particular technology to predict the relative combination of factors influencing the probability of awareness of mixed technologies. The explicit form of the function is specified as follows:

For Awareness

$$Y_{ij} = \beta_0 + \beta_1 Market + \beta_2 Cooperative + \beta_3 Extension\_Visit + \beta_4 Farm\_Area + \beta_5 Radio + \beta_6 PHL\_Farm + \beta_7 PHL\_Transport + \beta_8 PHL\_Storage + \beta_9 Farming\_Experience + \beta_{10} Nonfarm\_Income + \beta_{11} Area\_Cultivated + \beta_{12} Multi\_Techs \quad \text{--}2$$

For perception

$$Y_{ij} = \beta_0 + \beta_1 CS_{awareT} + \beta_2 RP_{awareT} + \beta_3 RT_{awareT} + \beta_4 MD_{awareT} + \beta_5 Extension + \beta_6 Credit + \beta_7 MaritalS + \beta_8 FExperience + \beta_9 Education + \cdots \text{-----------}3$$

Results

Socioeconomic Characteristics of the Farming Households

Table 1 presents the socioeconomic characteristics of the farming households. Results show that the average age of head of household was 42.5 years, and the farming experience was 23.48 years on average. The household size was also estimated to be an average of 10 members. Many of the farmers (47.6%) belonged to cooperative societies with an average of 8 years of membership. Only a small percentage of the household heads had access to financial credit (14%), mainly sourced from cooperative societies. The result of this study also indicated that about 13.6% of the farmers were visited by extension agents at least once per month.

Multivariate Probit (MVP) Model for Awareness/Perception Determinants

Table 2 presents the meaning and hypothesized signs of the vector of explanatory variables. It also shows the dependent and independent variables for the MVP regression on awareness and perception. The rationale for the inclusion of these factors was based on previous agricultural technology diffusion and adoption literature and the analysis of these systems. The dependent variables for farmers' awareness of PHL-reducing technologies (Awareness) and farmers' subjective assessment of the following characteristics of the technologies (technology Perception) are - Cheapness of the technologies compared to traditional ones, how easy to operate are they, their availability and labour-saving potentials. The explanatory/independent variables included farmer, farm and institutional factors postulated to influence the choice of technologies.

Table 1. Socioeconomic Characteristics of Farm Households

Variables	Means	Mini	Maxi	Std. Dev.
Educational status (years)	4.74	0	16	4.67
Age of household head (years)	42.51	20	70	10.78
Farming experience (years)	23.48	4	45	10.17
Household size	9.95	3	20	3.72
Cooperative membership (years)	8.33	1	25	5.32
Frequency of extension visit	0.25	0	3	0.68
Farm Distance (Km)	9.61	1	45	7.86
Market distance (Km)	186.48	0	1000	213.92
Agricultural land (Acres)	6.02	1	40	5.12
Cultivated land (Acres)	5.77	1	40	4.78
Variables	**Percentage**			
Marital status (Married)	97.9			
Access to credit (Yes)	14.0			
Extension visit (Yes)	13.6			
Non-Farm Income (Yes)	46.4			
Cooperative membership (Yes)	47.6			
Well off (Yes)	46.4			
Above poverty line (Yes)	59.8			

Table 2. Multivariate Probit Model for Awareness/Perception Determinants

Variable Name	Nature of Variable	Unit(measurement)	Variable description	A priori signs
<u>Dependent Variable – Awareness</u>				
	Dummies	Aware = 1; Otherwise = 0	Awareness of PHL reduction technologies below: 1. Reusable Plastic Crates (RP) 2. Cold Storage Chambers (CS) 3. Refrigerated Truck/Vehicle (RT) 4. Machine Drying (MD)	
<u>Independent Variables – Awareness</u>				
Market distance (Km)	Continuous	Km	Longest distance from farmer's location to market	-
Cooperative	Dummy	Yes = 1; No = 0	Cooperative Membership	+
Extension_Visit	Categorical	Frequency of visit	Frequency of extension visit	+
Farm_Area	Continuous	Acres	Quantity of farm area owned	+
Radio	Dummy	Yes = 1; No = 0	Household owns radio	+
PHL_Farm	Dummy	Yes = 1; No = 0	Postharvest loss at farm level	+
PHL_Transport	Dummy	Yes = 1; No = 0	Postharvest loss during tomato transportation	+
PHL_Storage	Dummy	Yes = 1; No = 0	Postharvest loss during tomato storage	+
Dependent Variable				
Perception attributes	Dummies	Yes = 1; No = 0	Perception of farmers on PHL technologies on features below:	
		Cheap=1; 0=Otherwise	Cheapness	
		Easy to operate=1; 0=Otherwise	Easy to operate	
		Available=1; 0=Otherwise	Availability	
		Labour saving=1; 0=Otherwise	Labour saving	
Independent Variables – Perception				
CS_Information_Sources	Categorical	Frequency	No of information sources for CS	+
RP_Information_Sources	Categorical	Frequency	No of information sources for RP	+
RT_Information_Sources	Categorical	Frequency	No of information sources for RT	+
MD_Information_Sources	Categorical	Frequency	No of information sources for MD	+
Extension	Dummy	Visited = 1; Otherwise = 0	Did Extension agent visit the farmer's household?	+
Credit_Access	Dummy	Have access = 1; Otherwise = 0	Accessing of credit by farmers	+

PHL at farm	Dummy	Experience losses=1, Otherwise=0	A farmer experienced losses of tomatoes at farm level	±
PHL at transport	Dummy	Experience losses=1, Otherwise=0	A farmer experienced losses of tomato during its transportation	±
PHL at Storage	Dummy	Experience losses=1, Otherwise=0	A farmer experienced losses of tomatoes at storage	±
Cooperative membership	Dummy	A member = 1; Otherwise = 0	A member of a cooperative	+
Marital_Status	Dummy	Married= 1; Single= 0	Farmer that is ever married	±
Farming_Experience	Continuous	Years	Experience in tomato cultivation	±
Education	Continuous	Years	Years of education	+
NonFarm_Income	Dummy	Yes = 1; No = 0	Income from non-farm activities	+
Area_Cultivated	Continuous	Acres	Area of land a farmer cultivated	+
Multi_techs	Categorical	Numeric	Number of PHL technologies adopted	+

Farmers' Awareness and Perception of Tomato Post-Harvest Loss Reduction Technology

Based on the five tomato post-harvest technologies profiled, on average, about 40% of the farm households were aware of them (Table 3). For the technologies profiled, about 2.28% and 22% characterized it as being cheap and available, respectively, Among the technology characterized, reusable plastic crates (≤ 76%) and chemical disinfectants (> 90 %) had the highest rate of awareness. On the source of their knowledge or awareness of this technology, farmer-to-farmer played a greater role (32.24 %), and this was followed by NGOs (26.17 %) and Extension agents (20.76%) (Table 3).

Table 3. Awareness of PHL Reduction Technologies

Prioritized Technology	Awareness	Source					Characteristics	
		Farmer-to-farmer	Extension Agents	NGO or Dev. Agents	Radio_TV	Other sources	Cheaper	Readily available
Reusable plastic crates(RP)	319(75)	243(57.8)	137(32.62)	219(52.1)	39(9.29)	3(0.71)	31(7.38)	51(12.14)
Cold Storage Chamber (CS)	64(15.24)	17 (4.05)	24(5.71)	40(9.52)	10(2.38)	0(0)	1(0.24)	1(0.24)
Refrigerated Truck (RT)	25 (5.95)	5 (1.19)	10(2.38)	11(2.14)	7(1.67)	(0.48)	1(0.24)	2(0.48)
Machine Drying (MD)	14(3.33)	3 (0.71)	6(1.43)	3 (0.71)	6(1.43)	2(0.48)	(0.48)	2(0.48)
Chemical Disinfectant (CD)	419(99.76)	409(97.3)	259 (61.67)	279 (66.34)	53(12.62)	3 (0.71)	13(3.1)	406(96.67)

**Figures in parentheses indicate percent distribution*

Evaluation of Tomato Post-Harvest Management Technologies

As a way of understanding how the farmers perceived modern (improved) and traditional methods (use of raffia basket, non-refrigerated trucks, sun-drying, shed-storage among others.) of tomato production and post-harvest management, they were asked to assess both sets of technologies, and prioritize them based on six criteria (Table 4). The majority (≥ 99 %) prioritised modern technologies and agreed that they reduce post-harvest losses, while only about 10% responded that the traditional methods do reduce losses. On which set of technologies was cheaper, only 6.19 % assessed the modern technologies as being cheaper, and in comparison, the traditional methods had >90 % of respondents agreeing that they were cheaper to procure. The technologies were also prioritized based on their ease of operation and recorded were: modern technologies (80.5%) easy to operate, and traditional methods (84.5 %) easy to operate (Table 4). Availability was another characteristic of the assessment. Only ≤ 5% agreed that modern (or improved) technologies were readily available, while >90 % agreed that traditional methods were readily available. Considering the labour-saving implication of the technologies, the labour-saving attributes of the modern technologies were more prioritized (97.62%) by the respondents than the traditional methods (23.57%) as labour-saving. On average, the overall perception of using these technologies to satisfactorily mitigate losses was as follows: 99% for those prioritizing the improved modern technologies and 2.4% for those prioritizing the traditional methods (Table 4).

Table 4. Comparative Evaluation of Tomato Post-Harvest Management Technology Perception

	Modern (Improved) methods	**Traditional methods**
Criterion	**Yes**	**Yes**
Reducing losses	417 (99.29)	10 (2.38)
Cheaper	26 (6.19)	409 (97.38)
Easy to operate	338 (80.48)	355 (84.52)
Readily available	19 (4.52)	419 (99.76)
Labor-Saving	410 (97.62)	99 (23.57)
Overall Satisfaction	412 (98.1)	21 (5)

**Figures in parentheses indicate percentage distribution*

Multivariate Probit Regression Result on Awareness

Packages of PHL tomato-reducing technologies (PHLRT) were available but not all farmers knew about them, which necessitated determining drivers of awareness of such technologies. The awareness of technologies available for preventing tomato post-harvest losses was jointly estimated using the multivariate probit (MVP) model. The MVP model takes binary dependent variables that are correlated; in this paper awareness of 4 types of PHLRT technologies were considered. It was represented in the model as Y_1 for those households aware of RP, Y_2 for those aware of CS, Y_3 for those aware of RT, and Y_4 for those who are aware of machine drying (MD) technologies. The model result is presented in Table 5.

As depicted in Table 5 out of nine explanatory variables included in multivariate probit model, 3 variables significantly affected awareness of RP technology; 2 variables significantly affected CS technology; 4 variables significantly affected RT technology and 2 variables influenced awareness of MD technology at different levels of significance. The Multivariate probit model fitness was reasonably good and the explanatory power of the independent variables in the model is satisfactory as indicated by Wald chi2 - $\chi 2$ (36) = 105.99, Prob > chi2 = 0.0000, which is significant at less than 1% level. The model is significant because the null hypothesis that the awareness decision of the 4 tomato PHL-reducing technologies is independent was rejected at 1% significance level. The likelihood ratio test in the model chi2 (6) = 108.776; Prob > chi2 = 0.0000 indicates the null hypothesis that the independence between awareness choice decision (rho21 = rho31 = rho41 = rho32 = rho42 = rho43 = 0) is rejected at 1% significance level and there are significant joint correlations for 4 estimated coefficients across the equations in the models. This verifies that separate estimation of the choice decision of the awareness of different technologies is biased, and the decisions to choose the 4 awareness of the technologies are interdependent for farmers' decisions.

Thus, the use of MVP model is justified for capturing a wider effect than single probit models. The significant null likelihood ratio test for the joint MVP model suggests that the farmers are jointly aware of the technologies. The values of the computed marginal effects are found to be the same as the coefficient estimates (b) of the MPV models (Table 5).

One or more of the independent variables including cooperative affiliation, farm area cultivated, losses of produce in transit, frequency of extension visit, and radio ownership, among others, are found to significantly influence awareness of PHL technologies. Generally, the result shows that the awareness of the tomato PHL reduction technologies do not provide common determinants.

In the case of RP technology, variables that influenced its awareness with their level of significance included membership of cooperative ($P<0.001$) frequency of extension visit ($P<0.001$), and Farm area cultivated ($P<0.05$); only Farm area cultivated was negatively related to awareness of RP technology. In the case of CS technology, Farm area cultivated ($P<0.1$) and losses through transit ($P<0.05$) were the predictors. Extension visit ($P<0.1$), Farm area cultivated ($P<0.05$), Radio ownership ($P<0.05$) and losses through transit ($P<0.1$) influenced awareness for RT technology; only radio ownership was negatively significant. Area of land cultivated ($P<0.05$) and transport loss ($P<0.05$) influenced awareness of MD technology.

Multivariate Probit Regression Result on Perception

The multivariate probit model (MVP) was used to estimate several correlated binary outcomes jointly. In this study, the perception of tomato producers on "cheapness (1), Easy to operate (2), Availability (3), and labour saving (4)" attributes of PHL-reducing technologies are correlated. Since the decisions are binary, the MVP model was found to be appropriate for jointly predicting the perception of these four attributes on an individual-specific basis and the parameter estimates are simulated maximum likelihood (SML) estimators. Thus, an econometric approach was employed to test the effects of the explanatory variables on the perception of a particular technology feature. Wald Chi2, $\chi 2$ (56) =105.51, is statistically significant at 1% significance level (Table 6), which indicates that the subset of coefficients of the model is jointly significant, and the explanatory power of the variables included in the model is satisfactory and acceptable.

The results of the likelihood ratio test in the model showed that the likelihood ratio test of $\chi2(6) = 16.923$, Prob > $\chi2$(Chi2) = 0.0096 was statistically significant at 1% significance level, indicating the null hypothesis that farmers' perceptions of the four technological attributes/features were independent be rejected. That means the likelihood ratio test of the null hypothesis of independency between the perception decisions (rho21 = rho31 = rho41 = rho32 = rho42 = rho43 = 0) was significant at 1% level of precision, which shows the goodness of fit of MVP model. Therefore, the likelihood ratio test of independency indicated that there were different attribute choice behaviours among smallholder tomato producer farmers. In this study, samples were drawn 5 times to increase the accuracy, which indicates the precision level of the sample (Table 6).

