Determinants of Improved Vegetable Seed Propagation Technologies in Tanzania: Evidence from Arumeru and Mvomero Districts

Selina P. Nombo & Onesmo Selejio[§]

Abstract

Improved seed propagation technologies (ISPTs) curb the shortage of quality seedlings for vegetable farmers. This study examines factors that influence the choice of improved vegetable seed propagation technologies in Arumeru and Mvomero districts, Tanzania for nursery beds and seedling trays. Descriptive statistics and a logit model are used to analyse data from 240 randomly sampled farmers. The results show that seedling trays are used by only 13% of all vegetable farmers, despite the technology's higher productivity and efficiency; and nursery beds are used by 87% of all farmers. The binary logit model results show that the choice of ISPTs is determined by access to seedling trays, credit, extension services and marital status. Thus, to increase the efficiency of transplant production and yield, the use of seedling trays for propagating vegetable seedlings should be promoted by increasing the availability of seedling trays and availing credit and extension services to vegetable farmers.

Keywords: seed propagation, seedling trays, adoption, random utility

JEL Classification: Q12, Q16, Q18

1. Introduction

Over the years, the adoption of improved technologies by farmers in developing countries has been viewed as a solution to low incomes in agriculture (Raju et al., 2015). Improved seed propagation technologies (ISPTs) create an opportunity for smallholder vegetable growers to increase production, reduce food prices, hunger and poverty in low-income countries, such as Tanzania. Since vegetables are important components of daily diets, their demand is high, which create opportunities to smallholder farmers who grow vegetables to increase incomes, especially in urban and peri-urban areas (Xaba et al., 2013). In addition, increasing vegetable productivity and production contributes to ensuring national food security, reducing healthy related problems and safeguarding against instability of vegetable markets (Raju et al., 2015). Literature suggest that the first step in vegetable production is to propagate healthy and quality seedlings. However, various reports related to vegetable and food security in Tanzania have noted that poor quality of seedlings is the major challenge toward enhancing vegetable production and productivity in Tanzania (Everaarts et al., 2011; Seeds of Expertise for the Vegetable in Africa (SEVIA), 2014; Odhong, 2017; Galanti, 2019).

[§]University of Dar es Salaam School of Economics: oselejio@gmail.com

Some empirical studies have found that seedling handling methods and management practices at nursery level contribute to their survival rate after transplanting and their subsequent growth performance and productivity (Odhong, 2017; Galanti, 2019). This implies that the methods employed by vegetable farmers to propagate the seeds must produce high-quality seedlings, which start with securing quality seeds, to establishing nursery, and maintaining them thereafter.

The most dominant technology for vegetable seed propagation in Tanzania is the seedbed/nursery bed, because it is the most practical and cheapest method (Asian Vegetable Research Centre (AVRDC), 1990; Galanti, 2019). However, the method has disadvantages, including poor quality of seedlings, root damage due to uprooting during transplanting, difficulty in controlling the spread of soil-borne diseases within the seedbed, and non-uniform final plant stand (SEVIA, 2014). Furthermore, the seedlings produced using seedbeds are transplanted with bare roots; hence, re-growth is less successful than sowing in seedling trays, especially when weather conditions are unfavourable for establishment (Odhong, 2017). Vegetable farmers lose about 60% of seeds when raising seedlings on the nursery beds (SEVIA, 2014).Moreover, these technologies could create excessive moisture and more air circulation, which may cause the fungal infection for the seedlings, commonly known as damping-off, thereby affecting the quality of the seedlings (Bok et al., 2006; Lin et al., 2015).

To address the problem of poor-quality seedlings, the Government of Tanzania (GoT) and development partners, such as AVRDC, SEVIA, and the Tanzania Horticultural Association (TAHA), have established intervention programmes geared at promoting the use of seedling trays in raising seedlings in the vegetable potential zones (Tanzania Agricultural Productivity Program (TAPP), 2012; AVRDC, 2014; SEVIA, 2014; MMA, 2017). The technology has been effective in improving the quality of seedlings as it is designed to provide an independent area for each seed to germinate and grow with good air circulation and drainage, which increase the efficiency of transplant (Bhimraj, 2011; Everaarts et al., 2011). A study conducted by SEVIA (2014) reported that the use of seedlings trays yielded about 25% to 48% more plants and seed use efficiency of 70% more than nursery beds. Yet, most farmers are still using the nursery beds, despite initiatives and strategies by the government and other stakeholders to demonstrate and disseminate the ISPT (TAPP, 2012; SEVIA, 2014; Odhong, 2017). Because of limited adoption of (ISPTs), the quality of seedlings remains poor and production remains low, which may lead to food insecurity.

Studies on vegetable production and nursery management in Tanzania and elsewhere have centred on the adoption of integrated pest and diseases control technologies, enhancement of the vegetable value chain and market governance. These include MMA, 2017; Mtui et al., *20*15; Rasheli & Temu, 2014; Sefa & Beda 2012; Emana et al., 2015; Maponya et al., 2014; AVRDC, 2014; Ratha et al., 2014; Manjunga et al., 2013;Odiakaet al., 2013; Asaduzzaman et al., 2011; Nwalieji &

Ajayi, 2009 among others. To date, empirical evidence on specific issue of vegetable seed propagation technologies and determinants of their adoption remains scanty, which calls for a need for adoption studies to consider factors that influence technology adoption decisions with regard to improving seed propagation technologies.

Hence, this paper has analysed the factors that influence the choice of vegetable seed propagation and nursery management technologies in Tanzania. The findings show that the adoption of ISPTs is still very low, as only 13% of vegetable farmers were found to use seedling trays. The results further show that factors that statistically influence the adoption of ISPT (seedling trays) include access to seedling trays, access to credit and extension services.

2. Literature Review

2.1 Overview of Seed Propagation Technologies

A vegetable nursery is a place or an establishment for raising or handling young vegetable seedlings until they are ready for more permanent planting (Munjuga et al., 2013). According to Bhimraj (2011), a nursery thrives on physical and financial resources. Despite these constraints, it is the best place for development of future vegetables. Nursery management refers to activities and practices undertaken to care for younger plants in the best way possible against pathogenic infections, insect pests, weeds, fertilization, watering, thinning, and hardening off (Munjuga et al., 2013; Odhong, 2017).

