Logit Models for Identifying the Factors that Influence the Adoption of Barley Production Technologies in Low Rainfall Areas

Emad K. Al-Karablieh*✉, Ahmad Sh. Al-Rimawi* and Doukhi A. Hunaiti**

ABSTRACT

A random sample of 300 barley farmers was interviewed during the cropping season 2002/2003 to investigate the factors explaining technology adoption of barley production technologies introduced by the national program. Logit model was used to estimate the relationships of adoption decision and the socioeconomic factors of farmers. Results showed that farm size, farmers' education, household income and availability of household labor are the most significant factors affecting the adoption of barley production technologies. Sharecropping, farmers' age and farm size have negative influence on the adoption of fertilizers, due to the increase in the operational costs. Education is the only factor with a positive effect on the adoption of fertilizers.

The sharecropper farmer is more likely to adopt the seed drill than other types of land tenure. The adoption of seed drills was negatively associated with farmers' age, land ownership, soil fertility and household size. Land ownership and family labor are both factors which negatively affect the adoption decision of herbicide application. Ecological zone, level of education, land ownership, soil depth, sharecropper farmers and percentage of hired labor were positively associated with the chances of adoption of new seed varieties, older farmers may be less willing to adopt new varieties. Agricultural policies could be used to create the conditions that would encourage farmers to adopt new technologies such as promoting proper land use planning, land consolidation, small plots lease system, providing incentives to use land according to suitability and comparative advantage, ensuring custom hiring services of machinery and provide an opportunity for extension services to inform farmers about new production technologies that increase farm productivity.

Keywords: Technology adoption, Logit models.

INTRODUCTION

The agricultural research systems are generally responsible for generating and developing innovations for increasing agricultural productivity. Technology development and transfer play a crucial role in attaining the main goal to increase agricultural output, productivity and farmers' income. Adoption of recommended technologies implies that technologies are relevant to the farmers' circumstances. If farmers become aware of technologies or modifications in the use of resources that are relevant to their circumstances and can improve their farm production and thus their welfare, they will most likely adopt these changes (World Bank, 2001).

* Department of Agricultural Economics and Agribusiness Management, Faculty of Agriculture, University of Jordan.
✉Email: Karablie@ju.edu.jo
** Associate Professor, Agricultural Economics and Rural Development, Faculty of Agriculture, Mu'tah University.
Received on 19/5/2008 and Accepted for Publication on 11/11/2008.

Barley is principally produced in Jordan in rainfed areas and mainly in low rainfall areas (150-400 mm/year). Average barley production was 28.5 thousand tons for the period (2001-2006), with an average cultivated area of 80 thousand hectares, while the average harvested area is 33.8 thousand hectares for the same period. Production varies considerably from year to year depending on rainfall amount and distribution. Even in the best production years, the national harvest covered only about 5% of the domestic requirements. Imports of grain normally covered through commercial channels an average of 750 thousand tons per year. The barley import requirement for the year 2006 was estimated to be 876 thousand tons whereas the national production was only 18.4 thousand tons harvested from 36.1 thousand hectares, while the cultivated areas of barley were 71.8 thousand hectares.

The Government of Jordan recently re-encourages barley producers to increase barley production by paying world market prices for their product in addition to an allowance of US$ 70 per cultivated hectare of barley. The official controlled prices change every year prior to cropping season. Nevertheless, farmers of the rainfed areas are sequential decision-makers, they wait for sufficient rainfall between October 15th and the end of December to decide on planting barley. Other farmers, who raise livestock, take the risk to plant barley before first rainfall in order to secure their livestock with the minimal feed requirements of green barley and straw. Consequently, the planted areas and yield production quantities vary from year to year. The price policy alone is not sufficient to increase barley production in Jordan as a whole. Al-Karablieh *et al.* (2002) found that the procurement price of cereal prior to the growing season is not an effective tool to increase domestic cereal production. They failed to find any significant positive price effect either on cereal production directly or on the area planted.

LITERATURE REVIEW

There is a potential for increasing barley production in the rainfed areas through the use of better technologies. The improved barley production technologies are introduced in packages that include several components, yet with low adoption rates. These include new seed varieties, fertilizers and corresponding cultivation practices. While the components of a package may complement each other, some of them can be adopted independently. However, new production technologies cannot be functional unless they are applicable in farm conditions, financially profitable, economically feasible, socially acceptable, sound to environments, sustaining to natural resources and widely adopted by farmers over large areas. A supply of appropriate technology is essential if extension services are to be worthwhile (Munyua, Adams and Thomson, 2002). Many technologies are becoming available to farmers but not adopted by the majority of farmers. The question arises: why some new technologies are not widely adopted by farmers? Is it the lack of compatibility of new technologies with the existing farming systems and/or are there other socio-economic factors that inhibit and constrain their adoption? (Sheikh et al., 2003). The World Bank (2001) reported that poor understanding by researchers and extension staff of the circumstances of farm households (that is the lack of farming system perspective) and poor linkages between researchers, extension staff and farmers are associated with an inability of applied research institutions to develop or adapt a technology that is appropriate for many of the common farming systems.

According to Rogers (1995), the rate of adoption of new technologies depends on socioeconomic characteristics, personal factors and communication behavior. These characteristics include age, years of education and size of the farm. Tripathi and Psychas (1992) presented the major socioeconomic factors which determine whether individual farmers and communities choose to adopt a farming technology. These include land tenure, labor requirements, management complexity and profitability. The rate of adoption of a new technology is subject to its profitability, the degree of risk and uncertainty associated with it, capital requirements, agricultural policies and the socioeconomic characteristics of farmers (Griffin et al., 1995). Although the exact classification of characteristics differs by author, these characteristics were grouped by Feder et al. (1985) into four categories; farm characteristics, household characteristics, technology characteristics and institutional factors. Research findings reveal that individual characteristics influence observed adoption decisions (Deuson and Day, 1990; Jarvis, 1981; Kebede et al., 1990; Sarap and Vashist, 1994). They also suggest that the use of information on the relationship between these characteristics and observed behavior can enhance policies for adoption.

Qasem and Mitchell (1986), Haddad (1988) and Duwayri (1991), discussed the factors that hinder or explain technology adoption within an economic framework. These factors include environmental constraints such as the physical features of the land, agro-climatic conditions, erosion, irregular and erratic rainfall precipitation. Thus, there are a high risk and uncertainty of drought occurring throughout the growing season. Technical constraints to production include a variety of factors such as lack of adequate and appropriate infrastructures and crop management practice. An appropriate technology was unavailable, or even sometimes an inappropriate technology was developed and transferred to farmers. Low productivity is due to the use of unsuitable land for cultivation and irregular rainfall. Farmers minimize their risks by limiting inputs to seeds and ploughing. However, there are many factors limiting barley production in rainfed areas and the importance of adopting a technology to suit local conditions must be stressed. Kebede et al. (1990) argue that the adoption of agricultural production technologies in developing countries is influenced by economic and social factors as well as by physical and technical aspects of farming and the risk attitude of farmers. From a policy standpoint, well targeted policies that provide incentives to use land according to suitability and comparative advantage can enhance overall social welfare by increasing income as well as by reducing degradation (Okumu, 2002).

Socio-economic constraints include the expected profitability of crops, the risk of drought, prices, the cropping systems, land tenure education and size of holdings, which limit the adoption of technology. Certain technologies (such as seed drills) are not adopted by farmers because their returns do not justify the cost for many farms. Avoiding the risk of crop failure is often more important to farmers than maximizing yields in good years. Farmers in low rain-fed areas minimize risk by growing drought-tolerant feed crops, such as barley and implementing a crop diversification to minimize outcome variations. Subsistence farmers are satisfied with their barley yield and are unlikely to adopt new technologies to increase their production, especially if they can buy subsidized barley products (Shideed and El Mourid, 2005; Shepley, 1988). The profit maximization theory is not sufficient enough to explain the adoption process of a new technology and the decisions made by farmers. Capital scarcity farmers, especially small farmers and risk consideration farmers are rarely in a position to adopt a complete package. The missing elements in the dissemination of barley production are failing to consider the socio-economic factors for farmers, where the producer skill in receiving and decoding information, farm-level resources, land quality, agro-climatic conditions and farming systems are felt to be among the important factors influencing the demand for new technologies. Components initially adopted will be those which provide the highest rate of return on total expenses (Byerlee and de Polanco, 1986). Bayri and Furtan (1989) found in their study that the impact of new wheat technology in Turkey shows that farmers with a high degree of education are moving away from the production of wheat and are instead concentrating on the production of other crops that require more intensive management such as vegetables, cotton and tobacco.

Institutional constraints of technology adoption are related to weak linkage in the organization of research and extension services and instability of agricultural policy and regulations. Market constraints include factors such as the lack of appropriate machinery, seeds, fertilizers, pesticides and labor which hinder the widespread diffusion of new technologies. The new technologies from the experimental stations have not been adopted by farmers as a complete package, because of the risk and because of the infrastructure necessary for the increased supply of inputs which were not sufficiently developed. Ransom et al. (2003) reported the lack of seeds to be the major constraint to the adoption of improved varieties, while the lack of knowledge of new varieties was the second major constraint for farmers in Nepal. This suggests that the packages are too complex to be adopted by the rainfed farmers and that their adoption may be gradual and on the long-term.

Information about these and other factors needs to be made available to planners. Such qualitative data in Jordan is lacking, while there is a demand for detailed socio-economic and socio-cultural studies of rural communities that would give a deeper insight into the working activities of such communities. The issues outlined above require that further research should address the socio-economic dimensions of the structural change in the rain-fed agriculture. Interest in the social and economic aspects of technology development and transfer has increased considerably in the recent years.

OBJECTIVES OF THE STUDY

The goal of the study is to provide a feedback to researchers, extension agents and policy makers about the soundness of the new technologies and the constraints that limit their adoption, to promote the adoption of new technologies and to have a positive socio-economic impact at the farm, at national and regional levels. The specific objective of this article is to examine the socio-economic factors explaining technology adoption of barley production to better understanding of farming systems and farming communities. A further objective is the identification of constraints (technical, socio-economic, policy-related) that hinder the wide adoption of introduced technologies and working on their solutions.

METHODOLOGY

The data employed were designed to measure the factors influencing the diffusion of new barley technologies in the rainfed areas. Irbid, Al-Mafraq, Amman and Al-Karak governorates represent 85% of the rainfed barley cropping areas in Jordan. A two-stage sampling procedure was employed. A number of villages was selected from these governorates and then a random sample of 300 barley farmers was selected and interviewed during July-October of the cropping season 2002/2003. Out of this sample, 93 were in rainfall zone 1 of less than 200 mm rainfall, 134 farmers were located in agro-climatic zone 2 (200-300 mm rainfall) and 73 farmers in zone 3 (300-400 mm rainfall).

An adopter is defined, in this study, as a farmer who had adopted at least one component of the technological package of barley production technique demonstrated by the national program. Farmers may choose parts rather than the whole package. Ryan and Subrahmanyan (1975) and Szmedra *et al.* (1990) postulate that each part of the package might be looked upon by farmers as a less risky activity than the complete package in terms of what the farmer could lose in the event of crop failure. For example, new seed varieties, fertilizers and corresponding cultivation practices can be adopted independently. So, many farmers adopt pieces of the package rather the entire package (Al-Karablieh and Salem, 1996). Szmedra *et al.* (1990) suggest that providing new technological information to producers should involve the presentation of a complete technological package as well as appropriate modifications or partial packages.

The variables expected to be positively correlated with the adoption of new technologies are: (1) the information-related variables; namely, years of schooling and farmer’s age, (2) the availability of household labor, (3) farm-level endowments; namely rainfall zones and locations, (4) land tenure of agricultural land, (5) non-farm sources of income and total income of the household and (6) the household structure (Al-Karablieh and Salem, 1999; Morris and Doss,1999; Sarap and Vashist, 1994).

To investigate the factors explaining technology adoption, the data were analyzed using the limited dependent variable regression. Adoption is treated as a binary variable, either adopted or non-adopted of recommended production practice. Y_i is defined as a sequence of dependent binary random variable taking the values of 1 or 0, X_i is a K-vector of known explanatory variables, B_o is a K-vector of unknown parameters and F is a certain known function. The functional forms most frequently used in applications are linear probability, probit and logit models (Amemiya, 1981). The linear probability model has a defect in that F of this model is not a properly distributed function, as it is not constrained to lie between 0 and 1. However, the probit model, like many other models using the normal distribution, may be justified by appealing to a central limit theorem. A major justification for the logit model is that the logistic distribution function is similar to a normal distribution function but with a much simpler form. With regard to probit and logit models, Amemiya (1981) concluded the difficulty to distinguish them statistically unless one has an extremely large number of observations. The choice between them is largely one of convenience and program availability (Perry et al., 1986; Amemiya, 1981; Hanushek and Jackson, 1977; Shidded and El Mourid, 2005; Gujarati, 1995). The logit model, however, is more common (Kebede et al., 1990; Bagi, 1983; Jarvis, 1981; Sarap and Vashist, 1994).

For this purpose, two models were analyzed using the limited dependent variable regression. Consider the following regression model as described by Maddala (1992):

$$y_i^* = \beta_0 + \sum_{j=1}^{k} \beta_j x_{ij} + u_i \qquad (1)$$

where (y_i*) is not observed. It is commonly called a "latent" variable, x's are the socio-economic factors, u_i is the error term. However, the latent variable can only be observed as a dichotomous variable as (y_i) is defined by:

$$y_i = \begin{cases} 1 & \text{if } y^* > 0 \\ 0 & \text{otherwise} \end{cases}$$

where (y_i) is a variable measuring the adoption/non-adoption of improved technologies. If the cumulative distribution of u_i is logistic, we have what is known as logit model as follows:

$$\log \frac{P_i}{1-P_i} = \beta_0 + \sum_{j=1}^{k} \beta_j x_{ij} \qquad (2)$$

where P_i is the probability of adoption. The left-hand side of this equation is called the *log-odds* ratio, thus the log-odds ratio is a linear function of the explanatory variables.

The logit models were used to assess the objectives of this study depending on adoption rate and degree of adoption, where the probability of adoption depends on the characteristics of the farmers. If the coefficient of a particular variable is positive, it means that higher values of that variable result in a higher probability of adoption, while a lower value of a particular variable implies a lower probability of adoption (Sarap and Vashist, 1994).

As indicated by Maddala (1992) and Griffiths *et al.* (1993), there is a problem with the use of the conventional R^2 measure when the explained variable has only two values. They suggest the proportion of correct predictions as a measure for the goodness of fit.

To represent the adoption of these practices, the dependent variables for new varieties, early planting, seed drill and combine, herbicides and fertilizers are treated as binary variables, whereas the recommended technology is either adopted or not. The following variables were taken in the analysis as independent variables.

Explanatory Variables	Mean	Description
Farm Size	103.87	farm size (dunums)
Per.Hired	0.59	percentage of hired labor input to total labor inputs
Zone200	0.31	a dummy variable with a value of (1) if the farm is located in the rainfall zone of 200 mm and (0) otherwise
Zone300	0.24	a dummy variable with a value of (1) if the farm is located in the rainfall zone of 300 mm and (0) otherwise
Family Labor	1.66	the number of economically active household members
Education	3.94	farmer's years of schooling
Total Income	257	total household income from farm and non-farm sources (JD)
Owner	0.87	a dummy variable with a value of (1) if the farmer owns the land and(0) otherwise
Share	0.34	a dummy variable with a value of (1) if the farmer is sharecropper and (0) otherwise
Stony	0.20	a dummy variable with a value of (1) if the farm soil is stony and (0) otherwise
Quality	0.56	a dummy variable with a value of (1) if the farm soil is fertile and (0) otherwise
Depth	0.49	a dummy variable with a value of (1) if the farm soil is deep and (0) otherwise
Age	55	farmer's age in years

Firm size is expressed in dunums and is expected to have a positive relationship with the adoption of new technologies. The components of the barley production technologies used in the analysis are represented as follows:

Technologies	percent	a value of (1) if the farmer adopts specific technology and (0) otherwise
Seed drill	0.06	if the farmer adopts seed drill
Fertilizers	0.11	if the farmer adopts fertilizers
Herbicides	0.13	if the farmer adopts herbicide application
New seed varieties	0.32	if the farmer adopts new seed varieties

Data on other components of the technological packages was not available, so the analysis was restricted to above components. Assuming a normally distributed error term, the maximum likelihood estimation procedure was used to estimate the logit models using a TSP program.

RESULTS AND DISCUSSION

Profile of Barley Farmers

Farmers' socioeconomic characteristics have a bearing on their behavior with respect to innovation adoption. The average age of farmers was 55 years, the average family size was 10 and the average family members working in farms were 1.66 person. Percentage of illiteracy was 44%, average education level was 3.9 years of education. As displayed in Table (1), all fitted models are statistically significant and have a high percent of correct predictions for all components.

The Recommended Barley Technology Package

The national programs, in a close collaboration with ICARDA, define the most suitable farming practices for barley production in the low rainfall area in Jordan. The practices which they recommend led to a significant increase in barley grain and straw, and were called full-package technologies. These technologies have the following characteristics: applicable by farmers, available at reasonable cost and do not require unreasonable changes in the farming system. The full-package includes the following practices (Oglah et al., 1994): (1) land preparation by using chisel plow, (2) seed bed preparation by duck foot plow, (3) early sowing before first rainfall (Mid-October to mid-November), (4) sowing by seed drill, (5) using a seed rate of 70-100 kg/ha., (6) using an improved variety of seed such as Rum, ACSAD 176 or Deir Alla 106, (7) using fertilizers at the rate of 50-100 kg/ha of diammonium phosphate incorporated into soil at the time of sowing depending on rainfall zones and (8) using chemical herbicides for weed control, especially in high rainfall zones. Results in farmer fields showed that grain yield can be increased by 14.7% when the improved variety Rum is used and by 40.7% when fertilizer is applied. On the other hand, straw yield was increased by 19.3% as a result of using the improved variety and by 43.6% in response to fertilizer (Mamdouh et al., 1994). Results indicate a large increase in the use of full-package technology. The full-package resulted in a significant barely yield increase over yield obtained with traditional practices, ranging form 24% to 275%. Rainfall use efficiency, expressed as kg grain/1 mm rain, was greater in the full-package and was 5.3 vs. 3.3 kg/mm for the 1991/1992 season (Mamdouh and Haddad, 1994).

Adopting Seed Drills

Adoption of seed drill is largely influenced by farm size, education, soil depth and land topography. Rainfall zones play a significant role in the adoption of seed drill, farmers in sufficient rainfall zones are more likely to adopt seed drill than farmers in low rainfall zones. The reason could be that return of barley in low rainfall zones does not justify the additional cost of seed drill.

The sharecropper farmer is more likely to adopt the seed drill than other types of land tenure, since they usually lease additional land on a sharecropping basis and cultivate it with full-time farming. Seed drill is more likely to be used by farmers who have more years of schooling, and limited farm sizes. This is to be expected, since it is easy to convince educated farmers with the benefits of new technologies.

The adoption of seed drills was negatively associated with farmer's age, land tenure, soil fertility and household size. Larger household size has a negative influence on the adoption of seed drill, as more family labor could be involved in the sowing operation. As the age increases, it seems to exist less interest in technology adoption. Old framers are more confident in their endogenous knowledge of farming practices.

Fertilizers' Application

Six out of 13 variables are statistically significant and could explain the adoption of fertilizers. Land tenure and sharecropping have negative influences on the adoption of fertilizers. Due to the increase in the operational costs, the farmer in both cases tends to save money for his family where the family labor is a part of it. As the age of the farmer increases, it seems that the farmer would be less interested in technology adoption. The last factor with the negative influence is the farm size. As the farm size increases, the farmer needs to use more labor and a higher quantity of fertilizers which in turn increases the total farm cost. This result supports the results of Kebed et al. (1990), Jarvis (1981) and Sarap and Vashist (1994) who found that the adoption of new cultivars and fertilizer use are significantly influenced by the farm size.

Education is the only factor with a positive effect on the adoption of fertilizers, because it is easier to convince educated people than illiterates with the new technology. Higher education provides farmers with greater access to agricultural information and they tend to become more innovative than less educated and illiterate farmers. This result supports the results of Igodan et al. (1988) and Salasya et al. (1998) on the socioeconomic factors influencing fertilizer adoption.

Herbicides' Application

The prediction rate compares a model’s predictions of the adoption decision with the actual choice made by the respondent. Results indicate that the model correctly predicts the decision to adopt herbicides by 89 percent. The effects of household income derived from farming, and education are expected to be positive. In addition, the farmer as a sharecropper is expected to have a positive effect in order to reduce the operational cost which comes from hired labor. Also, as the soil depth increases and land fertility increases, the adoption of herbicide application increases. These factors are expected to encourage the farmer to use more herbicides to get rid of weeds in the field. However, land tenure and family labor are both factors which affect the adoption decision negatively, to save more money for the farmer's family and the family labor will take over the weeding process. This is expected, since manual weeding is usually being a female task (Rassam, 1984). This result is in line with the results obtained by Owens et al. (1997) and Morris and Doss (1999).

Adopting New Seed Varieties

Nine of thirteen variables examined were significantly related to the adoption of new varieties; of these, only stony land, family labor and age of farmer were negatively related to the adoption. The negative correlation of stony land implies increasing the cost which stems from additional agricultural practices. Increasing the family labor implies that the family size increases. This will decrease the adoption scores as a result of the pressure on the household to use its low income to feed itself rather than investing it in modern inputs and innovations, which may be saddled with risks and uncertainties. More innovative farmers, therefore, tend to have smaller families (Igodan et al., 1988).

Table (1): Maximum likelihood estimates of logit models for the adoption of new production technologies.

Technology	**Seed drill**	**Fertilizers**	**Herbicides**	**New Seed Varieties**
Constant	-1.904 c	-17.452	-20.776	-2.442 a
Farm Size	0.0008 c	-0.0011 c	-0.0001	0.0004
Per.Hired	-0.0444	-0.4329	-0.4108	0.5559 b
Zone200	1.4322 c	18.9728	19.1302	1.0531 a
Zone300	1.0894	19.7633	19.3639	0.3479
Family Labor	-0.1794 b	-0.1386 b	-0.0997 c	-0.0770 c
Education	0.1356 a	0.1308 a	0.1369 a	0.1490 a
Total Income	0.0030	-0.0013	0.0076 b	-0.0006
Owner	-1.0434 b	-1.5218 a	-0.9779 b	0.5801 b
Share	0.2680	-1.1569 a	0.6908 b	0.8782 a
Stony	0.7189 b	-0.4782	0.3878	-0.3585 c
Quality	-0.7108 b	-0.0190	-0.5485 b	-0.1503
Depth	0.7016 c	0.2701	1.0578 a	0.5988 a
Age	-0.0422 b	-0.0364 a	-0.0131	-0.0190 b
-2 Log Likelihood	223.05	339.77	352.44	621.1
Sum Square Residuals	29.71	49.06	51.75	103.27
R^2	0.142	0.163	0.199	0.188
Percent of correct prediction	0.940	0.894	0.890	0.737

a, b and c indicate statistical significance at the 1%, 5% and 10% levels, respectively.

A negative relationship between age and likelihood of variety adoption exists due to younger farmers being more likely to be willing to innovate, older farmers may be less willing to adopt new verities given the heavy labor requirements. These results back up the result of Neil and Lee (1999). In the new seed varieties adoption equation, ecological zone, level of education, land tenure, soil depth, sharecropper farmers and percentage of hired labor were positively associated with the chances of adoption. This result supports the result obtained by Salasya et al. (1998) on the adoption of improved maize varieties in Kenya. Farm size seems to be unaffected by the adoption of new varieties. This is consistent with many other studies such as (Ruttan, 1977; Barker and Herdt, 1985). Furthermore, Matuschke et al. (2007) concluded that neither the farm size nor the subsistence level influences the adoption decision of new varieties, but the access to information and credit does in India.

The interpretation of the individual estimated parameters given in Table 1 must be done with care, since the left hand side of equation (1) is the logarithm of the odds of choice, not the actual probability. To interpret the effect of change in the explanatory factors on the probability of adoption, we need to solve for the change in the probability by taking the derivatives of the log likelihood function with respect to the coefficients. Initially, all dichotomous variables are set at zero and continuous variables at their means. Table (2) shows the marginal effects of the explanatory variables on the probability of adoption. When these variables have the value of 1 (adopter), all other variables are unchanged. For continuous variables, the value of a variable shows the average impact when the variable is allowed to vary over a specified range and all other variables are unchanged.

As farm size increases, the probability of adopting a combine harvester will increase by 0.05% per one additional dunum. Also, as the family labor increases by one member, the probability of adopting a combine harvester will decrease by 1.39%. However, as the education of the farmer increases by one year and as the total income increases by one Jordanian dinar, the probability of adoption will increase by 0.51% and 0.05%, respectively. The positive effect of farm size and total income can be generalized for the other technologies to be adopted except in the case of fertilizer application because it is accompanied with an increase in operational costs. In the case of family labor, the negative effect on technology adoption can be generalized. This can be explained either due to the increase in operational costs or due to that the farmer tries to save income for his family living costs.

Table (2): Marginal effect of explanatory variables on the probability of the adoption of new production technologies.

Technology	Seed drill	Fertilizers	Herbicides	New Seed Varieties
Farm Size	0.0000	-0.0001	0.0000	0.0001
Per.Hired	-0.0022	-0.0372	-0.0371	0.0982
Zone200	0.0726	1.6321	1.7258	0.1861
Zone300	0.0552	1.7001	1.7469	0.0615
Family Labor	-0.0091	-0.0119	-0.0090	-0.0136
Education	0.0069	0.0113	0.0123	0.0263
Total Income	0.0002	-0.0001	0.0007	-0.0001
Owner	-0.0529	-0.1309	-0.0882	0.1025
Share	0.0136	-0.0995	0.0623	0.1552
Stony	0.0364	-0.0411	0.0350	-0.0634
Quality	-0.0360	-0.0016	-0.0495	-0.0266
Depth	0.0356	0.0232	0.0954	0.1058
Age	-0.0021	-0.0031	-0.0012	-0.0034

Generally, the results indicate that a farmer who does not own his field (renting, sharecropping) is more able to adopt a technology that does not need capital investment such as new seed varieties when compared to the landowner. As expected, education and household income play a significant role in adopting agricultural technologies. Furthermore, it may be difficult to convince farmers who own poor and infertile lands with new technology. Additionally, the recommended package developed by researchers was generally not location-specific. It was rather made for a wide area without taking into account the considerable variability in the socio-economic and agro-ecological circumstances that farmers have.

CONCLUSIONS AND IMPLICATIONS

This study attempted to determine the social, economic, physical and technology specific factors that affect farmers' decisions to adopt new barley production technologies and analyzed the influence of the socioeconomic factors explaining the adoption. Farm size, household labor and type of land tenure play a significant role in the adoption of barley production technologies in Jordan. Logit models were used to quantify the effects of these factors on the adoption of technological components. Results show that farm size, education and availability of household labor are the most significant factors affecting the components. More educated farmers will gain higher benefits from improved information and it will be easy to convince these farmers to adopt new practices. The results will provide useful information for technology transfer. An understanding of how individual characteristics tend to influence adoption decisions can improve the effectiveness of technology in enhancing growth in productivity.

The results of the present research have implications for national agricultural policy. They could be used by policy-makers to extend their objectives by increasing the rate of technology adoption, creating the conditions that would encourage farmers to adopt new technologies, promoting proper land use planning, introducing small plot lease system, encouraging the establishment of farmer cooperatives to achieve economies of scale in production and land consolidation, in order to ensure the sustainability of development activities, because small land holdings make mechanization and investments in new technologies infeasible. Policies that provide incentives to use land according to suitability and comparative advantage can enhance the overall social welfare by increasing income as well as by reducing land degradation. Increases in productivity can be made possible by ensuring custom hiring services of machinery and providing an opportunity for extension services in order to build a campaign to inform all farmers how new practices lead to increased farm productivity, as well as the establishment of physical seed market infrastructure, efficient regulatory systems, in addition to the effective provision of appropriate information through the government extension service and other media.

REFERENCES

Al-Karablieh, E. K., Amer Z. Salman and Franklin M. Fisher. 2002. Forecasting wheat production: the case of the Irbid region in Jordan. ***Quarterly Journal of International Agriculture***,41(3):191-206.

Al-Karablieh, E. and M. Salem. 1996. Sequential adoption of divisible technologies in barley production in Jordan. ***Dirasat, Agricultural Sciences***, 23(1): 55-67.

Al-Karablieh, E. and M. Salem. 1999. Measuring the bias of new production technologies of barley in Jordan. ***Dirasat, Agricultural Sciences***, 26(1):106-113.

Amemiya,T. 1981. Qualitative response models: a survey. ***Journal of Economic Literature,*** 19 (4):1483–1536.

Bagi, F. S. 1983. A logit model of farmers' decisions about credit. ***J. Agricultural Economics***, (15): 13-19.

Barker, R. and R. W. Herdt. 1985. The rice economy of Asia. Resource for the Future. Washington, D.C.

Bayri, T. Y. and W. H. Furtan. 1989. The impact of new wheat technology on income distribution: A green revolution case study, Turkey, 1960-1983. ***Economic Development and Cultural Change***, 38 (1): 113-127.

Byerlee, D. and E. H. de Polanco. 1986. Farmers' stepwise adoption of technological packages: evidence from the Mexican Altiplano. ***American Journal of Agricultural Economics***, 68: 519-527.

Deuson, R. R. and J. C. Day. 1990. Transfer of sustainable technology in dryland agriculture: lessons from the Sahel in 1980s. ***Agricultural Economics,*** (4): 255-266.

Duwayri, M. 1991. Agricultural research, technology and training in Jordan. In seminar on agricultural policy analysis in Jordan. Food and Agriculture Organization (FAO) and Ministry of Agriculture.

Feder, G., R. Just and D. Zilberman. 1985. Adoption of agricultural innovations in developing countries: a survey. ***Economic Development and Cultural Change***, (33):255-298.

Griffin, G. R., D. T. Vere and D.W. Bootle.1995. An integrated approach to assessing the farm and market level impacts of new technology adoption in Australian lamb production and marketing system: the case of large lean lamb. ***Agricultural Systems***, (47): 175-198.

Griffiths, W. E., R. C. Hill and G. G. Judge. 1993. Learning and Practicing Econometrics, John Wiley and Sons, Inc (New York).

Gujarati, D. N. 1995. Basic econometrics. 3rd edition. McGraw-Hill, Inc., 568.

Haddad, N. 1988. Features of Jordan rainfed agriculture. Symposium on rain-fed and farming system in Jordan and neighboring countries: Sept. 10-14, 1988.

Hanushek, E. A. and J. E. Jackson. 1977. Statistical methods for social scientist. Academic Press, New York.

Igodan, C. O., Ohaji, P. E. and J. A. Ekpere. 1988. Factors associated with the adoption of recommended practices for maize production in the Kainji Lake Basin of Nigeria. ***Agric. Admin. and Extension***, 29: 149-156.

Jarvis, L.S. 1981. Predicting the diffusion of improved pastures in Uruguay. ***American Journal of Agricultural Economics***, (63): 495-502.

Kebede, Y., K. Gunjal and G. Coffin. 1990. Adoption of new technologies in Ethiopian agriculture: the case of Tegulet-Bulga district, Shoa Province. ***Agricultural Economics,*** (4): 27-43.

Maddala, G. S. 1992. Introduction to econometrics, second edition. New York: McMillan Publishing Company. 323-337.

Mamdouh, Q. and N. Haddad. 1994. The effect of full-package production technology on barley production in Jordan. in Haddad, N. and R. Tutwiler (ed.). Crop and livestock improvement in Mashreq region. Proceedings of the Mashreq workshop on increased productivity of barley, pasture and sheep in the critical rainfall zones: 13-15 December 1992, Amman, Jordan.

Mamdouh, Q., H. Saleh and A. Ghraibeh. 1994. Effect of improved varieties and fertilizer on barley yield in Jordan. in Haddad, N. and R. Tutwiler (ed.). Crop and livestock improvement in Mashreq region. Proceedings of the Mashreq workshop on increased productivity of barley, pasture and sheep in the critical rainfall zones: 13-15 December 1992, Amman. Jordan.

Matuschke, I., R. R. Mishra and M. Qaim. 2007. Adoption and impact of hybrid wheat in India. ***World Development***, 35(8): 1422-1435.

Morris, M. L. and C. R. Doss. 1999. How does gender affect the adoption of agricultural innovations? The case of improved maize technology in Ghana. Paper presented at the annual meeting of American Agricultural Economics

Associations (AAEA), Nashville, Tennessee, August 8-11.

Munyua, C., Adams, Ph. and Thomson, J. 2002. Designing effective linkages for sustainable agricultural extension information systems among developing countries in Sub-Saharan Africa, Proceedings of the 18th Annual Conference of the Association of International Agricultural and Extension Education. ***Journal of International Agricultural and Extension Education,*** 9(2).

Neil, S. P. and D. R. Lee. 1999. Explaining the adoption and disadoption of sustainable agriculture: the case of cover crops in Northern Honduras. Dept. of Agriculture, Resource and Managerial Economics. Cornell University. Working paper no. 31.

Oglah, M., Q. Mamdouh, I. Khraisat, R. Tutwiler and N. Haddad. 1994. Effectiveness of Mashreq barley demonstration in Jordan. in Haddad, N. and R. Tutwiler (ed.). Crop and livestock improvement in Mashreq region. Proceedings of the Mashreq workshop on increased productivity of barley, pasture and sheep in the critical rainfall zones: 13-15 December 1992, Amman, Jordan.

Okumu, B. N. 2002. The impact of high yielding varieties of wheat on economic performance, nutrient flows and soil erosion in the Ethiopian Highlands: the case of Ginchi watershed, Cornell University, Department of Applied Economics and Management, USA, A paper presented at the workshop on the green revolution in Asia and its transferability to Africa, Tokyo, Japan, December.

Owens, N. N., Swinton, S. M. and E. O. van Ravensway. 1997. Will farmers use safer pesticides? Dept. of Agr. Econ., Michigan State University. East Lansing, Michigan 48824. Working paper no. 1.

Perry, G. M., M. E. Rister, J. W. Richardson and W. R. Grant. 1986. Analysing tenure arrangements and crop rotations using farm simulation and probit analysis. ***Southern Journal of Agricultural Economics***, 18, 165-174.

Qsaem, S. and Mitchell. 1986. The problem of rainfed agriculture. In: *Agricultural Policy in Jordan* (Burrell, A.B., ed.). London: Ithaca Press, 30-40.

Ransom, J. K., K. Paudyal and K. Adhikari. 2003. Adoption of improved maize varieties in the hills of Nepal. ***Agricultural Economics***, 29(3): 299-305.

Rassam, A. M. 1984. Syrian farm household: women's labor and impact of technologies. M.A. Thesis, University of Western, Ontario, Canada.

Rogers, E. 1995. Diffusion of innovations. 4th edition. New York: The Free Press.

Ruttan, V. W. 1977. The green revolution: seven generalizations. ***International Development Review***, 19 (4): 16-23.