The values of the computed marginal effects were the same as coefficient estimates (*b*). One or more of the independent variables including multiple sources of information for CS/RT/MD, losses through transit/storage, non-farm income, number of technologies adopted, farm experience, credit access, marital status and the land area cultivated by the household heads have been found to significantly influence the perception of PHL reducing technologies for tomatoes. Sources of information for MD technology, losses at farm level, and square of years of education were highly correlated with some variables as shown during diagnostic analysis using spearman correlation; they are therefore excluded from the model.

The rho (ρ) values (ρ_{ij}) indicate that the correlation of each dependent variables (attribute choices). The ρ21 (the correlation between the perception of Ease to Operate and Cheapness attributes), ρ31 (the correlation between the perception of Technology Availability and Cheapness attributes), ρ32 (the correlation between the perception of Technology Availability and Ease to Operate attributes) were positive and statistically significant at 10%, 1% and 5% levels, respectively. The result indicates that tomatoes farmers choosing 'Cheapness' as an attribute were more likely to choose 'Ease to Operate' and 'Machine Availability' features (Table 6), while those who choose 'Machine Availability' feature were more likely to choose 'Ease to Operate' feature; while ρ43 (the correlation between the perception of Labour saving and Availability attributes) was negative and significant at 10% probability level, meaning that farmers that choose 'Labour saving' feature were less likely to choose 'Availability' feature of the technologies. This indicates that the possibility of having joint perception choice by all farmers was very low as the farmers had different mix of perceptions. This evidence suggests that choosing the right mix of perception for different post-harvest reducing technology features would be determined by different factors/variables for each attribute. (Table of the correlations (ρ_{ij}) not shown.) Also, the estimates of correlations between the regression error terms were not significant, indicating model adequacy.

From Table 6, on cheapness of modern technologies, access to multiple sources of information for cold storage (CS_Information_Sources) showed significant ($p<0.01$) and positive influence on the perception of technologies being cheap. Farmers who experienced losses in both transport and storage have significant negative ($p<0.05$ and $p<0.10$, respectively) perception of technologies being cheap. Having non-farm income also influenced the farmers' cheapness perception of technologies ($p<0.10$) negatively. Farmers who acquired multiple technologies (Multi_techs) had very strong positive and significant perception ($p<0.01$) that PHL-reducing modern technologies were cheaper. On the ease of operation for modern technologies (Easy to operate), only one variable was significant. The relationship between farming experience and perception of easiness to operate is negative and significant ($p<0.10$). Also, the result showed negative coefficient ($p<0.05$) for farmers who experienced PHL at the farm level as they did not perceive these technologies 'easy to operate'. Perception of the 'Availability' attribute was influenced positively and significantly at 1% level of probability by information sources (RT_Information_Sources).

Table 5. Estimated Multivariate Probit Model for Factors Influencing Awareness of Post-Harvest Loss Reduction Technologies

Variables	**RP_aware**			**CS_aware**			**RT_aware**			**MD_aware**		
	Coef.(b)	**Z**	**P>|z|**	Coef.(b)	**z**	**P>|z|**	Coef.(b)	**Z**	**P>|z|**	Coef.(b)	**z**	**P>|z|**
Market distance	0.0000598	0.17	0.863	-0.0001192	-0.33	0.743	0.0003261	0.74	0.461	-0.0005104	-0.86	0.391
Cooperative	0.6990403***	4.51	0	-0.2580703	-1.55	0.12	-0.3248466	-1.38	0.169	0.0264348	0.1	0.921
Frequency of extension visit	0.392558***	2.85	0.004	0.030732	0.27	0.787	0.2379631*	1.82	0.069	0.1571131	0.92	0.356
Farm area	-0.0365637**	-2.37	0.018	0.0281678*	1.92	0.055	0.0404603**	2.33	0.02	0.044399**	2.11	0.035
Radio ownership	0.4037637	1.48	0.139	0.5725886	1.46	0.145	-0.7718251**	-2.21	0.027	0.2918467	0.43	0.664
Farmgate loss	-0.0117246	-0.04	0.968	0.4938728	1.56	0.118	0.5652589	1.03	0.305	0.5521767	0.86	0.389
Transport loss	0.2387281	0.62	0.538	0.8173269**	2.2	0.028	1.093308*	1.85	0.064	1.41834**	2.2	0.027
Storage loss	0.3302307	1.37	0.171	-0.2527478	-0.9	0.368	0.6435204	1.33	0.183	0.3338977	0.59	0.557
Phone ownership	0.2149206	0.75	0.454	0.1822619	0.51	0.611	0.4296477	0.81	0.417	-0.1346199	-0.26	0.798
Constant	-0.2657495	-0.67	0.501	-1.770835***	-3.24	0.001	-2.151129***	-2.97	0.003	-2.752441***	-2.83	0.005