Seed is an embryonic plant enclosed in a protective out covering. It determines the yield potential, adaptation to environmental conditions, and resistance to insect pests and diseases (Bhimraj, 2011; Munjuga et al., 2013). Seed propagation is the process of creating new more plants from seeds, whilst a seedling is a young plant that is grown from the seed, especially one grown in a nursery for transplanting, and its development starts with the germination of the seed (Veiheij, 2004; Munjuga et al., 2013).

The first step in successful vegetable production is to raise healthy and vigorous seedlings (Kumar et al., 2004; Odhong, 2017). To ensure good plant growth performance and avoid yield losses, seedlings should be raised from an early stage in an environment that is free of insect pests and diseases. According to Veiheij (2004), raising seedlings is the most important means of developing cultivars in plant breeding. The reason is that young plants propagated from seeds require a lot of care, particularly during the early stages of growth. They have to be protected from adverse climatic conditions, such as temperature, heavy rains, drought, wind as well as pests, and diseases (Munjuga et al., 2013). Thus, for ensuring such protection, many vegetable crops are raised in nurseries before being transplanted to the field.

The methods of propagating seeds include direct field planting, field nurseries and sowing seed in containers. Direct field planting involves the gathering of seeds by farmers and sowing them directly in the field (Verheij, 2004). Before sowing, the soil is loosened to improve water infiltration to facilitate germination and fast growth of the crop. The disadvantages of this method include poor germination, stunted growth and delayed maturity and low yield. In addition, it is laborious and costly (Hatutale, 2010; Erika, 2013)

With field nurseries, the seeds are sown and the seedlings are raised in a well-prepared bed until they are ready for field transplanting, which is common in Tanzania (Verheij, 2004). Raising seedlings on seedbeds on small plots of land often results in poor and irregular emergence due to variation in size and quality, which lead to poor establishment of the seedlings after transplanting in the field and may result in a poor start for the crop (Wageningen University Research (WUR), 2012).

The other alternative is sowing seeds in containers, such as clay pots, plastic pots, polyethylene bags and multi-port seedling trays (Verheij, 2004). The use of trays in raising seedlings has become a commercial venture in vegetable production (Bhimraj, 2011). These trays are made of polypropylene and are re-usable, whereby the lifespan depends on handling. In addition, they have been designed to create a pre-calculated growing media and the right amount of moisture, since they have pre-punched holes to each cavity for proper drainage of excess water and right spacing (Kumar et al., 2004). The advantages of using the trays include reduced damping-off disease, improved germination, minimal disturbance to the root systems, ease in transportation and higher final seedling survival rate (TAPP, 2015; Verheij, 2004; Odhong, 2017). Hence, the expenses incurred for containers would be offset by high-profit margins due to high quality seedlings, which would result in high yield (Kumar et al., 2004).

Damping-off is a fungal seedling disease caused by *Rhizoctonia* and *Pythium,* which is more serious under warm and wet conditions. One of the symptoms of damping-off is the water-soaked lesions on the stem of seedlings at the point of contact with the soil. The lesions[1] soften the stem, causing the seedling to lodge and eventually dry up and die (AVRDC, 1990).

2.2 Conceptual Framework

Several factors affect the decision to select a new technology and continue using it. These factors fall into three categories: socio- economic characteristics, institutional factors and farm inputs. Institutional factors and characteristics of farmers affect the adoption of the technology indirectly by influencing knowledge and perception, which in turn influence farmers' decisions with regard to whether or not to use an innovation (Fig. 3).

[1]The lesion is any change in the tissue of an organism, usually cause by disease that may occur in plants as well as animals

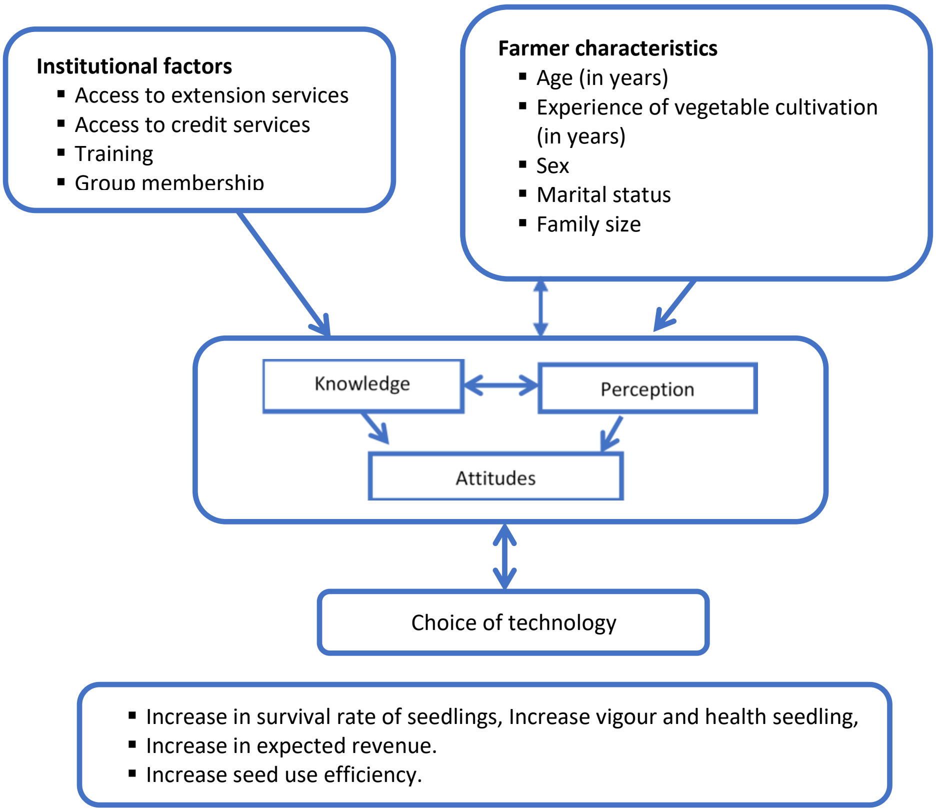

Figure 3: ***A Framework for Choice of Technology for Vegetable Seed Propagation***

The role of knowledge, perception and attitudes are crucial to the choice of seed propagation technology. The first phase in the choice of improved seed propagation is the acquisition of knowledge and acceptance of an innovation. Farmers seek to learn about the new technology/innovation, its application and the outcomes in terms of products, yield potential, environmental benefits, risks and costs. The knowledge that an individual acquire with regard to the technology is the basis of the perceptions and attitudes that she or he develops towards the technology (Meijeret al., 2015*)*. Because the farmers' perceptions on innovation emanate from the knowledge they have about the innovation, the two concepts are closely related. Knowledge and perceptions about an innovation together determine the attitude towards that innovation. Thus, a positive attitude towards an improved seed propagation technology will increase the likelihood of selecting it, whereas a negative attitude will reduce the probability of using improved seed propagation technology.

2.3 Empirical Literature

Several studies have examined factors that determine the choice of improved agricultural technologies (Idrisa et al., 2012; Odiaka et al., 2013; Raju et al., 2015;

Mwangi & Kariuki, 2015; Mutanyagwa et al., 2018). According to Raju et al. (2015) a farmer's decision about whether to adopt a new technology and how to adopt it derive from the dynamic interaction between the characteristics of the technology and an array of related conditions and circumstances. Thus, factors determining the adoption of a new technology can be put into the several categories; which include, for example, institutional factors, environmental factors and demographic factors (Odiaka et al. 2013); economic, institutional and human specific factors (Mwangi & Kariuki, 2015); household characteristics, farm and field characteristics, institutional and access related and technology specific attributes (Raju et al., 2015).

The variables in every category of the groupings do not have clear distinctive features. Thus, researchers seem to categorize the factors as to suit the investigated technology, the location, and the researcher's preference (Bonabona-Wabbi, 2002).To this end, this paper has categorized the factors that influence vegetable growers' decision-making on the use of improved seed propagation technologies into institutional and access related factors and farmers' characteristics. These factors include access to credit, farmer's age, farm group membership and contact with extension services, among other factors. The effect of the farmer's age in influencing the choice of technology tends to differ among studies. Some researchers found age to have a positive influence on the adoption of a technology. The intuition in this regard is that, with age farmers accumulate capital or credit easily (Bekele & Drake, 2003; Etoundi & Dia, 2008). In addition, some researchers view older farmers to have more experience; and they have more resources and authority, which make it more possible for them to try new innovations (CIMMYT, 1993). Conversely, as farmers advance in age, risk aversion increases and adopting a new technology seems less likely (Simtowe et al., 2007).

With regard to the sex variable, Abunga et al. (2012) found the rate of technology adoption to be higher among male farmers than female ones, and suggested that this result may be accounted to difference in ownership of productive resources in favour of men, such as land, labour and capital, which are critical for adoption of new technologies. In terms of perception, CIMMYT (1993) observed that women play a key role in most agricultural systems. Hence, it is pertinent for a new technology to reach female farmers. Farmer's experience has a positive influence on adoption, since through time, experienced farmers have tried out a number of profitable technologies, and with experience comes knowledge, which is a universally accepted truth (Meijer et al., 2015). Affliation to farmers' groups was found to be positively related to adoption of a technology. This may be so because such affiliations increase social capital and enhance the exchange of ideas among farmers (Asaduzzaman et al., 2011), which enable farmers to learn about the technology from other farmers or experts.

In many empirical studies, household size is used as a proxy for labour availability in the family. Owombo et al. (2012) posit that farming in most rural areas depend on the work force; primarily, it depends on family labour. Access to capital was found to influence positively the adoption of a new technology. Most of the technologies are associated with the use of inputs, such as fertilizer and pesticides, which go with capital utilization (Sheaban & Barrett, 2016). Access to credit was found to be related positively to technology adoption (Adeoye et al. 2011; Idrisa et al., 2012). With this finding, the researchers contend that access to credit relaxes the income constraints of farmers, which enables them to purchase key inputs, even to afford hiring labour.

Some studies found a positive relationship between farmers' access to extension services and profitability of farms (Agbebi, 2012; Oladele, 2011). Others found that access to extension services leads to more efficient transmission of information to farmers and adoption of innovations (Tesfu, 2014). Thus, extension visits help to reinforce the message and enhance the accuracy of implementation of the technology packages.

3. Methodology

3.1 Theory

To investigate the determinants of adoption of vegetable seed propagation technologies, the paper has adopted random utility theory (McFadden, 1974), as put forward by Walker and Ben-Akiva (2002). Random Utility Theory is the most common framework that has been used to develop discrete choice models. One assumption of the theory is that decision-makers act rationally; hence, they select, among alternatives, one choice that maximizes their utility.

In this study, a farmer is motivated to accept a recommended practice if the practice is profitable, compatible with the existing farming system, divisible, simple to use, has relevance for his labour use, farm inputs, marketing, credit, community values, and crop situation. Purcell and Anderson (1997) observed that farmers would adopt new technologies, modify their resource use, when they believe that the proposed change is relevant to their circumstances and can help them achieve their objectives.

The empirical model for adoption of seed propagation technologies is derived from the random utility of an individual decision-maker (q). Each decision-maker has a particular set of personal attributes$x^I \in X^I$; faces his predetermined choice set $A(q) \in A$, which is defined by a set of choice attributes $x^E \in X^E$. Each q decision maker associates to each $A_j \in (q)$ a utility U_{jq}. Since it is not possible to have complete information regarding all the elements q considered by the decision maker, it is possible to assume that U_{jq} is the sum of two components, expressed algebraically as:

$$U_{jq} = V_{jq}(\beta|x) + \varepsilon_{jq} \qquad (1)$$

where V_{jq} is a measurable and systematic part and ε_{jq} is a random part. The systematic part is a function of the measurable attributes $x = \{x^I, x^E\}. V_{jq}$ includes a vector of parameters $\boldsymbol{\beta} = \{\beta_1, \beta_2, \ldots, \beta_n\}$. The q decision maker selects the maximum-utility available from alternatives in his or her choice set $\boldsymbol{A}(q)$ if and only if: $U_{jq} \geq U_{iq}$, $\forall A_i \in \boldsymbol{A}(q) \Leftrightarrow V_{jq} - V_{iq} \geq \varepsilon_{iq} - \varepsilon_{jq}$, $\forall_{Ai} \in \boldsymbol{A}(q)$.

3.2 Data

This study is on smallholder vegetable farmers who propagate seedlings. The analysed data were collected in the regions of Arusha and Morogoro in Tanzania, specifically in the districts of Arumeru (Lake Tatu, Olkang'adu and Karangai villages) and Mvomero (Mkuyuni, Manza and Nyandira villages), during the period of January - February 2016. The selection of the districts for the study was based on their prominence in vegetable growing and productivity (PASS, 2013; Everaarts et al.,2011). Arumeru district is located in the Northwest of Arusha region and Mvomero district is located in Northeast of Morogoro region. A multi-stage random sampling procedure was used to select districts, wards, villages and vegetable farmers. At the first stage, two regions (Arusha and Morogoro) and two districts (Arumeru and Mvomero) were purposively selected based on the intensity of vegetable production and their accessibility. The second stage involved selecting randomly six representative villages, three from each district. At the third stage, a proportional sampling technique was used to select farmers to be included in the sample from each sampled village, as summarized in Table 1. The number of vegetables farmers randomly selected from the sampled villages was 240.

Face-to-face interviews were conducted using a semi-structured questionnaire to all 240 sampled vegetable farmers. The semi-structured questionnaire was used due to its flexibility, as it offers an opportunity to prompt and probe deeper into a given situation and explain or rephrase the questions if they were to be unclear to the respondent. The data collected to determine factors that influence the choice of technologies included socio-economic characteristics, institutional factors, technologies adopted by farmers to propagate seeds, operational costs, and constraints encountered, among others. To complement the primary data, secondary data on basic district information, such as the location of the villages, were collected from the agricultural offices of the two districts, Sokoine National Agriculture Library (SNAL), TAHA, and from websites.

Table 1: Sample Size of Surveyed Villages

District	Village	Population	Sample Size	Sample Proportion (%)
	Nyandira	480	48	19.87
Mvomero	Mkuyuni	290	29	12.00
	Manza	399	41	16.52
	Olkang'andu	492	49	20.37
Arumeru	Lake tatu	384	36	15.90
	Karangai	370	37	15.32
	Total	**2415**	**240**	**100**

3.3 Empirical Model

The econometric model was specified as follows.

$$Y_i^* = X_i'\beta + U_i \qquad (2)$$

Y_i=1 if $Y_i^* > 0$ and $Y_i = 0$ if $Y_i^* \leq 0$ unobservable

The study takes the choice between seedling trays and nursery bed technology to be influenced by socio-economic and institutional factors. Since the dependent variable is dichotomous, the study adopted the logit model. Although logit and probit models give qualitatively similar results, the logit model was chosen over the probit model due to its mathematical simplicity, comparatively. The linear probability model (LPM) could not be used due its tendency to be heteroskedastic. In addition, the predicted probabilities for LPM can lie outside the (0,1) interval. Thus, the dependent variable was the choice of seed technology, given by the latent variable Y^*,which is an index of the unobserved propensity for an event to occur. In the binary logit model, seedling trays were represented as 1, while nursery bed as 0, as the two alternative methods of seed propagation, whereby $U_i$follows the standard logistic distribution and is unobservable.

The probability of choosing an alternative over not choosing it is expressed by the logit equation (Equation 3) where Λ represents the cumulative distribution function of a standard logistic of random variables:

$$P[Y_i = 1] = \Lambda(X_i'\beta) = \frac{\exp\,(X_i'\beta)}{1 + exp(X_i'\beta)} \qquad (3)$$

Whereby $P[Y_i = 1]$ is the probability of the i^th farmer choosing seedling trays and is influenced by explanatory variables in Equation (3) and β represents a vector of parameters associated with the explanatory variables.

The relationship between a specific variable and the outcome of the probability was interpreted through the marginal effect, which accounts for the partial change in the probability. The marginal effect associated with continuous explanatory variables X_k on the probability $P[Y_i = 1]$, holding the other variables constant, was derived as:

$$\text{Marginal Effect of } X_k = \text{limit } [Pr(Y = 1|X, X_k + \Delta) - Pr(y = 1|X, X_k)]/\Delta)] \qquad (4)$$

as Δ gets closer and closer to 0

The marginal effect on dummy variables was estimated differently from continuous variables. Since discrete changes in the predicted probabilities constitute an alternative to the marginal effect when evaluating the influence of a dummy variable, such an effect was derived as,

$$\text{Marginal Effect of } X_k = Pr(Y = 1|X, X_k = 1) - Pr(y = 1|X, X_k = 0) \qquad (5)$$

The marginal effects provide insights into how the explanatory variables shift the probability of technology use. Using the econometric software STATA Version 13, the marginal effect for each variable was computed, while holding other variables constant. Prior to estimating the model, the independent variables were examined for possible strong relationship among them. Table 2 summarizes the variables used in the model.

Table 2: Definition and Measurement of Independent Variables and Their Expected Results

Variable	Variable label	Expected Sign	Theory/Logic Behind
X1= Sex	Sex of respondent (1=male, 0=female	+	Males and females perceived situations differently. Also, based on culture, female lack access to resources.
X2=EXPERI	Number of years of being engaged in vegetable cultivation	+	With experience comes knowledge, a universally accepted truth. Therefore, the experience can influence the decision to use seedling trays, *ceteris paribus*.
X3= Edu	Education level of respondent(1=formal, 0=informal)	+	Education brings enlightenment. Therefore, the more educated the farmer is, the more informed he or she is capable of making decisions.
X4=ACCE_TRAY	Easy access to trays (1=easy, 0= otherwise	+	A farmer can use technology when it is accessible. Hence, accessibility can influence the use of trays.
X5=AGE	Age of respondent measured in years	±	Age is the primary underlying characteristic of adoption decisions. Age and use of agricultural technologies depend on the type of technology introduced.
X6= EX_CO	Extension contact (1=Yes, 0= No)	+	Availability of extension services raises the efficiency of communicating information to farmers and increases the chance of adopting the innovations.
X7=FARM_G	If farmer belongs to any farming group	+	Groups create social capital and enhance exchange of ideas.
X8=CRED_ACCESS	Access (1=Yes, 0= Otherwise)	+	The credit helps farmers to purchase technology and the associated farm inputs.
X9= F_S	Number of family members in the household	+	The use of tray requires labour. Household members determine labour availability.
X_{10}=MARI_STA	Marital status (1=married, 0= not married	+	Being married imply stability and being settled. This can influence the adoption of the technology positively.

