Using Multiple Logistic Regressions to Evaluate the Adoption Rate of Feed Block Technology by Sheep Owners in Jordan

Raed Mahmmod Al-Atiyat* and Mohammed Ali Bdour**

ABSTRACT

This study analyzed factors that contributed to successful Adoption Rate (AR) of feed blocks technology by sheep owners of the south Jordanian governorate, Ma'an, in the year 2002. By using the multiple logistic regression model, the AR was ten times higher in graduated owners than in illiterate owners (Odds Ratio (OR) was 9.98, 95% CI 2.9-20). Secondary educated owners came in second position then primary educated owners and finally elementary educated owners with AR values of 5.50, 3.66 and 1.87, respectively. On the other hand, AR was around three times more (OR 2.92, 95% CI 1.86-3.84) under intensive production system and two times more (OR 2.05, 95% CI 1.60-2.36) under semi-extensive system compared with extensive production system. To sum up, the sheep owners of higher education and intensive production system were faster in adoption of the technology compared to farmers of the other educational levels and production systems. Factors such as flock size, home type and source of technology information were not significant. There might be other factors that enhance the adoption rate, but these factors were not considered in the present study and are worthy to be studied in the future.

Keywords: Logistic regression, Technology adoption, Feed blocks, Sheep owners.

INTRODUCTION

In recent years, logistic regression have become widely used in scientific papers. There are three reasons for this. Firstly, it provides an estimate of odds ratios (with confidence interval) for the relationship between two binary ("yes or no") variables. Secondly, it enables us to examine the effects of other variables on that relationship. Thirdly, it has a special and very convenient interpretation in treatment-control studies (Martin and Altman, 2000). The logistic regression gives the option of reporting Odds Ratios (OR) instead of logistic regression coefficients. In any case, it's easy to convert one to the other, since OR is logarithmic exponential of regression coefficients (Davies et al., 1998; SAS Program, 1998). Although logistic regression and odds ratio is commonly used in many studies, they were not used in animal production studies till first presented as a useful tool in animal health (Keil et al., 2001) and breeding studies (Van Hagen et al., 2004).

Regarding animal production, development of new technology for better production cannot be useful unless adopted by animal owners. For a binary response variable, such as a response to a yes-no question regarding any technology adoption, a commonly used model is the logistic regression model (Long, 1997). Actually, the

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owners have not adopted many improved technologies developed by agricultural research institutions. The main reason was due to less consideration of the owners' variables (characteristics) which is the most neglected step in initial setting of adoption program (El-Mourid et al., 1997). Therefore, using logistic regression to examine the effects of owners' characteristics may give a better setting for future adoption programs.

Owners often seek alternatives to traditional feed ingredients because of cost or unavailability. Use of byproduct feed ingredients can reduce costs or may become an alternative feed during periods of forage shortages. Therefore, byproduct feeds can provide economical sources of protein and energy (Capper et al., 1989; Hadjipanayiotou et al., 1975). On the other hand, poor quality roughage comprises the only part of the diet for ruminant animals in many countries of the world for a considerable part of the year (Preston and Leng, 1987). Jordan is an example of such countries in which animals are in negative energy balance and supplementary byproduct feeds with energy and nitrogen have been used for improving their nutritional status (Harb and Shourfa, 1982; FAO, 1994). Such supplements are urea/molasses feed blocks which have been widely advocated to increase the intake and digestibility of poor quality pastures and roughages (Leng, 1984; Hadjipanayiotou et al., 1993). Sheep generally tolerate a wide variety of feed ingredients and byproducts that are generally useful when fed in low to moderate amounts (Miller and Thompson, 2003). For example, sheep in Jordan, consuming poor quality pastures and as a consequence suffering productivity problems, have benefited from the use of these feed blocks (Haddad et al., 1997a).

