



Review Article

Empirical review on determinants of potato and onion production technology packages adoption in Ethiopia

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Abstract

Vegetable production technology packages adoption is essential for intensifying its productivity thereby improve the income of smallholder farmers in Ethiopia. Analog to vegetable, production adoption of Potato and onion also play a great role in improving the daily livelihood of farmers. However, there are few studies on its technology adoption to encourage farmers to substitute their production methods by modern production techniques and maximize return from the sector. The objective of this review paper is to review determinant factors of vegetable technology package adoption in Ethiopia by using the finding of popular published empirical researches. The findings of the review identified that, adoption of potato and onion technologies in Ethiopia is low due to different constraints caused by demographic factors, socio-economic factors, institutional factors and technological factors. Similarly, different empirical researches which are reviewed by this review paper identified different types of potato and onion production technology packages like improved seed varieties, fertilizers, quality seed, irrigation services, crop protection methods, and storing house. As a result of the above combinations of vegetable production technology adoption factors, the expected outcome to be obtained from the sector is still poorly performed. By considering the importance of these potato and onion production technology packages, applying and implementing the procedures of adoption bring the decision to adopt technologies and improve the extent of it thereby sustain potato and onion production in Ethiopia.

Introduction

Ethiopia has a comparative advantage in production of horticultural commodities on account of its favorable climate at different agro-ecologies like tropical, its proximity to European and Middle Eastern markets and cheap labor [1-3]. Ethiopian smallholder farmers produce vegetable crops for food and income as they are sources of vitamins, minerals and income for those involved in production and marketing [1,2,4].

Potato is the world's most important root and tuber crop worldwide; grown in more than 125 countries and it is one of the short cycling crops well suited to the double cropping [5,6]. It is potentially produced in Ethiopia due to larger arable land which is suitable for its production and it is listed as one among the list of major food crops that are consumed across the country but it was limited to homestead as a garden crop and gradual rise in production [1,7,8].

In Ethiopia, 968,969,644 tons of potato were produced on 69,610.81 hectares of land with the yield of 139.20 during 2017/2018 production season [9] and 1044,436.359 tons of potato were produced on 73,677.64 hectares of land with the yield of 141.76 during 2018/2019 production season [1]. Productivity of potato is far less than other countries due to constraints threatening subsistence farms in Ethiopia due to diseases, lack of improved seed, knowledge, clean storage sites and backward production system [1,10,11]. The importance of potato continues to rise due to increased urbanization and demand results which serves as source of nutrition, contributes huge shares to national economy, improves food security and income for smallholder farmers through its value-added products [10,12-15].

Onion is produced largely in Ethiopia for its daily uses, economic benefits, demanded due to its easy of production and for the export market purposes [16-18]. The area under onion is increasing from time to time as a result of its high profitability



per unit area, ease of production, and the increases in small scale irrigation areas [19]. The area harvested, production, and yield of onion in Ethiopia during 2018/2019 where 28,942 hectares, 33,947 tons and 11.70 tons/ha, respectively [7].

Agricultural technology adoption is an essential strategy for increasing agricultural productivity, achieving food self-sufficiency, alleviating poverty, reduce land degradation as adoption follows innovation that follows awareness, interest, evaluation, trial, and adoption stages; changes that farmers undergo in accepting new ideas, innovations in agriculture and the decision to select different types of agricultural technologies from the existing technologies [20,21]. The drivers of technology adoption broadly include factors that positively promote technology adoption, and access to different agricultural related information which help farmers to make decision of adopting technologies [22,23].