Among the variables assumed to influence the choice of seed propagation technologies, age was found to have relationship with education level (ρ=0.28) and, on the other hand, farming experience and belonging in farm group were correlated (ρ=0.17). However, these correlation coefficients do not signify the occurrence of perfect multicollinearity. In this regard, we followed the "do nothing school of thought". As Blanchard observed, multicollinearity is essentially a data deficiency problem; thus, sometimes we have no choice over the data we have for empirical analysis (Gujarati. 2009).

4. Results and Discussion

4.1 Socio-economic Characteristics of the Vegetable Farmers

The descriptive statistics show that vegetable farmers who use seedling trays were found to fall mostly within the age groups of 18–40 years and 41–50 years (about 90%). For the nursery beds, about 70% of the farmers with nursery beds fall within the same age groups (i.e., 18–40 years and 41–50 years), which account for about 85% of all the farmers within these two age categories (Table 3). The average age of the vegetable farmers was about 41 years and economically active family members were four people per household. These statistics imply that a majority of respondents belong to the youth groups (18–50 years) and use inferior technology of seed propagation. The results differ with those of Nwalieji and Ajayi (2008), who found middle-aged farmers to be highly involved in the use of improved vegetable production practices. However, their youthfulness is advantageous in that they are supposed to be physically able and more mentally vigilant in learning about new technologies than older farmers.

The result with regard to the average family size, the size of four economically active members, is large enough to contribute substantially to labour availability for farm activities, since most of the farms depend on labour (Edriss & Simtowe, 2003; Asaduzzaman et al., 2011; Mutanyagwa et al., 2018).

The descriptive statistics further show that an average vegetable farmer had attained formal education (mainly primary school education). This level of education is sufficient for them to understand the functioning of improved seed propagation technologies. The result is consisent with that of Mutanyagwa et al.(2018), who found that most of the farmers in the sample they used had attained at least primary education.

With respect to sex and marital status, the study found that vegetable farming was dominated by male farmers, as shown in Table 3. These results are similar to those of Lavison (2013), Xaba et al. (2013) and Adeayo (2011), who found married males to dominate vegetable production in West Africa. The reason that may explain this bias in favour of men is that most women do not own land and most married women have to get the consent of their husbands to undertake such activities. In addition, studies conducted by the World Bank in Africa, indicate that when a crop is commercial, men are more likely to take over from women, leaving them to engage in producing crops for home consumption and to undertake other household activities.

Table 3: Characteristics of Vegetable farmers by a method of propagation

Description	Method of Propagation						P-value
	Seedling Tray		*Nursery Beds*		*Total*		
	N	*%*	*N*	*%*	*N*	*%*	
Gender							
Male	24	13.3	157	86.7	181	100	
Female	7	11.9	52	88.1	59	100	0.077
Total	31	12.9	209	87.1	240	100	

Marital status							
Married	30	14.9	172	85.1	202	100	
Not married	1	2.6	37	97.4	38	100	0.025
Total	31	12.9	209	87.1	240	100	
Education level							
Formal education	31	13.6	197	86.4	228	100	
Informal education	0	0	12	100	12	100	0.318
Total	31	12.9	209	87.1	240	100	
Family size							
1–5	3	6	47	94	50	100	
6–10	25	14	153	86	178	100	0.143
Above 10	3	25	9	75	12	100	
Total	31	12.9	209	87.1	240	100	
Age (years)							
18–40	14	12.2	101	87.8	115	100	
41–50	14	16.1	73	83.9	87	100	0.430
Above 50	3	7.9	35	92.1	38	100	
Total	**31**	**12.9**	**209**	**87.1**	**240**	**100**	

4.2 Characterization of Vegetable Seed Propagation Technology

The analysis of the survey revealed that most of the vegetable seeds were transplanted and some were directly planted, such as carrots and amaranth. Furthermore, the practiced technology by farmers included nursery beds and seedling trays. Majority of farmers (87%) were found to use nursery beds for seed propagation, whereas only 13% were found to use seedling trays (Figure 2).This finding is similar to that of Everaarts et al. (2011) who found that field nurseries were a commonly used method for vegetable transplants production in Tanzania. Despite advantages associated with the use of seedling trays,(including good germination, high survival rate, disease-free seedling, intact root system, and seed use efficiency), the uptake of the technology was very low, relative to field nurseries.

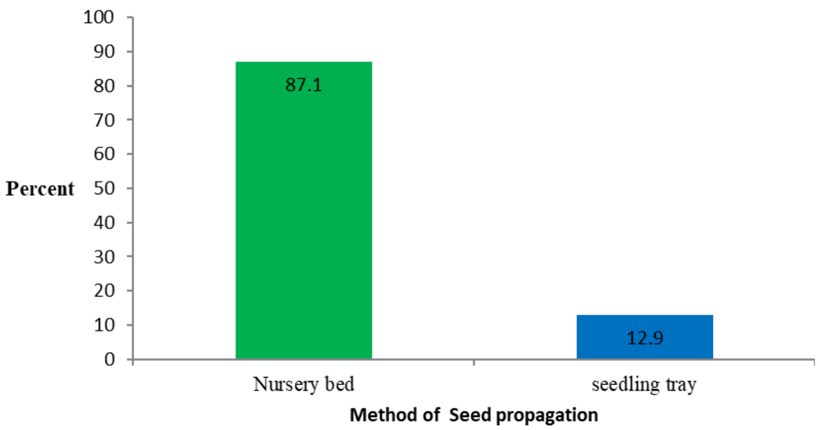

Figure 2: Percentage Distribution of the Respondents and Seed propagation Technologies in the Study Area

Furthermore, as shown in Table 4, the study findings showed that the main commercial vegetables cultivated in the study area were tomatoes (80.4% of farmers) and sweet peppers (26.7% of farmers), with eggplant being cultivated by 10.4% of the farmers. In addition, the area under vegetable production was, on average, 0.5 acres. Farmers were found to use both improved and recycled seeds, with more than 84% of adopters of seedling trays using improved seeds. The study also found that fertilizer application was common among those raising seedlings in the seedbed.