Feed blocks made from agro-industrial byproducts are helping Jordan's sheep and goat owners survive seemingly interminable drought. This appreciated work done by National Center for Agricultural Research and Technology Transfer (NCARTT) teamed with the International Center of Agricultural Research in Dry Areas (ICARDA) to develop and promote feed block technology throughout the Mashreq/Maghreb Project (Haddad et al., 1997b). Since early of 1990s, ICARDA promoted several livestock production technologies to be adopted in Jordan. These technologies included the use of sponges and PMSG hormones, urea treated straw, early weaning of lambs and vitamin A injection and agriculture by-products feed block (ICARDA, 1994; Hadjipanayiotou, 1997; Treacher, 1997). Regards feed blocks, Jordan as well as other neighboring countries began investigating the use of them as animal feed in the 1980s (Hadjipanayiotou et al., 1987). The objective was to find substitutes for barley and costly feed concentrates. Therefore, their use was promoted heavily at owner field by incorporation of ICARDA, NCARTT and Ministry of Agriculture on television, radio and in the press. In general, training was offered to sheep owners to implement this technology on daily-basis operation of their farms. Apart from the low price, owners found that sheep fed with feed blocks did not drop their wool and stopped eating wool (a sign of malnourishment), their health and fertility improved (Al-Haboby et al., 1999).

Worldwide, shortly after dissemination of any technology, research is conducted to determine the adoption rate of that technology. For example, the adoption rate of feed block technology was 36% among owners attending field days and hosting demonstrations in Mashreq-Magreb countries (Mashreq/Maghreb Annual Report, 1997). Likewise in Jordan, a result of study found that 35% of sheep owners used this technology on continuous basis (Mashreq/Maghreb Annual Report, 1998). However, few researchers studied the factors responsible for such adoption on continuous basis by sheep owners. A better understanding of the
factors of adoption by the owners may help in developing technology dissemination program in future. The present research was carried out in Jordan to identify the factors that enhance the adoption of the feed blocks technology by sheep owners.

MATERIALS AND METHODS

Study Population and Sheep Owners

A survey was conducted in the south governorate of Jordan, Ma'an in the year 2002. The owners, randomly selected on the basis of five different regions in Ma'an, were personally interviewed. The five regions were Wadi Mousa, Showbak, Udroah, Aeyl and Al-Fjaij. The regions in this study were considered due to small area and similarity of geographical and community characteristics. A total of 51 sheep owners were randomly selected on the basis of 10 owners of each region. An exception was interviewing 11 owners from Wadi Mousa because two brothers of different characteristics are owners of one flock, and it was assumed to consider them as two separate owners. All owners were rearing a total of 7392 sheep heads. The owners were with three flock sizes as follows: small (less than 50 heads), medium (51-150 heads) and large (more than 150 heads). Owners were classified according to production system parameters (level of mobility into nomadic –extensive- (highly mobile), transhumant – semi-extensive- (semi-mobile) and sedentary –intensive- (agro-pastoral). Another production system parameter was used to classify owners is home type (being owner is resident in a house, a tent or both of them).

Interview Procedure and Statistical Analysis

A questionnaire was prepared to collect information related to adoption and use of feed blocks by sheep owners in Jordan. The survey covered sheep owners who were attendees of feed block demonstration trails prepared by NCARTT. Owners were specifically asked about their sheep flock size and production system parameters (flock mobility and home type). They were also asked about their level of education; illiterate, elementary, primary, secondary and graduate. Information related to manufacture and store of feed blocks was questioned as well as the source of the information (Extension); NCARTT, Agriculture Ministry Directorate (AGMD), Media (TV, Radio, Newspaper) and owner to owner extension. The questionnaire included general information related to governorate and geographical region.

Data were analyzed using multiple logistic regression analyses (SAS, 1998). For a yes-no answer to an adoption question, the logistic regression model was used to describe relationship between a categorical response variable and a set of predictor factors when the sample size is mainly too small or the events are too sparse (SAS, 1998) as it is the case in the present study. The analyses were computed to estimate effects of the following factors; education level, flock size, level of mobility, home type and source of information on the adoption rate of feed block technology by sheep owners. The following linear logistic regression model was used;

\[
\text{logit}(p) = \alpha + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5
\]

(Pampel, 2000)

where:

logit : is the log of odds for relative adoption rate of feed block.

p: the relative adoption probability of feed block technology in regards to studied factors.

\(\alpha\) : Intercept.

\(b_1, b_2, b_3, b_4\) and \(b_5\) are regression coefficients for studied independent factors: education \(X_1\), flock mobility \(X_2\), source of information \(X_3\), flock size \(X_4\) and housing type \(X_5\), respectively.

Thus, stepwise logistic regression for Chi-square \(\chi^2\)
test with Yates' correction, was carried out comparing the levels of each independent factor on the relative adoption rate of feed block which was assessed by Odds Ratio (OR) considering one level as a reference group. The stepwise logistic regression removed independent factors with a non-significant difference ($P > 0.05$) from the regression model. If $P < 0.05$, then the factor contributes significantly to the prediction of the outcomes. On the other hand, the odds ratio is often the ratio of the probability that the event of interest occurs to the probability that it does not (Martin and Altman, 2000). In this study, odds ratio is estimated by the ratio of the number of owners who adopted feed block technology to the number of those who did not. The ORs were estimated for confounding factors using PROC LOGIST in the SAS software package (SAS, 1998).

**RESULTS AND DISCUSSION**

**General Description of Owners' Characteristics**

Table 1 presents the descriptive data of the studied population of 51 sheep owners who were trained to apply feed block technology. Regarding the production system parameter, the majority of owners (45%) were raising their sheep on the extensive production system. Only 39% of sheep owners were rearing their flocks on the semi-extensive system. Apparently, owners using the intensive system were small in number (14%). On the other hand, the home type showed quite large percentage (59%) of owners who lived in both tent and house. The rest of owners lived in either only a house or a tent. It is also important to indicate that owners were classified into four groups of different educated levels by various percentages where illiterate owners have the smallest percentage (12%) (Table 1). Overall, 43 owners (84%) were promoted and encouraged by NCARTT to use feed block technology, whereas the other owners were promoted by either AGMD, media or another owner. Further, from three different flocks sizes, 57% of the owners in this study were rising sheep flocks of medium sizes (Table 1). This description of characteristics that assign owners to their production systems is important to be considered when explaining further outcomes of this study.

<table>
<thead>
<tr>
<th>Production system, Flock mobility</th>
<th>No. of Owners</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extensive (Nomadic)</td>
<td>23</td>
<td>45</td>
</tr>
<tr>
<td>Semi-extensive (Transhuman)</td>
<td>20</td>
<td>39</td>
</tr>
<tr>
<td>Intensive (Sedentary)</td>
<td>7</td>
<td>14</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Production system, Home type</th>
<th>No. of Owners</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>House</td>
<td>12</td>
<td>24</td>
</tr>
<tr>
<td>Tent</td>
<td>9</td>
<td>18</td>
</tr>
<tr>
<td>Both</td>
<td>30</td>
<td>59</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Education</th>
<th>No. of Owners</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illiterate</td>
<td>6</td>
<td>12</td>
</tr>
</tbody>
</table>
Adoption Feed Block Technology

Out of the 51 sheep owners described in Table 1, only 34 (~67%) owners adopted and disseminated the technology on their farm operations, while the rest (~33%) did not adopt this technology (Table 2). Therefore, Chi-Square test was used through stepwise Maximum Likelihood Estimates analysis to test significant number of adopters to non-adopters. These results came to be significantly different ($\chi^2 = 5.45, P<0.02$ - Table 2) and in higher proportion to that reported in Mashreq/Maghreb Annual Report (1997). Moreover, the results are supported by many researchers in which transfer of technology is critical to be adopted fast by majority of owner on the short run (El-Mourid, 1997). