Agriculture and Food

AIMS Agriculture and Food, 3(3): 216–228.
DOI: 10.3934/agrfood.2018.3.216
Received: 02 May 2018
Accepted: 06 July 2018
Published: 20 July 2018

http://www.aimspress.com/journal/agriculture

Research article

Factors influencing the adoption of improved wheat varieties by rural households in Sindh, Pakistan

Abbas Ali Chandio and Yuansheng Jiang*

College of Economics, Sichuan Agricultural University, Huimin Rd. 211, Wenjiang District, Chengdu, China

* **Correspondence:** Email: yjiang@sicau.edu.cn; Tel: +862886290883; Fax: +862886291110.

Abstract: This study examines the factors affecting the adoption of high-yield wheat varieties by wheat farmers in Sindh, Pakistan. A cross-sectional data of randomly selected 240 wheat farmers from Shaheed Benazirabad and Naushahro Feroze districts in the middle region of Sindh, Pakistan were collected for this study. We performed the probit model to estimate factors that influence the adoption of improved wheat varieties. The results drawn from the estimations show that the adoption of improved wheat varieties by farmers in the study area was positively and significantly influenced by education, farming experience, landholding size, tube-well ownership, extension contact and access to credit. The study recommends that public and private sectors should encourage access to extension service to improve of dissemination of certified seed of wheat crop among the growers through trainings, workshops and seminars.

Keywords: adoption; wheat; improved varieties; Pakistan

1. Introduction

Presently, developing countries are facing two key challenges such as ensuring food security and poverty alleviation. The enhancement of crop production is considered an important for improving the welfare of small-scale farmers in these countries. With rapidly growing population rate and limited cultivable farm land, in the agriculture sector technological involvement seems to be the only viable option for developing economies to feed the increasing population and generate employment. The adoption rate of high-yield varieties by large and smallholder farmers is expected to provide impetus to increase crop production, which can help to reduce poverty and increase rural

household food security [1–3]. Pakistan's economy is primarily based on agriculture sector and this sector accounts for almost 19.5% to the GDP and employs 42.3% of the labor force. An estimated population of Pakistan is 199.1 million. Out of total population 80.72 million lives in urban areas whereas 118.38 million lives in rural areas, which are directly or indirectly engaged in farming related activities for their livelihood [4]. In terms of the cultivated area, production and yield, wheat is the largest and main staple food crop followed by rice and maize in Pakistan. Wheat crop alone contributes 9.6% value addition in agriculture and 1.9% to the GDP of Pakistan [4]. For 2016–2017, area sown for wheat is estimated at 9052 (000 hectares), 1.9% lower than last year's area sown of 9224 (000 hectares). The estimated wheat production remained 25.750 million tonnes, indicating an increase 0.5% over the last year's production of 25.633 million tonnes (GOP, 2017) (Table 1).

Table 1. Area, production and yield of wheat in Pakistan

Year	Area		Production		Yield	
	(000 Hectares)	Change (%)	(000 Tonnes)	Change (%)	(Kgs/Hec.)	Change (%)
2010–2011	8,901	−2.5	25,214	8.2	2833	11.0
2011–2012	8,650	−2.8	23,473	−6.9	2714	−4.2
2012–2013	8,660	0.1	24,211	3.1	2796	3.0
2013–2014	9,199	6.2	25,979	7.3	2824	1.0
2014–2015	9,204	0.1	25,086	−3.4	2726	−3.5
2015–2016	9,224	0.2	25,633	2.2	2779	1.9
2016–2017[a]	9,052	−1.9	25,750	0.5	2845	2.4

Note: [a] Provisional (July–March). Source: GOP (2014, 2017 p. 28, 24)

In Pakistan, since 1971 almost one hundred and seven (107) improved wheat varieties have been developed and released. About 25 percent leads to increase in wheat productivity by using improved varieties [5]. The main varieties grown throughout the Sindh province of Pakistan are such as Benazir, Galaxy**,** TD1, SKD1 (Sakrand-I), Kiran, Abdul Sattar, Maxi, Sahher and local Sindhi respectively [6–8]. However, rate of adoption of improved high-yield wheat varieties is quite low in developing countries like Pakistan. The small-scale wheat farmers make use of traditional varieties whose productivity is quite low as compared to the improved wheat varieties. It is due to various technical and socio-economic constraints including limited supply of improved seeds varieties, less adoption of modern agricultural technology, high prices of fertilizers and inadequate credit facilities for purchase of agricultural inputs are the major socio-economic constraints [9–11].

Farooq et al. [10] observed that less accessibility and high prices of improved wheat varieties are the main reasons for its quite low adoption and resulted in lower wheat production in Pakistan. Similarly, Pandit et al. [12] observed that replacement of traditional wheat varieties with improved and certified varieties increased wheat productivity. The extensively adoption of improved wheat varieties will manifold the wheat production in Bangladesh. Adoption of IWVs compared to the conventional varieties increased the wheat production and doubled the returns for wheat crop growers [13]. To solve these problems, public seed sectors such as Pakistan Agricultural Research Council (PARC), Punjab Seed Corporation (PSC), Sindh Seed Corporation (SSC), NWFP Agricultural Development Authority (ADA), Balochistan Department of Agriculture (BDA), and private seed sectors including 367 national seed companies including 5 multinational seed companies

have made restless efforts to bring about change in agricultural production system of the farmers. They have introduced modern agricultural technologies like use of improved high-yield varieties, fertilizers and as well as improved farm implements, in relation to crops, which seem to increase in yield. This shows that there are various factors directly or indirectly affecting adoption of modern agricultural technologies that are believed to bring about change in farmers' productivity [14]. Improving agricultural productivity at the household level is important to achieve food security [15]. The determinants of adoption of IWVs has been examined for several countries in different regions of the world including China [16], India [17], Turkey [18], Ethiopia [19–22], Nigeria [23], Ghana [24], Kenya [25], Sudan [26], Tanzania [27] and Eastern Zambia [28], respectively. In Pakistan few studies have done [6–8,29–31], but they examined technical efficiency of yield of wheat and impact of agricultural credit on the yield of wheat. Several socioeconomic factors affecting adoption of wheat varieties such as farm size [18,32–35], farm assets like tube-well and tractor-ownership [36,37], household savings [38], off-farm income [39–41], financial constraints [42], accessibility of credit [8,43–45], ownership of livestock [46], own farmland, non-farm work [47], gender of the household head [3,48–50], formal education, family size, experience, market distance, appropriate usage of fertilizers, better irrigation systems, hired labour, fertility of soil, climatic conditions [7,39,51–53], contact with extension agents, participating in several agricultural related programs and trainings, membership to farmer groups [54], field visit days [55] and use of information communication technology (ICT) [56–58], respectively. Therefore, the main purpose of the present paper is to assess the determinants of adoption of improved wheat varieties in Sindh, Pakistan.

2. Materials and methods

2.1. Study area and sampling method

The field survey was conducted in two districts of Sindh province of Pakistan namely Shaheed Benazirabad previously known as Nawabshah and Naushahro Feroze. The total area of district Shaheed Benazirabad is 4502 Sq.Kms whereas total population is 1,071,533 persons. Out of total population, 282,359 (26.35 percent) live in urban areas while 789,174 (83.19%) live in rural areas. The average family size of this district is 6.0 [59]. On the other hand, the area of district Naushahro Feroze is 2945 Sq.Kms. Further, total population of this district is 1,087,571 persons. Out of total population, 192,404 (17.69 percent) live in urban areas and 895,167 (82.31 percent) live in villages. The average family size of this district is 5.8 [59]. Agriculture is the main activity in these two districts of Sindh province of Pakistan and main crops grown are wheat, sugarcane, rice, maize vegetables and fruits, respectively. Agriculture sector of these districts is in transition phase and modern agricultural technology is being adopted quite rapidly by large and smallholder farmers and as a consequence the crops production as well as the food security situation improved over the last few years. The present paper used survey data, which was collected from two districts of Sindh province of Pakistan during November to December, 2016. The data were collected using multi-stage random sampling method. At the first stage, Sindh province was purposely selected. At the second stage, two districts (Shaheed Benazirabad and Naushahro Feroze) were randomly selected for this study, where wheat is one of the major crops grown. Eight villages from each district were randomly selected at the third stage. At the final stage, 240 wheat farmers from selected villages (15

wheat farmers from each village) were personally interviewed using the well-designed detailed survey questionnaires. The survey covered a number of socioeconomic characteristics information of the sampled wheat farmers such as age formal education, family size, farming experience, farm size, market distance, credit availability, extension, tractor ownership and tube-well ownership, respectively. The data was analyzed utilizing probit regression model to determine the factor influencing adoption of IWVs in the study area.

2.2. Theoretical and empirical framework

Adoption of modern agricultural technology and usage of main farm inputs are the outcomes of optimization by heterogeneous agents [60,61]. This optimization takes place in the existence of information, accessibility of formal credit, constraint budget and the availability of modern agricultural technology and other farm inputs. Consequently, farmers are assumed to maximize their utility function subject to these constraints [62]. The variance among the utility from adoption of improved varieties (U_{iA}) and the utility from not adoption of modern agricultural technology (U_{iN}) may be represented as (U_i^*) such that a utility maximizing the rural household, i, will choose to adopt modern agricultural technology if the utility gained from adopting is higher than the utility from not adopting modern agricultural technology ($U_i^* = U_{iA} - U_{iN} > 0$). Meanwhile these utilities are unobservable, they can be shown as a function of observable elements in the latent variable model as expressed in Eq.1. By following studies [61–65] the adoption decision can be modeled in a random utility framework as follows:

$$U_i^* = X_i'\phi + \mu_i$$

$$U_i = \begin{cases} 1 \ if \ U^* > 0 \\ 0 \ otherwise \end{cases} \quad (1)$$

Where, U_i^* is the latent variable which denotes the probability of the farmer's decision to adopt IWVs, and takes the value '1' if the farmers adopt IWVs, '0' otherwise. The term X_i' indicates explanatory variables explaining the adoption decision, ϕ is a vector of parameters to be estimated, and μ_i denotes the error term assumed to be independent and normally distributes as $\mu_i \sim N(0, \sigma^2)$. Based on the above mentioned theoretical model and earlier studies experiences [62, 63, 65–69] we selected our explanatory variables and specified an empirical probit regression model as follows:

$$U_i = \psi_0 + \psi_1 X_1 + \psi_2 X_2 + \psi_3 X_3 + \psi_4 X_4 + \psi_5 X_5 + \psi_6 X_6 + \psi_7 X_7 + \psi_8 X_8 + \psi_9 X_9 + \psi_{10} X_{10} + \xi_i \quad (2)$$

Where, U_i is adoption of improved wheat varieties (1 if the farmer adopts improved wheat varieties and 0 otherwise), X_1 denotes age of household head in (years), X_2 represents household head's schooling in (years), X_3 represents farming experience in (years), X_4 represents household size in (numbers), X_5 represents farm size in (acres), X_6 represents market distance in (Km), X_7 represents tractor ownership (1 for ownership, 0 otherwise), X_8 represents tube-well (1 for ownership, 0 otherwise), X_9 represents extinction (1 for contact to extension, 0 otherwise), X_{10} represents credit

facility (1 if household have availed credit facility, 0 otherwise), ψ_0 to ψ_{10} are the coefficient terms and ξ_i is the error term.

3. Results and discussion

3.1. Descriptive analysis

Summary statistics and explanation of the variables are displayed in Table 2. The results show that the average age of the household head is 42 years while an average of 7 years, farmers had formal education. Whereas, the average farming experience of the farmers is 25 years. The average family size is almost 9 persons in the study area. Further, land assets are very much important endowment for rural households; an average farm size is almost 14 acres. The mean distance from village to the inputs market is about 8 kilometers. Additionally, about 37 percent respondents had tractor ownership. After the tractor ownership, tube-well ownership of the respondents is the next very important farm asset and about 53 percent of the respondents had their own tube-wells. Finally, about 48 percent of the wheat farmers had access to extension services while 68 percent had availed credit facility.

Table 2. Socio-economic characteristics of the wheat growers.

Variable	Description	Mean	SD
Age	Age of household head in years	42.875	11.565
Education	Household head's schooling in years	7.008	4.818
Experience	Experience of the sample respondents in years	25.795	7.623
Household size	Number of total family members in the household	8.916	2.569
Farm size	Area under wheat crop in acres	13.621	12.921
Distance	Distance of market in kilometers	8.033	4.550
Tractor	1 if farmer has tractor ownership, 0 otherwise	0.379	0.486
Tube-well	1 if farmer has tube-well ownership, 0 otherwise	0.533	0.499
Extension	1 if farmer has extension contact, 0 otherwise	0.483	0.500
Credit facility	1 if farmer has availed credit facility, 0 otherwise	0.683	0.466

Source: Survey results, 2016.

Table 3 reports the difference in a number of socioeconomic characteristics of the sampled farmers that adopted the improved wheat varieties and those that did not adopt in the study area. The results show that the difference in formal education is negative and statistically significant at 1% between adopters and non-adopters of improved wheat varieties. Likewise, the difference in farming experience is negative and significant at 5 percent. Similarly, the mean area allocated to adopters and non-adopters of improved wheat varieties is 17.48 and 11.62 acres and the difference in farm size is negative and significant at 5 percent. Additionally, the results show that the difference in distance of inputs market is positive and statistically significant at 10 percent, demonstrating that not adopters of improved wheat varieties farmers are farther away from main inputs markets compared to adopters of improved wheat varieties in the study area. In addition, most of adopter of improved wheat varieties had farm assets ownership like tractor and tube-well ownership and had more access to

credit, compared with non-adopters of improved wheat varieties. Finally, there is no significant difference in age, household size and access to extension services between both groups of adopters and non-adopters of improved wheat varieties in the study area.

Table 3. Difference in socioeconomic characteristics of adopters and non-adopters of IWVs.

Variable	Adopter	Non-adopter	Difference	t-value
Age	44.3443	43.3770	−0.96721	−0.418
Education	8.6066	6.4754	−2.13115	−2.625***
Experience	27.5246	24.5410	−2.98361	−2.396**
Household size	9.1475	9.0164	−0.13115	−0.277
Farm size	17.4867	11.6269	−5.85984	−2.237**
Access to credit	0.9016	0.6557	−0.24590	−3.223***
Access to extension service	0.3934	0.4426	0.04918	0.477
Distance to market	8.3443	9.6885	1.34426	1.673*
Tractor ownership	0.4262	0.2623	−0.16393	−1.800*
Tube-well ownership	0.4754	0.2459	−0.22951	−2.425***

Note: ***, ** and * imply 1, 5 and 10 percent level of significance, respectively.
Source: Survey results, 2016.

3.2. Empirical analysis

3.2.1. Determinants to the adoption of improved wheat varieties

In Sindh, Pakistan, improved wheat varieties are produced and marketed by the formal sectors and directly purchased by rural households from public like Sindh Seed Cooperation (SSC) and private companies include Bayer Pakistan (Private) Limited, FMC, Syngenta and Four Brothers Seeds Corporation Pakistan under a better quality assurance system was defined as improved or certified seed. In Rabi season (October–November), wheat is mainly grown in over all areas of Sindh, Pakistan and is harvested in March and May [6,7,70]. Probit regression model was employed in estimating factors that affect adoption of improved wheat varieties. The empirical results of the model are reported in Table 4. This study used dummy dependent variable, which takes the value 1 if the farmer adopted improved wheat varieties and 0 otherwise. The LR chi^2 value is statistically highly significant at 1 percent level, demonstrating the robustness of variables included in the probit regression model. Education plays a fundamental role in adopting of new agricultural technology; the coefficient of education is significant at 10 percent and positively associated to the adoption of improved wheat varieties. This results show that better educated farmers get technical information on new technology from research stations and extension contact. Further, educated farmers more likely to adopt improved wheat varieties, which is consistent with the findings of the studies [71–74], they found significant relation of education with adoption of improved wheat varieties. The coefficient of farming experience variable is significant at 5 percent and showing positive association with adoption of improved wheat varieties. This result implies that more experienced wheat growers have better technical knowledge, able to assess the ricks related with use of modern agricultural technology and are more likely to be getting possible profits from investment in new technology [37,75,76]. The

study further shows that the coefficient of farm size variable is also significant at 5 percent and positively associated with adoption of improved wheat varieties. The land as a basic input shows that large landholding farmers are more likely to have more opportunities to learn about modern technologies by first experimenting with innovations to see their results before adopting on large scale. This finding is confirmatory with the findings of the studies [8,19,72,73], who found positive effects of farm size on adoption of the new technology. The coefficient of distance to market is statistically insignificant and showing right positive linked with adoption of IWVs in the study area; this means distance increase to inputs market increase transaction and information costs, thus, reducing the likelihood of the farmers to adopt new wheat technology [64,72,77–80]. The coefficient of tube-well ownership is found to be significant at 5 percent, while the coefficient of extension contact is positive but not significant. Finally, the coefficient of credit facility is found to be significant at 5 percent and showing positive association with adoption of IWVs. Credit availability is a very important factor in adoption of new technology. This result implies that those wheat growers with credit facilities are more likely to adopt improved wheat varieties in the study area. This result is confirmatory with the findings of the studies [23,72,81].

Table 4. Parameter estimates the adoption of improved wheat varieties.

Variable	Coefficient	z	P>|z|	[95% Conf.	Interval]
Age	−0.0078 (0.0136)	−0.57	0.567	−0.0346818	0.0189987
Education	0.0402 (0.0236)	1.70*	0.089	−0.0060631	0.0865111
Experience	0.0396 (0.0209)	1.89**	0.059	−0.0014363	0.080819
Household size	0.0737 (0.0589)	1.25	0.211	−0.0417276	0.189311
Farm size	0.0273 (0.0135)	2.01**	0.044	0.0007342	0.0539923
Distance	0.0035 (0.0241)	0.15	0.884	−0.0438694	0.0509503
Tractor ownership	−1.0944 (0.3004)	−3.64***	0.000	−1.683318	−0.5055991
Tube-well ownership	0.5327 (0.2725)	1.96**	0.051	−0.0013344	1.066876
Extension	0.1368 (0.2182)	0.63	0.530	−0.2907848	0.5645794
Credit	0.4422 (0.2333)	1.90**	0.058	−0.015149	0.8997058
Constant	−1.1119 (0.6444)	−1.73*	0.084	−2.374994	0.1511511
LR chi^2 (10)	32.19				
Prob > chi^2	0.0004				
Pseudo R^2	0.1488				
Pseudo likelihood	−92.04176				

Note: Robust standard errors in parentheses. ***, ** and * imply 1, 5 and 10 percent level of significance, respectively.
Source: Survey results, 2016.

3.2.2. Marginal effect analysis

Adoption of improved wheat varieties is likely to be influenced by several socioeconomic characteristics of the wheat farmers. Table 5 reports the results of marginal effects analysis. The findings of marginal effects estimation show that education, farming experience, household size, landholding size, tube-well ownership, extension contact and credit availability positively influenced the adoption rate of improved wheat varieties in the study area. The marginal coefficients of

education level is (β_2 = 0.0082), which imply that 1 percent increase in formal education, the probability of adopting improved wheat varieties will increase at 0.0082 percent. Likewise, the coefficient of farming experience is (β_3 = 0.0081); this implies that 1 percent increase in farming experience; the adopting probability of the wheat grower would increase by 0.0081 percent. Whereas, the coefficient of household size is (β_4 = 0.0150). Further, the coefficient of farm size is (β_5 = 0.00055); this results implies that 1 percent increase in farm size the adopting probability of the wheat grower would increase by 0.0055 percent. The coefficients of tube-well ownership, extension contact and credit availability were positive and significant. These results imply that 1 percent increase in these variables the probability of adopting of improved wheat varieties will enhance by 0.11, 0.02 and 0.09 percent, respectively.

Table 5. Determining adoption of improved wheat varieties (Marginal Effect).

Variable	Marginal effect	z	P>|z|	[95% Conf.	Interval]
Age	−0.0016 (0.0028)	−0.57	0.568	−0.007093	−0.007093
Education	0.0082 (0.0047)	1.73*	0.084	−0.0011	0.01753
Experience	0.0081 (0.0041)	1.94**	0.053	−0.000094	0.016306
Household size	0.0150 (0.0119)	1.26	0.209	−0.00842	0.038561
Farm size	0.0055 (0.0026)	2.10**	0.036	0.000368	0.010809
Distance	0.0007 (0.0049)	0.15	0.884	−0.008963	0.010409
Tractor ownership	−0.2584 (0.0745)	−3.47***	0.001	−0.404576	−0.112353
Tube-well ownership	0.1111 (0.0574)	1.93**	0.053	−0.001456	0.223758
Extension	0.0279 (0.0446)	0.63	0.532	−0.05958	0.115437
Credit	0.0997 (0.0576)	1.73*	0.084	−0.013241	0.212803

Note: Robust standard errors in parentheses. ***, ** and * imply 1, 5 and 10 percent level of significance, respectively.
Source: Survey results, 2016.

4. Conclusions and policy implications

Adoption of improved high-yield variety is a key input factor for the enhancement of crop production and food security status of the farmers in Pakistan. On the other hand, in rural Pakistan, rate of adoption of improved wheat varieties is relatively low, especially among smallholder farmers. The main purpose of this research is to examine the determinants of adoption of improved wheat varieties in Sindh, Pakistan by using the probit model. This study used a random sampling method to collect the data from 240 wheat growers through a face to face interview. The results drawn from the estimations reveal that the adoption of improved wheat varieties by farmers in the study area was positively and significantly influenced by education, farming experience, landholding size, tube-well ownership, extension contact and access to credit. Based on the empirical findings of this paper, our study suggests that public and private sectors should encourage access to extension service to improve of dissemination of certified seed of wheat crop among the growers through trainings, workshops and seminars, respectively. Credit availability was found as one of the very important factors influencing the adoption of improved wheat varieties in the study areas. In rural areas of Pakistan, agricultural credit is mainly provided to the farmers by ZTBL, Commercial Banks, Domestic Private Banks, Microfinance Institutions and NGOs, respectively. Credit facilities are very

important for the growth of agricultural sector and rural development. Therefore, it is also recommend that formal sources of credit should supply timely and easy agricultural credit to farmers at the sowing time of wheat crop and farmers get more benefit.

Acknowledgments

The authors of this paper are sincerely thanks the editor and anonymous reviewers for their insight comments that have significantly improved the manuscript. The authors are also thankful to the College of Economics, Sichuan Agricultural University, Chengdu, China for its financial and moral support.

Conflict of interest

The authors of this research work declare that they have no conflict of interests regarding the publication of this paper.