Number of obs = 420
Wald chi2(36) = 105.99
Log likelihood = -452.62084
Likelihood ratio test of rho21 = rho31 = rho41 = rho32 = rho42 = rho43 = 0
chi2(6) = 108.776 Prob > chi2 < 0.0001

Table 6. Estimated Multivariate Probit Model for Factors influencing Farmers' Perception of Post-Harvest Loss Reduction Technologies

	Cheapness (1)				**Easy to Operate (2)**				**Availability (3)**				**Labour saving (4)**			
Variable	Coef.(b)	**StdErr**	**z**	**P>|z|**	Coef.(b)	**StdErr**	**z**	**P>|z|**	Coef.(b)	**StdErr**	**z**	**P>|z|**	Coef.(b)	**StdErr**	**z**	**P>|z|**
CS_Information_Sources	0.5428**	0.2195	2.47	0.013	-0.1215	0.1834	-0.66	0.508	0.3795	0.2475	1.53	0.125	-0.3505	0.4438	-0.79	0.43
RP_Information_Sources	0.1865	0.1732	1.08	0.282	0.0669	0.1128	0.59	0.553	0.0121	0.1740	0.07	0.945	0.4022	0.2879	1.4	0.162
RT_Information_Sources	0.1443	0.3675	0.39	0.695	0.1336	0.2824	0.47	0.636	0.5051*	0.2857	1.77	0.077	-0.6304	0.3968	-1.59	0.112
Extension	-0.1577	0.4646	-0.34	0.734	0.0518	0.2426	0.21	0.831	-0.1045	0.3558	-0.29	0.769	-0.8726*	0.4689	-1.86	0.063
Credit_Access	-0.4671	0.5093	-0.92	0.359	-0.2901	0.2205	-1.32	0.188	0.8209***	0.3164	2.59	0.009	-0.6226	0.4853	-1.28	0.2
Cooperative membership	0.3623	0.2799	1.29	0.196	-0.1722	0.1688	-1.02	0.308	-0.0470	0.2883	-0.16	0.871	-0.5621	0.4964	-1.13	0.257
PHL at transport	-3.0672**	1.3027	-2.35	0.019	0.2776	0.3483	0.8	0.425	-0.1211	0.4967	-0.24	0.807	0.1065	0.5981	0.18	0.859
PHL at Storage	-0.4554*	0.2479	-1.84	0.066	0.1906	0.1709	1.12	0.264	-0.3098	0.2926	-1.06	0.29	1.0637**	0.4626	2.3	0.021
Marital_Status	-0.3069	0.6710	-0.46	0.647	-0.0927	0.5917	-0.16	0.875	-1.3777**	0.6179	-2.23	0.026	2.6518***	0.9400	2.82	0.005
Farming_Experience	-0.0031	0.0133	-0.23	0.816	-0.0148*	0.0078	-1.91	0.056	0.0170	0.0143	1.19	0.235	-0.0365	0.0229	-1.59	0.111
Education	-0.0139	0.0260	-0.54	0.592	-0.0255	0.0159	-1.6	0.109	-0.0089	0.0266	-0.34	0.737	0.0208	0.0423	0.49	0.623
NonFarm_Income	-0.5641**	0.2874	-1.96	0.05	-0.0174	0.1602	-0.11	0.913	-0.1377	0.2843	-0.48	0.628	-0.0854	0.4036	-0.21	0.832
Area_Cultivated	0.0061	0.0242	0.25	0.801	-0.0008	0.0163	-0.05	0.962	0.0532***	0.0176	3.02	0.003	-0.0174	0.0297	-0.59	0.557
Multi_techs	1.5789***	0.4441	3.56	0.00	0.4575	0.3515	1.3	0.193	-0.1186	0.2788	-0.43	0.671	0.3929	0.3487	1.13	0.26
Constant	2.8292***	0.8390	-3.37	0.00	0.8941	0.7024	1.27	0.203	-1.0823	0.7138	-1.52	0.129	0.1849	0.9208	0.2	0.841

Number of obs = 420
Wald chi2(df=68) = 116.84
Log likelihood = -347.47692
Likelihood ratio test of rho21 = rho31 = rho41 = rho32 = rho42 = rho43 = 0
Chi2(6) = 16.923; Prob > chi2 = 0.0096
Multivariate probit (MSL, # draws = 5)
Wald chi2(56) = 105.61
Prob > chi2 = 0.0001
*Note: Regression coefficient is significant for coefficients with: * = p<0.10; ** = p<0.05; *** = p<0.01*

Credit Access and Area Cultivated had a strong positive and significant influence ($p<0.01$) on the farmers' perception on 'Availability' of the technologies. Marital Status had a significant negative relationship with the perception on 'Availability' of the technologies ($p<0.05$). A lot of labour and resources go into tomato production or farming yet smallholder farmers experience severe losses of up to 40 % due to inadequate labour. Farmers were asked about their perception of these modern technologies on 'Labour Saving' features. Extension agents' visitations to farmers showed a negative ($p<0.10$) influence on labour saving perception. Marital status had a very strong positive influence ($p<0.01$) on Labour Saving perception. PHL at storage also had a positive and significant influence on perception of farmers on 'Labour saving' ability of the technologies. Generally, the result showed that the perception of farmers on the tomato PHL reduction technologies did not provide common determinants, with each feature/attribute having a different sort of determinants.

Discussion

The mean age of farmers in this study was 42.5 years, this is within economic active age and an average farmer would have more energy for tomato farming and can bear risks. This agrees with earlier studies, that found farmers who were actively involved in farming, were within the age bracket of the present study, averaging approximately 43 years (Olaniyi and Adewale, 2010; Idrisa *et al*., 2012; Jamilu *et al*., 2014; Onyedicachi, 2015). The educational status of the farmers shows that the average number of years of formal education is approximately 5, with a maximum of 16 years. With the average year of education, farmers will be able to read and write simple instructions for agricultural innovation intake, especially when translated into local languages or the language of instruction at lower school grades. This also agrees with a similar study conducted on the adoption of post-harvest processing technology and improved cassava varieties, where farmers with the basic level of education dominated the adoption process (Udensi *et al.,* 2017; Udensi *et al*., 2011). It further resonates with the findings of Njabulo (2018) and Nyambose and Jumbe (2013) that higher education levels increase the chances of adopting no-till conservation agriculture because educated farmers are more likely to easily understand and be receptive to new technology or innovations.

The high rate (97.9%) of marital status among the farmers implies that the tomato farmers in Kaduna are predominantly married people. In most agricultural activities especially at the rural farm level, married people dominate. Udensi *et al.*, (2011), observed that married people were the most dominant in their study of the adoption of improved cassava varieties in Abia State, which is the same as this study. The implication of this is that most of these farmers have family responsibilities which further justifies the reason to support them to become more productive. Farming is a full-time occupation in the study area (99.8%), and the farmers have an average year of farming experience of about 23 years. The implication is that the farmers were conversant with the challenges facing tomato production losses and were able to discern which technologies best addressed the challenges better compared to those with lower experience. Farming experience has a bearing on the efficiency of performing and managing a specific task that results in high productivity. This finding resonates closely with that of Komolafe *et al.,* (2014) who found high farming experience among maize farmers positively influenced maize productivity. The study also showed that only a small percentage of the households have access to credit (14%) mainly sourced from cooperatives. This may affect the adoption of PHL reduction technology and tomato productivity especially when farmers are not financially capable to adopt the technology from their resources. This data indicates that about 13.6% of the farmers visited by extension once or up to three times.

Household size is regarded as the number of people resident in the same household and sharing a common pool of household resources (Ojiako *et al*., 2015). The average household size was 10 persons, and this may imply more farmhands work on tomato farms. Again, this could be attributed to the polygamous culture of the study area which allows men to marry more than one woman. In adoption studies, household size is considered an important socioeconomic variable used to measure labour availability or endowment in traditional agricultural production (Baffoe-Asare, 2013). This implies that farm households with more individuals are expected to be in a better position to supply the labour needs of the household regarding innovation uptake and as such more predisposed to adopt improved technology packages (Nkamleu, 2007). Another prominent variable that could explain the behaviour of tomato farmers includes the distance from their homes to major access roads linking their farms. The average farm distance (from the homestead) was 10km. The maximum distance to the farm was 45km beyond the walkable limit. The average market distance was 186 km, with a maximum distance of 1000 km (outside the state), and a minimum of '0 km' signifying the market in the village. Tomatoes are produced in large commercial quantities in Northern Nigeria and transported to the South for commercial marketing, so farmers could travel long distances to access large urban markets to maximise profit; for example, transporting tomatoes from Kaduna (in the North) to Lagos and Ibadan (in the South) could take close to 1000 km.

Farm size is the total farmland under cultivation. The study showed that a larger landholding may inspire farmers to seek more knowledge to help manage their farms and farm produce as there could be many risks to bear. Njabulo's, (2018) alternate perspective was that with larger plots of land, management becomes more difficult, and it may require more resources to purchase adequate inputs and technologies for the scale of production. Knowledge-based farm management would enable farmers to take necessary precautions thus avoiding risks of failure. However, small farm sizes may inspire the farmer to inter-crop to maximize land use. Therefore, farm size may or may not influence awareness of PHL technologies' specific direction in an empirical model. It means that the commercialization of tomatoes increases with farm size, thereby promoting awareness of other storage technologies except for RP. The positive relationship is in line with the work of Daberkow and McBride, (2003), who found out in their survey titled 'Farm and operator characteristics affecting the awareness and adoption of precision agricultural (PA) technologies in the US that increasing farm size led to a greater likelihood of PA awareness. On the contrary for RP, Hassan *et al.*, (2019) found a negative and significant relationship between farm size and awareness of ICT, which means that with the increase in farm size the awareness of farmers on the use of ICT decreased. Losses in transit positively and significantly influenced awareness of cold storage (CS), refrigerated trucks (RT), and machine drying (MD). The non-significant, though positive, coefficient of losses in transit on RP might suggest that losses in transit have little effect on farmers' behaviour in acknowledging RP. According to Caixeta-Filho and Péra, (2018), the most obvious quantitative and qualitative agricultural product losses are due to improper transport and storage as the product is moved from production to consumption sites. Their direct causes are both elusive and diverse: poor road maintenance, improper use of vehicles and their systems, inadequate packaging, insufficient transportation services during the harvest's peak, poor cargo handling, fraud and sub-standard product loading, among others. Additionally, adverse weather, lengthy transit time (especially due to vehicle breakdown), delay in loading and offloading (due to queues at the loading or offloading bay), and transfer terminal conditions may lead to product moisture loss and, consequently, weight loss and rot. All these challenges induce farmers to start looking for solutions that lead to awareness of appropriate technologies that can contain produce losses. The frequency of extension visits positively and significantly influenced awareness of RP ($p<0.001$) and RT ($p<0.1$) technologies only; while being a cooperative member influenced awareness of RP technology positively ($p<0.1$), but with no significant influence on CS, RT, MD and CD technologies. This supports the assertion of Gambo, (2020), that the challenges of managing post-harvest losses were not insurmountable, what was needed here was to create awareness among farmers through capacity building, extension services and practical demonstrations of post-harvest losses mitigating technologies to ensure quick adoption and wider acceptance. Among the strategies proposed to mitigate PHL by Gambo, (2020) was for the government or relevant private organization to effectively promote the adoption of appropriate loss-reducing technologies to improve crop handling, storage, and processing, and, according to him, that could hardly succeed if farmers and other stakeholders are not aware of it. Radio channels are supposed to play significant roles in creating awareness of the various options that can be available to farmers. In this study, the non-significant awareness from ownership of radio ownership, although positive except for refrigerated trucks could be an indication that radio stations are inadequate in airing and promoting beneficial agricultural programs to the farmers. Most of the smallholder farmers in Nigeria are not aware of the existence of the Nigeria Stored Products Research Institute (NSPRI), let alone the various equipment it has developed for post-harvest management of agricultural produce.

The innovation diffusion theory assumes that innovations are well-developed but the individual's inability to adopt them is due to improper communication (Shampine, 1998; Nemutanzhela and Iyamu, 2015). To encourage adoption, the use of extension, experiment station visits, on-farm trials, and other means of expression to transmit technical information should be emphasized. In this study, awareness creation was through cooperative membership, mass media (radio and phone ownership) and extension visits among others. It was surprising that mobile phones did not have any influence on awareness of the technologies given their versatility. Many countries have started taking advantage of mobile phones to send targeted alerts and useful information to farmers, even in their local dialects. Farmers need support to use these channels to get needed information on technologies.

On farmers' perception, a multivariate probit (MVP) model was used to determine the perception of farmers on the attributes/features of selected technologies. Farmer perception of the effectiveness of a particular technology determines their willingness to use it. Buadi *et al*., (2013) argue that farmers' perception influences their decision to participate in agricultural extension programs, adopt new technologies, and apply them. According to Abudulai *et al*., (2011), knowledge of farmers' perception of the effectiveness of agricultural services contributes to improving the design, planning, and quality of the services offered.

Farmer perception of some features/attributes (Cheapness, Easy to operate, Availability and Labour saving) of PHL-reducing technologies was examined using a multivariate probit model. Previous studies have shown that technology variable modelling may be influenced by farm, farmer, and institutional factors (Roger, 2003; Ashraf *et al*., 2014; Ghimire *et al*., 2015). The perception on the cost or cheapness of the cold storage technology (CS) is strengthened positively with access to multiple sources of information (CS_Information_Sources). Farmers are more likely to accept change if they are being provided with more information, either through education or training (Ali *et al*., 2014; Leggesse *et al*., 2015). The farmer's likelihood to perceive the cost of the technology as cheap may increase by 0.66 due to the farmer's access to many sources of information. According to Lowenberg-DeBoer and Erickson, 2019, the added value of an innovation or technology needs to be demonstrated and made visible (Lowenberg-DeBoer and Erickson, 2019). The information sources create awareness among farmers and increase their knowledge about the attributes of the technology in question, this is in line with David and Abbyssinia, (2017). Sources of information to farmers in this study included farmer-to-farmer, extension agents, radio/TV and NGOs, among others. Farmers commonly use multiple information sources to increase their knowledge about agriculture technologies (Toma *et al*., 2018).