Table 4: Percentage Distribution of the Respondents and Commercial Vegetables Grown

	Number of Farmers ((percent)	
Vegetable grown	**Yes**	**No**
Tomato	193 (80.4%)	47(19.6%)
Sweet pepper	64(26.7%)	176(73.3%)
Eggplant	25(10.4%)	215(89.6%)

4.3 Regression Results

A binary logit model was used in this study to determine factors influencing the choice of vegetable seed propagation technologies, namely, the seedling trays and nursery beds. The empirical results are summarized in Table 5. The model was statistically significant ($p<0.000$). From the results of the estimated coefficients, four regressors were statistically significant. These variables include access to trays ($p<0.05$); access to credit ($p<0.05$); extension service contact ($p<0.05$); and marital status ($p<0.05$).Thus, these results provide evidence to reject the null hypothesis in favour of the alternative hypothesis, since at least one of the independent variables influences the probability of using seedling trays.

As expected, the results showed that the marital status of the respondents has a positive influence on the probability of using seedling trays to raise vegetable seedlings ($p<0.05$), as shown in Table 5). This result means that married smallholder farmers were 5% more likely to use seedling trays relative to those who are not married, holding other factors constant. We expect a married couple to make a joint decision,and that they would choose a propagation method that improves yield. In addition, married farmers have higher motivation of ensuring that they provide for their families. A married couple can also take higher risk and decide jointly to invest in a new technology to improve the socio-economic status of the family. Thus, they may be more inclined to choose any innovation that increases crop yield than unmarried respondents. These results are similar to findings by Tesfay (2010) and Tesfu (2014), who found marital status to havea positive influence on the adoption of modern agricultural technologies.

Access to credit facilities was positive and statistically significant in influencing the probability of using seedling trays to raise seedlings at $p<0.05$. That is to say, farmers who had access to credit were more likely to use seedling trays by 8% relative to those who had no access to credit, *ceteris paribus*.

Table 5: A Binary Logit Model Results Showing the Determinants of Seed Propagation Technology in the Study Area

Variables	Coefficient	P>|z|	Std error	Marginal effect	P>|z|	Std error
SEX	-0.6000	0.345	0.6355	-0.0246	0.416	0.0302
EXPERI	-0.0338	0.286	0.0317	-0.0012	0.322	0.0012
AGE	0.0186	0.512	0.0283	0.0007	0.508	0.0010
ACCE_TRAYS	2.2744	0.000	0.5573	0.1233	**0.011****	0.0487
FARM_G	0.6657	0.231	0.5559	0.0242	0.272	0.0221
CRED_ACCESS	1.6345	0.001	0.5116	0.0845	**0.036****	0.0403
HH_S	0.0458	0.848	0.2385	0.0016	0.850	0.0086
MARI_STA	2.7436	0.003	1.4144	0.0518	**0.004****	0.0180
EX_CON	1.8978	0.000	0.6462	0.0735	**0.012****	0.0311
Constant	-8.2822		1.6434			

Notes: * means significant at **=5% level of significance, Number of observation =240
Prob>chi2=0.0000

Credit affords farmers additional capital, which could be used to invest in a new technology or to acquire labour, seeds, fertilizer and other inputs. Similar findings were reported by Sheaban and Barrett (2016), Mwangi and Kariuki (2015), and Owombo et al. *(*2012). These researchers found independently in different developing countries that credit access significantly influenced the use of improved agricultural technologies by smallholder farmers. The implication of this finding is that availability of agricultural credit to farmers, coupled with technical support from extension officers, can increase the number of farmers using seedling trays. The study observed that the main source of credit was savings schemes, commonly known as VICOBA. As well, the constraints to credit were lack of collateral, high interest rates, and fear of taking risks.

With regard to the availability of seedling trays, farmers with easy access to trays were 12% more likely to use trays compared to farmers with no easy access to trays. The results were close to those of Raju et al. (2015, Badmus and Yekinni (2011), and Tadesse (2009), who found that the availability of exotic vegetable seeds and improved seeds influenced positively vegetable production and profitability.

Furthermore, access to extension services positively and significantly influenced by the use of seedling trays in seed propagation ($p<0.05$). A smallholder vegetable farmer who accessed extension services was more likely to use seedling trays by 7% relative to a smallholder farmer who did not contact an extension agent. Extension officers impart knowledge of agronomic practices to smallholder farmers (Rahman, 2007). Thus, a smallholder vegetable farmer with knowledge of agronomic practices could be applying farming techniques in a better way than one without such knowledge. The findings are consistent with those of Fintrac (2019), Maponya et al. (2014), and Alene and Manyong (2007), who argue that regular contacts with extension agents facilitate the acquisition of knowledge of improved vegetable production technologies.

To this end, the study suggests that extension agents need to visit vegetable farmers regularly to offer technical support and disseminate information. However, the study found that extension services to vegetable farmers was not readily available due to a shortage of extension officers in the sampled villages, with 51 percent of the farmers mentioning inadequate extension services as one of the main constraint of seed propagation[2]. As already suggested, coupling agricultural credit with technical support from extension officers may lead to increasing the number of farmers using seedling trays.

5. Conclusions

This study examined the factors that influence the choice of improved seed propagation technologies. The study shows a wider policy implication for the adoption of improved agricultural technologies in general and seedling trays, in particular in Tanzania. As regards factors underlying the choice of ISPT, the findings showed that access to seedling trays, and access to credit and extension services influence significantly the adoption of ISPT (seedling trays). The first step in vegetable production is to raise healthy and vigorous strong seedlings. Thus, programmes that facilitate the availability of the propagation technologies will enhance the vegetable production subsector and increase profitability of farmers. This would be achieved through the provision of affordable agricultural credit to vegetable farmers by financial institutions. Affordable agricultural credit will encourage farmers to practice commercial farming and to adopt innovative technologies. Correspondingly, the government should work to expand and strengthen extension services, which would help farmers to make right decisions with regard to the adoption of good technologies in seed propagation technologies and farming practices in general.

In addition, the findings show that raising seedlings in seedling trays is a profitable venture. However, the proportion of farmers using this technology that was found to be superior is still low, with a majority of the vegetable farmers in the study area using field nurseries. Among the reasons found to account for low use of seedling trays were credit constraints, cost of trays and associated activities, such as media preparation and tray filling. Moreover, some farmers were even not aware of the existence of the technology. Therefore, to increase the use of this technology, there is a need for the government and concerned development partners to promote the use of seedling trays technology to vegetable farmers by disseminating information about the economic advantages and other benefits of the technology through, for example, training, workshops, and farm field schools with the support of extension workers. As well, the government should create avenues for farmers to get affordable credit. Although the cost of the initial investment for the use of seedling trays is high, the cash outflows for the investment would be recovered from the cash inflows generated by the investment, given the technology's higher productivity.