References

1. Moyo S, Norton GW, Alwang J, et al. (2010) Peanut research and poverty reduction: Impacts of variety improvement to control peanut viruses in Uganda. *Am J Agric Econ* 89: 448–460.
2. Word Bank (2007) The world development report 2008: Agriculture for development. World Bank publications, Washington, DC.
3. Kassie M, Shiferaw B, Muricho G (2011) Agricultural technology, crop income, and poverty alleviation in Uganda. *World Dev* 39: 1784–1795.
4. Government of Pakistan (2017) Pakistan economic survey 2016–17. Agricultural statistics of Pakistan. Finance division: Government of Pakistan URI.
5. Ahmad F (2009) Food security in Pakistan. *Pak J Agric Sci* 46: 83–89.
6. Koondhar MA, HeGe, Magsi H, et al. (2016) Comparing economic efficiency of wheat productivity in different cropping systems of Sindh province, Pakistan. *J Saudi Soc Agric Sci*.
7. Buriro RA, Khooharo AA, Talpur GH, et al. (2013) Technical efficiency of wheat farming in Sindh province of Pakistan. *Pak J Agric Agric Eng Vet Sci* 29: 77–87.
8. Chandio AA, Jiang Y, Joyo MA, et al. (2016) Impact of area under cultivation, water availability, credit disbursement, and fertilizer off-take on wheat production in Pakistan. *J Appl Environ Biol Sci* 6: 10–18.
9. Fatima H, Khan MA (2015) Influence of wheat varieties on technical efficiency and production of wheat crop in Pakistan (in selected area of Punjab). *Sarhad J Agric* 31: 114–122.
10. Farooq A, Ishaq M, Yaqoob S, et al. (2007) Varietal adoption effect on wheat crop production in irrigated areas of NWFP. *Sarhad J Agric* 23: 481–485.
11. Chandio AA, Jiang Y, Magsi H (2016) Agricultural sub-sectors performance: An analysis of sector-wise share in agriculture GDP of Pakistan. *Int J Econ Finance* 8: 156.
12. Pandit DB, Islam MM, Sufian MA (2008) Participatory variety selection in wheat and its impact on scaling-up seed dissemination and varietal diversity. *Bangladesh J Agric Res* 32: 473–484.
13. Shah NA, Saeed I, Farooq A, et al. (2012) Adoption and economic impact of improved wheat varieties in rainfed pothwar, Punjab, Pakistan. *J Biotechnol Pharm Res* 3: 94–103.

14. Endrias G (2003) Adoption of improved sweet potato varieties in boloso sore woreda, sothern Ethiopia. M. Sc. Thesis, Alemaya University.
15. Belay K (2001) Factors influencing adoption of high yielding maize varieties in southwestern Ethiopia: An application of logit analysis. *Q J of Int Agric* 40: 149–167.
16. Wu HT, Ding SJ, Pandey S, et al. (2010) Assessing the impact of agricultural technology adoption on farmers' well-being using propensity-score matching analysis in rural China. *Asian Econ J* 24:141–160.
17. Sahu RP, Prasad A, Ram D (2010) Adoption of improved wheat cultivation technologies in Unnao district of uttar pradesh. *Indian Res J Ext Edu* 10: 25–28.
18. Mazid A, Amegbeto KN, Keser M, et al. (2009) Adoption and impacts of improved winter and spring wheat varieties in Turkey. International center for agricultural research in the dry areas (ICARDA).
19. Shiferaw B, Kassie M, Jaleta M, et al. Adoption of improved wheat varieties and impacts on household food security in Ethiopia. *Food Policy* 44: 272–284.
20. Tesfaye S, Bedada B, Mesay Y (2016) Impact of improved wheat technology adoption on productivity and income in Ethiopia. *Afr Crop Sci J* 24: 127.
21. Mulugeta T and Hundie B (2012) Impacts of adoption of improved wheat technologies on households' food consumption in southeastern Ethiopia. Economists (IAAE) triennial conference, 18–24 august, Foz do Iguacu, Brazil.
22. Kotu BH, Verkuijl H, Mwangi W, et al. (2000) Adoption of improved wheat technologies in Adaba and Dodola Woredas of the Bale highlands, Ethiopia. CIMMYT.
23. Odoemenem IU, Obinne CPO (2010) Assessing the factors influencing the utilization of improved cereal crop production technologies by small-scale farmers in Nigeria. *Indian J Sci Technol* 3: 180–183.
24. Al-Hassan R, Jatoe JBD (2002) Adoption and impact of improved cereal varieties in Ghana. Paper prepared for the workshop on the green revolution in Asia and its transferability to Africa. Organised by foundation for advanced studies in international development (FASID), from 8 th to 10 th December, 20002, in Tokyo, Japan.
25. Gamba P, Ngugi C, Verkuijl H, et al.(2003) Wheat farmers seed management and varietal adoption in Kenya. CIMMYT.
26. Briema AEE, Elnow MM, Elimam EE, et al. (2013) Impact of improved seeds on small farmers productivity, income and livelihood in Umruwaba locality of north Kordofan, Sudan. *Russ J Agric Socio-Econ Sci* 20: 203–208.
27. Mussei A, Mwanga J, Mwangi W, et al. (2001) Adoption of improved wheat technologies by small-scale farmers in Mbeya district, southern highlands, Tanzania. CIMMYT.
28. Khonje M, Manda J, Alene AD, et al. (2015) Analysis of adoption and impacts of improved maize varieties in eastern Zambia. *World Dev* 66: 695–706.
29. Ahmad N, Jan I, Ullah S, et al. (2015) Impact of agricultural credit on wheat productivity in district Jhang, Pakistan. *Sarhad J Agric* 31: 65–69.
30. Fayaz M, Jan D, Jan AU, et al. (2006) Effects of short term credit advanced by ZTBL for enhancement of crop productivity and income of growers. *J Agric Biol Sci 1*: 15–18.
31. Bashir MK, Gill ZA, Hassan S, et al. (2007) Impact of credit disbursed by commercial banks on the productivity of sugarcane in Faisalabad district. *Pak J Agric Sci* 44: 361–363.

32. Mwangi M, Kariuki S (2015) Factors determining adoption of new agricultural technology by smallholder farmers in developing countries. *J Econ Sustainable Dev* 6: 208–216.
33. Ahmed AU, Bagchi KK (2004) Factors and constraints for adopting new agricultural technology in Assam with special reference to Nalbari district: An empirical study: J. Contemp. Indian Policy.
34. Gabre-Madhin EZ, Haggblade S (2004) Successes in African agriculture: Results of an expert survey. *World Dev* 32: 745–766.
35. Uaiene RN, Tenywa JS, Taulya G, et al. (2011) Determinants of agricultural technology adoption in Mozambique. Discussion papers, No. 67E.
36. Ali A, Erenstein O, Rahut DB (2014) Impact of direct rice-sowing technology on rice producers' earnings: Empirical evidence from Pakistan. *Dev Stud Res Open Access J* 1: 244–254.
37. Chandio AA, Jiang Y (2018) Determinants of adoption of improved rice varieties in northern Sindh, Pakistan. *Rice Sci* 25: 103–110.
38. Frongillo EA, Olson CM, Rauschenbach BS, et al. (1997) Anne Kendall nutritional consequences of food insecurity in a rural New York state county. Institute for research on poverty discussion paper, NO. 1120–97.
39. Awotide AB, Abdoulaye T, Alene A, et al. (2014) Assessing the extent and determinants of adoption of improved cassava varieties in south-western Nigeria. *J Dev Agric Econ 6*: 376–385.
40. Diiro GM (2013) Impact of off-farm income on agricultural technology adoption intensity and productivity. IFPRI.
41. Reardon T, Stamoulis K, Pingali P (2007) Rural nonfarm employment in developing countries in an era of globalization. *Agric Econ* 37: 173–183.
42. Chang Y, Chatterjee S, Kim J (2014) Household finance and food insecurity. *J Fam Econ Issues* 35:499–515.
43. Chandio AA, Jiang Y, Wei F, et al. (2017) Famers' access to credit: Does collateral matter or cash flow matter?—Evidence from Sindh, Pakistan. *Cogent Econ Finance* 5: 1369383.
44. Gundersen C, Gruber J (2001) The dynamic determinants of food insufficiency. Second food security measurement and research conference, food assistance and nutrition research report.
45. Ribar D, K Hamrick (2003) An analysis of poverty and food sufficiency dynamics. Washington, DC, USDA economic research service.
46. Ali A, Khan MA (2013) Livestock ownership in ensuring rural household food security in Pakistan. *J Anim Plant Sci* 23: 313–318.
47. Owusu V, Abdulai A, Abdul-Rahman S (2011) Non-farm work and food security among farm households in northern Ghana. *Food Policy* 36: 108–118.
48. Kassie M, Ndiritu SW, Stage J (2014) What determines gender inequality in household food security in kenya? Application of exogenous switching treatment regression. *World Dev* 56: 153–171.
49. Obisesan A (2014) Gender differences in technology adoption and welfare impact among nigerian farming households. *MPRA Pap* No.58920.
50. Lavison RK (2013) Factors influencing the adoption of organic fertilizers in vegetable production in accra. M. Sc. Thesis, Ghana University.
51. Adeoti AI (2008) Factors influencing irrigation technology adoption and its impact on household poverty in Ghana. *J Agric Rural Dev Trop Subtrop* 109: 51–63.
52. Debebe S, Haji J, Goshu D, et al. (2015) Speed of improved maize seed adoption by smallholders farmers in southwestern Ethiopia: Analysis using the count data models. *J Agric Econs, Extens Rural Develop* 3: 276–282.