Farmers that experienced losses of their products during transportation or storage did not see the technologies as cheap. Emana and Gebremedhin, (2007) opined that poor handling and packaging of products can lead to losses, however, the perception of farmers, seeing the technologies as expensive will discourage acquisition, thus causing losses to continue. A unit increase in the number of machines owned by a farmer will increase the perception probability of the technologies being cheap by 158%

This study revealed that as farming experience increased, perception of ease of operating PHLRT decreased and could be interpreted as farmers who have more years of experience might be older and are not as savvy with technologies as younger farmers who have more disposition towards change. However, this contradicts the study carried out by Meseret, (2014) that years of experience were positively related to farmers' perception of innovations, but agrees with Wosene *et al.,* (2018). On 'Availability' of technologies perception, is strongly influenced by multiple sources of information (RT_Information_Sources), sources of information will make farmers locate where the technologies are available; one more source of the technology will increase farmers' perception on 'Availability' by 7.7%. The study showed that farmers with better credit access perceived technologies to be readily available which is in line with the work of Elias *et al.,* (2016) and Ahmed, (2016). When farmers have access to credit or finance, the acquisition of new technologies and improved farm practices becomes less of a challenge as the funds would be available to seek out these technologies; and farmers who cultivate larger farm areas are most likely to be credit-worthy to acquire new and modern technologies and services, which agrees with the work of Mogesa and Taye, (2017) that technology availability increased with increasing access to farmland. In this paper, an increase in the area cultivated by a unit will increase perception on technology availability by 1.7%. On marital status, being single will increase perception on availability of the machine by 61.8%; singles have more time to look for the technologies.

'Labour saving' is the perception of farmers on how PHLRT reduce the use of manual labour. Extension visitation is negatively related to perception on 'Labour saving'; this result is in line with the result obtained by Tegegn, (2013) who found a negative impact of agricultural extension service on the probability of choosing collector and retailer outlets.

The farmer's likelihood to perceive these technologies as having the capacity to save labour may increase by 1.06 times due to PHL at Storage and understanding of the technologies' demands. Married farmers, especially in polygamous cultures with accompanying large family sizes are expected to perceive these assets as labour saving. The technologies in question can be too labour demanding, but being married may strengthen the probability of perception of a reduction in labour required (especially hired labour) for the technologies by 2.23 times

The overall results of this study indicate that the perception of farmers to invest in PHL technologies was highly driven by socioeconomic factors and the attributes of the technology. Thus, a better understanding of constraints that influence farmers' perceptions is very important while designing and implementing the technologies. Conscious and concerted advocacy, coupled with frequent exposure to information sources, are needed to increase positive perceptions of these technologies and their attributes.

Conclusion

The study sought to determine the level of PHLs reduction technologies awareness and perception that farmers have regarding PHL technologies. Overall, farmers in Kaduna were aware of PHL reduction technologies but did not necessarily form positive perceptions about them. Information about specific PHL reduction technologies was spread mainly through farmer-to-farmer, extension agents, and development agencies or NGOs. Frequent contact or exposure to information sources is needed to increase awareness of the various modern technologies. Farmers are most likely to try a new practice based on recommendations from peers and/or neighbours. Strengthening farmer cohesion (or cooperative) groups is important and even made effective by combining it with farmers' field demonstration practices.

The study also concluded that farmers in Kaduna State perceive PHL reduction technologies as being able to reduce losses, easier to operate, save labour and gives overall satisfaction. The study concluded that one or more of the independent variables including multiple sources of information for CS/RP/MD, farm experience and years of education of the household heads, and attributes of the technologies significantly influenced the perception of tomato PHL-reducing technologies. It was also noted that farmers with better access to credit formed stronger positive perceptions, especially on the availability of PHL reduction technologies. The perception of farmers in Kaduna State to invest in PHL technologies was highly driven by socioeconomic factors and the attributes of the technology. Thus, a better understanding of constraints that influence farmers' perceptions is very important while designing and implementing the technologies.

Recommendations

Since farmer education, information sources, and credit access, among others, could assist farmers to investigate some technology characteristics to form the right perception about them, policymakers should come up with policies to strengthen extension service institutions, adult education/training in agricultural-related issues and rural banking. Targeting the farmers at their household or community levels through a door-to-door approach, or the farmers' field schools (FFS) will increase the chances of group awareness and perception where various members can positively influence each other's knowledge, awareness, and perception of innovation. Given the farmers' exposure to different information media such as radio, TV, cell phones, relevant organizations could take advantage of these channels to drive perception changes by designing simplified targeted advocacy programs for the farmers.

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