Adoption of improved agricultural production technologies is a means through which demand for vegetables can be met [24]. The rate of technology adoption in Ethiopia is very low and average adoption rate is estimated to be less [25,26]. Variations in adoption of different technologies cannot be improved unless proper measurement is taken to increase farmers' experience to get benefits of using technologies [27]. Adoption of modern technologies, improving capacities to maximize their investment by using quality seed enable farmers to increase income, reduce hunger, sustain food security, contributes to economic development [27-29]. Vegetables are lost along postharvest activities such as transportation, storage and consumption; due to perishable nature and biological nature of production process, vegetables productions are risky investment activities (FAO, 2020). Smallholder farmers lack the awareness, training and access to intermediate processing technologies to effectively manage fruits and vegetables after harvest [1,30]. Cultivation of Vegetable was not largely practiced in Ethiopia due to small-scale farming systems and poor pre- and post-harvest handling techniques [31].

Practice of potato and onion production technology adoption components of farmers include improved varieties, seed rate and quality, chemical sprays, fertilizer, land preparation, inappropriate agronomic management practices, number of seed, seed storage, integrated water and awareness about disease and management of it while production and productivity of potato and onion in Ethiopia are very low because of poor quality seed tubers, use of inappropriate agronomic management practices, lack of integrated water, nutrient pest management and unavailability of seed tubers of improved varieties [27,32-36]. Productivity of potato and onion is far less than other countries due to constraints threatening subsistence farms in Ethiopia due to diseases, lack of improved seed, use of inappropriate agronomic management practices, lack of integrated water, nutrient and pest management, lack of improved varieties and absence of technologies knowledge clean storage sites and backward production system [1,10,31,33,34]. Similarly, incapability of farmers not to apply the full recommended technology contributed low quantity of potato [35].

Among the commonly known challenges of potato and onion production and technology adoption in Ethiopia are high cost of improved varieties, lack of certified accessibility of input, existence of labor which delay adoption, lack of finance and market, lack of awareness and training, poor extension contact and credit services, lack of knowledge and social network which regard with the diffusion of improved varieties and less technology adoption [15,37-45].

Different empirical studies of potato and onion production technology adoption in Ethiopia mostly focused on some part of the technology adoption rather than the full package of technology which is resulted in disintegrated usage of the technology. So, adoption of full potato and onion production technology packages increases productivity of them thereby improve income of smallholder farmers. Thus, this review takes into account of reviewing different empirical articles to identify determinants of adoption of potato and onion production technology packages in Ethiopia. Therefore, the objective of this paper is to review the empirical results of potato and onion production technology package adoption in Ethiopia.

Materials and methods

Empirical researches published in recommended journals and nationally released reports of the government like CSA's (Central Statistical Agency's) were used in order to review and support the background justification determinants of vegetable production technology adoption in Ethiopia. The secondary data were obtained from different sources like Google scholars, Google, and Haramaya University websites. The articles obtained were selected depending on the acceptance of the journal and downloaded from popularly used journals obtained for this review. To review determinants of potato and onion production technology package adoption, the peer-reviewed empirical articles which are properly reviewed and articles composed of different factors like demographic factors, socio-economic factors and institutional factors of potato and onion production technology adoption selected over others. Then, the statistical result of each model of articles compared with other, similarities and differences of the results were discussed for more justification of factors of potato and onion production technology adoption in Ethiopia.

Techniques of determining potato and onion production technology adoption

Most researches of empirical studies which are conducted by taking potato and onion production technology adoption as their concern at different areas were reviewed and summarized depending on their types of variables, models used for analyze, and decision of their technology adoption. Diriba, et al. [46] used Duration models to analyze determinants of farmers' potato technology adoption. Feleke, et al. [28] used binary logistic regression for factors influencing the adoption of Belete potato variety. Ketema, et al. [15] identified and analyzed determinants of potato production technology package adoption by using Two-limit Tobit model. Similarly, Khalil, et al. [47], used multiple regression model to identify the effect

of technology adoption on potato yield. Probit was used for analyzing factors adoption of potato improved varieties [40]. Amare, et al. [48] used experiment using Bombay Red onion variety to identify effect of plant spacing and fertilizer on the yield and Yewendwesen [43] used quantitative assessment and descriptive analysis techniques to identify determinants of onion technology package adoption.