53. Simtowe F, Kassie M, Diagne A, et al. (2011) Determinants of agricultural technology adoption: The case of improved pigeonpea varieties in Tanzania. *MPRA Pap* 50:325–345.
54. Dansoabbeam G, Bosiako JA, Ehiakpor DS, et al. (2017) Adoption of improved maize variety among farm households in the Northern Region of Ghana. *Cogent Econ Finance* 5: 1416896.
55. Hagos BG, Hadush M (2017) Does improved wheat seed adoption benefit farmers? Empirical evidence from Southern Tigrai, Ethiopia. *J Agric Crops* 3: 1–11.
56. Adesina AA, Baidu-Forson J (1995) Farmers' perceptions and adoption of new agricultural technology: Evidence from analysis in Burkina Faso and Guinea, West Africa. *Agric Econ* 13: 1–9.
57. Aldosari F, Shunaifi MSA, Ullah MA, et al. (2017) Farmers' perceptions regarding the use of information and communication technology (ICT) in Khyber Pakhtunkhwa–northern Pakistan. *J Saudi Soc Agric Sci* 2017.
58. Zhang Y, Wang L, Duan Y (2016) Agricultural information dissemination using ICTs: A review and analysis of information dissemination models in China. *Inf Process Agric* 3: 17–29.
59. Government of Pakistan (2010) Pakistan economic survey 2010–11. Finance division: Government of Pakistan URI.
60. Foster AD, Rosenzweig MR (2010) Microeconomics of technology adoption. *Annu Rev Econ* 2: 783–789.
61. Janvry AD Dustan A, Sadoulet E (2010) Recent advances in impact analysis methods for ex-post impact assessments of agricultural technology : Options for the consultative group on international agricultural research (CGIAR). Independent science and partnership council.
62. Asfaw S, Shiferaw B, Simtowe F, et al. (2012) Impact of modern agricultural technologies on smallholder welfare: Evidence from Tanzania and Ethiopia. *Food Policy* 37: 283–295.
63. Feleke S, Zegeye T (2006) Adoption of improved maize varieties in southern Ethiopia: Factors and strategy options. *Food Policy* 31: 442–457.
64. Asfaw S, Shiferaw B, Simtowe F, et al. (2011) Agricultural technology adoption, seed access constraints and commercialization in Ethiopia. *J Dev Agric Econ* 3: 477.
65. Kohansal MR, Firoozzare A (2013) Applying multinomial logit model for determining socio-economic factors affecting major choice of consumers in food purchasing: The case of Mashhad. *J Agric Sci Technol* 15: 1307–1317.
66. Feder G, Just RE, Zilberman D (1985) Adoption of agricultural innovations in developing countries: A survey. *Econ Dev Cultural Change* 33: 255–298.
67. Heisey PW, Tetlay KA, Ahmad Z, et al. (2010) Varietal change in post-green revolution agriculture: Empirical evidence for wheat in Pakistan. *J Agric Econ* 44: 428–442.
68. Gao XM, Wailes EJ, Cramer GL (1995) Double-hurdle model with bivariate normal errors: An application to U.S. rice demand. *J Agric Applied Econ* 27: 363–376.
69. Matijevic-Aleksic N, Dulic B, Rolovic Z (2012) Understanding the adoption of systemic innovations in smallholder agriculture: The system of rice intensification (SRI) in Timor Leste. *Agric Syst* 108: 64–73.
70. Khokhar B, Hussain I, Khokhar Z (2010) Effect of different irrigation frequiencies on growth and yield of different wheat genotypes in Sindh. *Pakistan J Agric Res* 23: 108–112.
71. Ullah A, Shah SNM, Zheng S, et al. (2014) Impact of education and certified seeds on wheat production in Kohat, Pakistan. *Asian J Agric Ext Econ Sociol* 4: 42–48.
72. Leake G, Adam B (2015) Factors determining allocation of land for improved wheat variety by smallholder farmers of northern Ethiopia. *J Dev Agric Econ* 7: 105–112.

73. Kebede D, Ketema M, Dechassa N, et al. (2016). Determinants of adoption of wheat production technology package by smallholder farmers: Evidences from eastern Ethiopia. *Turkish J Agric-Food Sci Technol* 5: 267–274.
74. Mirani Z, Leske GW, Labano AH, et al. (2002) Farmers' adoption of recommended technology for rice in larkana district of sindh province of Pakistan. FAO, Rome, Italy.
75. Sall S, Norman D, Featherstone AM (2000) Quantitative assessment of improved rice variety adoption: The farmer's perspective. *Agric Syst* 66: 129–144.
76. Ahmad N, Jan I, Ullah S, et al. (2015) Impact of agricultural credit on wheat productivity in district Jhang, Pakistan. *Sarhad J Agric* 31: 65–69.
77. Zegeye T, Taye G, Tanner D, et al. (2001) Adoption of improved bread wheat varieties and inorganic fertilizer by small-scale farmers in Yelmana Densa and Farta Districts of northwestern Ethiopia. Ethiopia agricultural research organization (EARO), CIMMYT.
78. Beshir H, Emana B, Kassa B, et al. (2012) Determinants of chemical fertilizer technology adoption in north eastern highlands of Ethiopia: The double hurdle approach. *J Res Econ Int Finance* 1: 39–49.
79. Ersado L, Amacher G, Alwang J (2004) Productivity and land enhancing technologies in northern Ethiopia: Health, public investments, and sequential adoption. *Am J Agric Econ* 86: 321–331.
80. Okuthe IK, Ngesa FU, Ochola WW (2000) Socio-economic determinants of adoption of improved sorghum varieties and technologies among smallholder farmers in Western Kenya. Ministry of Agriculture and Egerton University, Kenya.
81. Tura M, Aredo D, Tsegaye W, et al. (2010) Adoption and continued use of improved maize seeds: Case study of central Ethiopia. *Afr J Agric Res* 5: 2350–2358.

AIMS Press