Ryan, J. G. and K. V. Subrahmanyan. 1975. Package of practices' approach in adoption of high-yielding varieties: An appraisal. ***Econ. and Polit. Weekly***, Dec., 110.

Salasya, B. D., W. Mwangi, H. Verkuijl, M. A. Odendo and J.O. Odendo. 1998. An assessment of the adoption of seed and fertilizer package and the role of credit in smallholder maize production in Kakamega and Vihiga districts, Kenya. Mexico, D. F.: CIMMYT and Kenya Agricultural Research Institute.

Sarap, K. and D.C. Vashist. 1994. Adoption of modern varieties of rice in Orissa: a farm level analysis. ***Indian Journal of Agricultural Economics,*** (49): 88-93.

Sheikh, A. D., T. Rehman and C. M. Yates. 2003. Logit models for identifying the factors that influence the uptake of new `no-tillage' technologies by farmers in the rice–wheat and the cotton–wheat farming systems of Pakistan's Punjab. ***Agricultural Systems***, 75(1): 79-95.

Shepley, S. C. 1988. Wheat subsidy policies in the Hashemite Kingdom of Jordan: Economic Analysis. The United State Agency for International Development.

Shideed, K. H. and M. El Mourid. 2005. Adoption and impact assessment of improved technologies in crop and livestock production systems in WANA region. ICARDA. Aleppo, Syria.

Szmedra, P. I., M. E. Wetzstein and R. W. McClendon.

1990. Partial adoption of divisible technologies in agriculture. ***The Journal of Agricultural Economics Research*,** 42 (3): 20-26.

The World Bank. 2001. Agricultural extension and research: achievements and problems in national systems, The World Bank Group.

Tripathi, B. and Psychas, P. 1992. The AFNETA alley farming training manual - Volume 1: Core course in alley farming, Food and Agriculture Organization (FAO), Rome.

نماذج لوغاريتمية احتمالية لتحديد العوامل المؤثرة في تبني تقنيات إنتاج الشعير في المناطق قليلة الأمطار

عماد الكرابلية* ✉، احمد الريماوي*، دوخي الحنيطي**

ملخـص

تمت مقابلة عينة عشوائية من 300 مزارع خلال الموسم 2002/ 2003 لاستقصاء العوامل التي تفسر تبني تقنيات إنتاج الشعير الحديثة التي أدخلت من قبل البرامج الوطنية. تم استخدام النموذج اللوغاريتمي لتقدير العلاقة بين قرار تبني التقنيات الحديثة والعوامل الاقتصادية والاجتماعية للمزارعين.أظهرت النتائج أن حجم المزرعة وتعليم المزارع ودخل الأسرة وتوفر العمالة العائلية هي أكثر العوامل التي تؤثر في تبني التقنيات الحديثة لإنتاج الشعير. وتبين ان المشاركة وحجم الحيازة وعمر المزارع كان لها تأثير سلبي في تبني الأسمدة الكيميائية وذلك لزيادة التكاليف التشغيلية، بينما وجد أن مستوى التعليم للمزارع هو العامل الايجابي الوحيد المؤثر في تبني الأسمدة الكيميائية. وكان المزارعون بالمشاركة هم الأكثر ميلا إلى تبني البذارة مقارنة بأنواع الحيازة الأخرى، وتبين أن هناك علاقة عكسية بين عمر المزارع وملكية الحيازة وتدني خصوبة التربة وحجم الأسرة من ناحية، وتبني البذارة من ناحية أخرى. وكلما زادت مساحة الحيازة كانت هناك إمكانية اكبر لتبني الحصادة الآلية. من جهة أخرى، فإن ملكية الحيازة وتوفر العمالة العائلية كان لهما تأثير سلبي في تبني استخدام مبيدات الأعشاب. وتبين أن المنطقة المطرية ومستوى التعليم وملكية الأرض وعمق التربة والمشاركة وارتفاع نسبة العمالة المستأجرة لها علاقة ايجابية مع تبني الأصناف المحسنة. ويمكن استخدام السياسة الزراعية لخلق الظروف التي تؤدي إلى تشجيع المزارعين على تبني التقنيات الحديثة مثل: إدخال مخططات استعمال الأراضي، وادخال نظام تأجير قطع الاراضي الصغيرة، وتجميع الاراضي في جمعيات تعاونية، وادخال نظام حوافز لاستخدام الأراضي تبعا لملاءمتها وميزاتها النسبية، وضمان توفير خدمة تأجير المعدات الزراعية، وتوفير فرص للمرشدين الزراعيين للقيام بحملات إرشادية للمزارعين حول التقنيات الحديثة التي تؤدي الى زيادة الإنتاجية.

الكلمات الدالة: تبني التقنيات الحديثة ، نموذج لوغاريتمي احتمالي.

* قسم الاقتصاد الزراعي وإدارة الأعمال الزراعية، كلية الزراعة، الجامعة الأردنية، عمان، الأردن.

✉ البريد الإلكتروني: Karablie@ju.edu.jo

** أستاذ مشارك، الاقتصاد الزراعي والتنمية الريفية، كلية الزراعة، جامعة مؤتة، الكرك، الأردن.

تاريخ استلام البحث 2008/5/19 وتاريخ قبوله 2008/11/11.