Mitikuand Tadesse [49] used SAS model to analyze adaptability of onion improved varieties. Nazziwa-Nviiri, et al. [50] used double-hurdle model to reveal determinants of improved fertilizers. Kiruthika [51] descriptively analyzed adoption of integrated pest management in onion. Adgo [52] used tobit model to evaluate farmers' onion production technology adoption. Abduelsalam, et al. [53] used statistical packages for social sciences to identify factors of adoption and distribution of improved onions seeds. Yirga, et al. [54], used multivariate probit model to illustrate what factors drive farmers to adopt potato technology packages when compared with other agricultural products like barely, wheat and faba bean. Okello, et al. [55] used different models like probit, Poisson and Tobit models to discuss factors of adopting certified seeds of potato. Probit model is used for analyzing determinants of adoption of modern potato varieties [56]. Diriba, et al. [37] also used Three-stage probit regression model for analyzing decision to adopt potato improved varieties. Anik and Salam [57] used Cragg's double hurdle models to identify determinants of adoption and level of adoption of onion.

Determinants of potato and onion production technology package adoption review

Different authors of empirical research of potato and onion production technology adoption in different areas classify the factors of technology adoption and interpret a significant effect of each variable. Depending on the existing literatures these factors are classified as: i. demographic factors (include age, gender, family size and etc), ii, Socio-economic factors which include education level, size of farm, and etc; iii. Institutional factors like extension services, credit services, access to information on technologies and etc; iv. Technological related factors which can be expansion of innovation, improved seed, and adoption of technology. The work outcome of Bekele, et al. [58] revolved over these factors.

Demographic factors

Age: The empirical study of Diriba, et al. [37] and Diriba, et al. [46] revealed that as age increased farmers adopt more of potato improved varieties and irrigation, respectively. Similarly, Nigussie, et al. [19] discussed the direct relationship between onion productivity and technology handling regarding with the age of the farmers. This might be due through time as their age increased household become experienced about the existing or new technologies. Age teaches farmers about what types of agricultural technologies exist, how they are applicable, their advantages and disadvantages and learn more through creating social network when to decide to adopt technologies. But, the research result of Diriba, et al. [37] and Begum, et al. [56] revealed that as age of household increased their adoption

of potato improved varieties reduced while Roessali, et al. [59] identified indirect relationship between age of farmers and adoption of true shallot seed of onion. This contradicting result might occur due to differences in area of study as accessibility of different technologies, attributes related with it and different alternatives technologies supplemented with others where farmers have probability of selecting one over other and dropping other/s as his/her age increased.

Sex: Being male or female significantly affected potato technology adoption of households as different empirical research authors discussed. Accordingly, the research outcomes of Nazziwa-Nviiri, et al. [50] and Abebe, et al. [40] found that male households are more likely adopt improved fertilizer used for potato production than female as females are constrained mainly by fixed cost of it and Diriba, et al. [37] found that male adopt more improved potato varieties than female as males spend more time in farming than their female counterparts. In developing countries agricultural farming are frequently undertaken by males since it is traditionally practiced and females are discouraged to participate in potato farming, purchase different, not accessed different sources of credit, and restrict themselves to in home due to the force of culture behind them.

Family size: Existence of large number of labors contribute for how to adopt different types of potato technology packages through generating different ideas, advices, participating as labor force to prepare land, weed, share experiences from others and making collective discussion. In line with the result researches of different empirical studies, large family size and potato technology adoption have the same route direction [19,28,37,40] discussed that larger family size can improve the handling of technology thereby increase productivity of onion. Against to this, Diriba, et al. [37] and Roessali, et al. [59] suggested that larger family size less adopt potato and of onion improved varieties, respectively. This is because low income family members unable to purchase improved varieties of potato unless the concerned bodies subsidize them.

Socio-economic factors

Education: Empirical research outcomes of potato and onion production technology adoption found that level of education that households attended has a great contribution for farmers to adopt technology packages. Farmers easily aware of what types of technology to adopt, expect outcome and a bundle of benefits of adopting it. The findings of Feleke, et al. [28], Abebe, et al. [40] and Diriba, et al. [37] suggested that increased level of education attended by farmers pledge them adopt different packages potato production technologies in Ethiopia while Abduelsalam, et al. [53], Begum, et al. [56] and Tadesse [42] discussed role of education on the adoption of innovations onion varieties as educated farmers have more confidence in his own application technologies package adoption which contributes to efficient production system. Contrast to this other research outcome of Diriba, et al. [37], identified that farmers technology adoption of improved varieties and irrigation usage are reduced when compared with intercropping strategies as their level of education

increased. This is due to since intercropping is provided as one of technology adoption, farmers in developing countries want fight fluctuation of climate by planting different plants and cropping potato which might enable them to achieve goal.

Land allocated: Literatures of empirical research mostly found that land size allocated for potato production increase the probability of farmers to adopt different technology packages. Over a large size of land farmers increase their productivity and then probably will have the access of technology packages than farmers with small land size. The research findings of Nazziwa-Nviiriet, et al. [50] and Okello, et al. [55] revealed that the size land allocated for potato production increase the chance adopting potato technology packages. Abduelsalam, et al. [53], Roessali, et al. [59] and Anik and Salam [57] discussed expanding area coverage for onion improves adoption of innovations onion varieties. But, Ketema, et al. [15] found that land size has negative effect on adopting potato technology adoption. These contradicting results might occur between empirical research studies due to type of crops largely produced in the area which could shift from potato to others, labors who manage the production of potato, climate, income of farmers, and the existing market for different agricultural products which might favor or disfavor potato technology adoption.

Institutional factors

Extension services: The relationship between farmers and extension services facilitate the easy adoption of potato and onion production technology. Abduelsalam, et al. [53] and Anik and Salam [57] discussed role of extension on the adoption of innovations onion varieties as it improves productivity of the product. But, the findings of different researches come up with negative effect of extension on potato technology adoption. Diriba, et al. [37] and Ketema, et al. [15] identified that extension services negatively affected adoption of potato irrigation and other technologies. These results might occur that as the days of contacting farmers increased farmers might become less adopt potato technology since most of the time extension agents go to farmers to collect information about quantity produced to prepare their reports.

Credit services: Credit encourages farmers to purchase and adopt different potato and onion production technology packages which many literatures also frequently and positively related it with technology adoption. Different scholars like Feleke, et al. [28] and Abebe, et al. [40] found that access to credit services help farmers to adopt potato technology adoption while Anik and Salam [57] and Adgo [52] clearly discussed credit provided from different sources improve onion technology adoption. Using credit for productive purposes enable farmers to purchase improved varieties, pesticides, fertilizers, quality seed, rent land, purchase pumps and storing materials. Unlike these findings Diriba, et al. [37] identified that credit negatively affected potato irrigation technology adoption. These controversial results occur due to mostly in developing countries farmers traditionally create a suitable irrigation services from the existing water bodies without incurring costs while they use credit for purchasing and adopting other potato production technologies.

Information: The findings of different empirical researches like Diriba, et al. [37] and Abebe, et al. [40], realized that information from different sources help farmers to facilitate to adopt potato technology packages. Radios, television, friends, NGOs, market, are sources of information that farmers use them to acquire information and knowledge of how and when to adopt technologies. Effective and regulatory Information about market reforms make participants better-informed and transactions more transparent through inducing onion technology adoption by smallholder farmers [60].

Technological factors

The overall role of factors of adopting potato and onion production technologies is less or more to discuss how technological factors are used in production. Technological factors are the packages of technologies which enable farmers to produce more potato and onion through introducing different technologies like improved varieties, fertilizers, seed quality, irrigation, cropping methods, how to protect crop and harvest and where to store it. Different empirical researches of authors found and discussed that technological factors which are used in a single or a combination of different technologies are the central factors of potato and onion production technology adoption. Different researches were undertaken by considering how these technologies are applied, used and accessed for farmers to improve the product while some of them were rely on how to adopt and what factors determine their adoption. The technological factors of onion were largely issued through identifying how different technologies can be adopted to the production of onion through different experiments.

Accordingly, Bekele and Abebo [61] discussed the role of water irrigation technology to improve yield and productivity of onion for income improvement. Method of growing onion with other selected vegetables (intercropping) reduce insect pests, increase the productivity per unit of land as it allows crop diversification as well as reduce financial risk in the event of crop failure and farmers can easily manage their produced from disease [62]. Among these authors Feleke, et al. [28], Khalil, et al. [47], Yirga, et al. [57], Diriba, et al. [37], Nazziwa-Nviiri, et al. [50], Diriba, et al. [37] and Ketema, et al. [15] revealed that different types of technological factors positively affected potato technology adoption.

Constraints of potato and onion production technologies

The importance of potato continues to rise due to increased urbanization and demand results which serves as source of nutrition, contributes huge shares to national economy, improves food security and income for smallholder farmers through its value-added products [10,12-15]. The potato crop is subjected to numerous abiotic (primarily temperature- and precipitation-related events) and biotic risks affecting sustainability of production [63].

Among different factors which affect potato production in Ethiopia include lack of farm land, low price of the crop at harvesting but high price of seed tubers at planting, occurrence of natural hazards, seeding rate, problems related with using improved seeds, diseases, storage problems, shortage of money



to purchase agrochemicals, and insufficient seed tubers during planting [10]. Financial, inputs, institutional constraints and lack of training on production and adoption of onion are the major bottlenecks along adoption of onion [64]. Onion is widely produced under rainfed as well as irrigated conditions in different agro ecologies for both consumption and income in Ethiopia but its productivity is constrained by different problems especially factors related with production adoption which include the use of lower yielding and unadaptable varieties [65,66]. Lack of information about the specificity of onion transacted on markets can be a strong impediment to technology adoption [60]. The shortage of quality seed is the major limiting factor of onion production adoption caused by inappropriate use of NP fertilizers and plant spacing [48].

Conclusion and policy implication

Vegetable is one of the horticultural products which is largely produced in Ethiopia, its productivity and technology adoption is constrained and low due to different factors of production like absence of sufficient improved seed/varieties, lack of knowledge and training, absence of clean storage sites and backward production system. Adoption of Potato and onion production technology packages plays a great role in increasing productivity, income and sustainability of livelihood of smallholder farmers in Ethiopia. Adoption of these technologies do not take place in the society at one time rather decided to be adopted after farmers look at types and advantages of the technologies to adopt or not to adopt. But many empirical literatures identified that adoption of potato and onion production technology packages found at lower level due to economic problems of purchasing improved varieties, fertilizers, quality seed, diseases, and irrigation services and insignificance role of extension workers.

In Ethiopia, lower income and incapability of farmers led not to adopt full potato and onion technology production packages which is resulted in using the products for home consumption, unparalleled size of land allocated for products' production and their productivity constrained to generate low income for farmers. The literatures also identified that different demographic, institutional, socio-economic and technological factors directly or indirectly contributed less adoption of potato and onion production technology packages. In order to bring improved potato and onion production technology adoption in Ethiopia, farmers should be aware of how to adopt and providing education based training from extension workers, supplying new and environmentally adaptable improved potato and onion varieties, reducing the price of seed, training how to prepare and use compost, timely providing inorganic fertilizers and reducing its price, utilizing the existing water bodies and enabling farmers to access irrigation services, teaching and training farmers to protect crop from diseases and farmers should have good storing site for potato and onion as the products are perishable product, conducting research about adoption of these products especially onion technology adoption needs to be undertaken as it was not undertaken plentifully in Ethiopia. So, considering all these issues plays a vital role for potato and onion production technology packages in Ethiopia.

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