[2]The constraints facing vegetable farmers in seed propagation were analysed. However, they are not presented in this paper.

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References

Abunga, M., Emelia, A., Samuel, G. & Dadzie, K. (2012). Adoption of modern agricultural production technologies by farm households in Ghana: What factors influence their decisions? *Journal of Biological Agriculture and Healthcare,* 2(3), 1–14.

Adeoye, L. B., Olajide-Taiwo, F. B., Adebis, A., Usman, J. M. & Badmus, M. A. (2011). Economic analysis of watermelon based production system in Oyo State Nigeria. *Journal of Agricultural and Biological Science,* 6(7): 53–59.

Agbebi, F. O. (2012). Assessment of the impact of extension services on fish farming in Ekiti State, Nigeria. *Asian Journal of Agriculture and Rural Development*, 2(1): 62–68.

Alene, A. D. & Manyong, V. M. (2007). Gains from High-Yielding Varieties with and without Complementary Technologies: The case of Improved Cowpea in Northern Nigeria. *Journal of Agricultural and Food Economics*, 2(1): 1–14.

Asaduzzaman, M., Naseem, A. & Singla, R. (2011). Benefit-cost assessment of different homestead vegetable gardening on improving household food and nutrition security in Rural Bangladesh. Paper presented at the Agricultural and Applied Economics Association 2011 AAEA and NAREA joint Annual Meeting Pittsburgh, Pennsylvania, July 24–26: 2011.

AVRDC (1990). *Vegetable production training manual.* Asian Vegetable Research and Development Center. Shanhua, Tainan. 447 pp.

AVRDC (2014). Vegetable production training empowers farmers to achieve profitable growth in Babati, Districts, Tanzania. http://avrdc.org] site visited on 12/180/202115.

Badmus, M. A. andYekinni, O. T. (2011). Economic analysis of exotic vegetable production among urban fandama women farmers in Akinyele local government Area Oyo state, Nigeria. *International Journal of Agricultural economics and Rural Development,* 4(1): 19–24.

Bhimraj, B. (Ed) (2011). *Resource book on Horticulture, nursery management.* Yashwantrao Chavan Maharashtra Open University, Nashik. 268pp.

Bok, I., Madisa, M., Machacha, D., Moamogwe, M. & More, K. (2006). *Manual for Vegetable production.* Department of Agricultural Research, Gaborone, Botswana. 57pp.

Bonabana-Wabbi, J. (2002). Assessing factors affecting adoption of agricultural technologies: The case of Integrated Pest Management (IPM) in Kumi district, Eastern Uganda. MSc thesis, Virginia Polytechnic Institute and State University, Blacksburg Virginia, USA. 96–103pp.

CIMMYT, (1993). The *Adoption of Agricultural Technology*: *A guide for survey design.* 88pp.

Edriss, A. K. & F. Simtowe, (2003). *The dynamics of groundnut production, efficiency, profitability and adoption of technology in Sub-Saharan Africa*: *The Malawi case.* International Publishers and Press, Las Vegas, USA.

Emana, B., Afari-Sefa, V., Dinssa, F.F., Ayana, A., Balemi, T. & Temesgen, M. (2015). Characterization and assessment vegetable production and marketing systems in the humid tropics of Ethiopia. *Journal of International Agriculture,* 54(2): 163–187.

Erika, O. (2013). *Production Guidelines sweet pepper (capsicum annuum).* Department of Agricultural, forestry and Fisheries Pretoria. 20pp.

Etoundi, S. M. N. & Dia, B. K. (2008). Determinants of the adoption of improved varieties of maize. Proceedings of the African Economic Conference: 2008, Cameroon, pp. 397–413.

Everaarts, A.P., Putter H. & Amon, W. (2011). A survey of field vegetable production in Tanzania, recommendations for improvement.[http://edepot.wur.nl/195026] site visited on 22/7/202117.

Fintrac (2019). Feed the future Tanzania Mbogana Matunda, USAID 2019 quartely report retrived from https://pdf.usaid.gov/pdf_docs/PA00TTZ6.pdf.

Galanti, R. (2019). Improved Vegetable Production and Mulching technology manual in Northern Tanzania. Retrived from https://horticulture.ucdavis.edu.

Gujarati, D. N. & Porter, D.C. (2009). *Basic econometrics* (5^{th} Ed.). McGraw-Hill Higher Education. New York. 342pp.

Hatutale, G. (2010). The effect of plant population and mulching on green pepper (*capsicum annuum L*) production under irrigation. MSc dissertation, University of Free State Bloemfontein, South Africa. 65pp.

Idrisa, Y.L., Ogunbameru, B.O. & Madukwe, M.C. (2012). Logit and Tobit analyses of the determinants of likelihood of adoption and extent of adoption of improved soybean seed in Borno State, Nigeria. *Greener Journal of Agricultural Sciences,* 2(2): 037–045.

Kajembe, G.C., Julius, F., Nduwamungu, J., Mtakwa, P.W. & Nyange, D.A.(2005). Impact of indigenous-based interventions on land conservation: A case study of a soil conservation and agro- forest project Arumeru Districts Tanzania. *Journal of land degradation and development,* (6): 311–325.

Kumar, S., Josh, P. K. & Pal, S. (2004). *Impact of vegetable research in India.* National Center for Agricultural Economics and Policy Research, New Delhi. 243pp.

Lavison, R. K. (2013). Factors influencing the adoption of organic fertilizer in vegetable production in Accra. MSc dissertation, Legon University, Ghana. 90pp.

Lin, L. Luther, G. & Peter, H. (2015). Raising healthy tomato seedlings. Asian Vegetable Research and Development Center. AVRDC Publication No. 15–795. Shanhua, Tainan.

Maponya, P., Modise, D., Heever, V. D., Mahlangu, S., Baloyi, N., Maluleke, M. ,,, & Walt, M. V. D. (2014). The establishment of vegetable and fruits markets and nurseries, a case study in Greater Sekhukhune District, Limpopo province South Africa. *Journal of Agricultural Science,* 6: 144–174.

Meijer, S. S., Catacutan, D., Ajayi, O. C., Sileshi, G. W. & Nieuwenhuis, M. (2015). The role of knowledge, attitudes and perceptions in the uptake of agricultural and agroforestry innovations among smallholder farmers in sub-Saharan Africa, *International Journal of Agricultural Sustainability* 13(1): 40–54.

MMA, (2017). Horticultural study; Phase 1: Mapping of production of fruits and vegetables in Tanzania file:///c:/users/user/downloads/vegetable%20scooping%20study%20in%2 0 tanzania%202017%20(20 (1).pdf] site visited on 10/9/2021.

Mtui, H.D., Maerere, A.P., Bennett., M.A. & Sibuga, K.P. (2015). Effect of mulch and different fungicide spray regimes on yield of tomato (*solanumlycopersicum l*) in Tanzania. *African Journal of Food, Agriculture Food, Agriculture, Nutrition and Development*, 15(1): 9607–9619.

Munjuga, M. R., Gachuiri, A. N., Ofori, D. A., Mpanda, M. M., Muriuki, J. K., Jamnadass, R. H. & Mowo, J. G. (2013). *Nursery management, tree propagation and marketing: a training manual for smallholder farmers and nursery operators.* Nairobi: World Agroforestry Centre. 60pp.

Mutanyagwa, A. P., Isinika, A., Kaliba, A. (2018). The factors influencing farmers' choice of improved Maize seed varieties in Tanzania. *International Journal of Scientific Research and Management,* 6(4).

Mwangi, M. & Kariuki, S. (2015). Factors determining adoption of new agricultural technology by smallholder farmers in developing countries. *Journal of Economic and Sustainable Development,* 6*(*5*).*

Nwalieji, A. H. andAjayi, A. R. (2009). Farmer's adoption of improved vegetable production practices under fadama phase one development project in Anambra State of Nigeria. *African Journal of Biotechnology,* 8(18): 4395–4406.

Odhong, J. (2017). Tanzania farmers embrace vegetable farming to access more high value markets and improve nutrition. https://africa-rising.net/tanzania-farmers-embrace-vegetable-farming-to-access-more-high-value-markets-and-improve-nutrition/.

Odiaka, O.E., Osupala, A. & Odiaka, N.I. (2013). Factors influencing the adoption of technologies on vegetable crops by small-scale farmers in Makurdi local government area of Benue state, Nigeria. *International Society for Horticultural Science,* 4(2): 1–22.

Oladele, O. I. (2011). Contribution of indigenous vegetables and fruits to poverty alleviation in Oyo State, Nigeria. *Journal of Human Ecology,* 34(1): 1–6.

Owombo, P. T., Adiyeloja, D. K., Koledoye, G. F., Ijigbade, J. O. & Adeogbo, M. A. (2012). Gross margin analysis of Amaranth vegetable production in Ondo State, Nigeria. *Journal of Agricultural and Biodiversity Research,* 1(6): 91–96.

Rahman, S. (2007). Adoption of improved technologies by the pig farmers of Aizawl district of Mizoram, India. *Journal of Livestock Research for Rural Development,* 19: 4–11.

Raju, G., Huang, W. & Rudra B. S. (2015). *Factors affecting adoption of improved rice varieties among rural farm households in Central Nepal.* Elsevier India Pvt Ltd. 22 (2015) 35–43. doi:10.1016/j.rsci.2015.05.006.

Rasheli, G. A. & Temu, A. (2014). Market governance among vegetable smallholder farmers of Mgeta, Tanzania. *Journal of Co-operative and Business Studies,* 2(1): 22–27.

Ratha, K., Rajwant, P., Kalia, K., Tewari, J.C. & Roy, M. M. (2014). *Plant Nursery management: Principles and practices.* Central Arid Zone Research Institute, Jodhpur. 40pp.

Sefa, V. A. & Beed, F. (2012). Enhancing vegetable value chains in rice-based and sole crop production systems to improve household income and consumption in Morogoro. Presented at Africa RISING East and Southern Africa Research Review and Planning Meeting, Arusha, Tanzania: 1 to 5 October 2012. AVRDC. The World Vegetable Center: Tainan.

Seeds of Expertise for Vegetable Sector in Africa (SEVIA). (2014). Potential positive impact of production techniques on yield. SEVIA Workshop, 18/3/2014.

Sheaban, M. & Barrett, C. B. (2016). Ten striking facts about agricultural input use in sub-Saharan Africa onpress. 72pp.

Tadesse, A. (2009). Analysis of factors determining the adoption of agricultural inputs through multipurpose cooperatives in Tahtay-Koraro Woreda, North West Zone, Tigray, Ethiopia. MSc dissertation, Mekelle University, Ethiopia. 25pp.

Tanzania Agriculture Productivity Program (TAPP). (2012). Increased incomes through better farming. Retrieved from http//www. tanzania-agric-org site].visited on 27/10/2015.

TAPP (2015). Tanzania Agricultural productivity program final report 2009–15. http://crsps.net/wp-content/uploads/2015/9/25–M-5–Mruma-TAPP-.pdf] site visited on 2/4/2016.

Tesfay, G. B. (2010). Economic analysis of smallholder vegetable production in Tigray Ethiopia. A case of IMPS's Alamata Wereda Pilot Learning Project. MSc dissertation, Makelle University, Ethiopia. 33–38 pp.

Tesfu, M. H. (2014). Adoption of modern agricultural technologies in Urban agriculture; a case study in Mekelle city- vegetable growers. MSc dissertation, Makelle University, Ethiopia. 115pp.

Veiheij, Ed. (2004). *Propagating trees.* Digigrati, Wageningen Netherland. 102pp.

Walker, J., Ben-Akiva, M. 2002. Generalized random utility model. *Math. Soc. Sci.*, 43: 303–343.

World Bank (2009). The World Bank annual report 2009 year in review. Retrieved from http://www.world bank.org., doi: 22/7/2016.

Wageningen University & Research (WUR). (2012). Improved vegetable cultivation in Tanzania good for farmer and consumer. [http://www.wur.nl/ en/show/ Improved-vegetable-cultivation-in-Tanzania-good-for-farmer-and-consumer.htm] site visited on 22/4/202016.

Xaba, B. G. & Masuku, M. B. (2013). Factors affecting the productivity and profitability of vegetable production in Swaziland. *Journal of Agricultural Studies,* 1(2): 37–52.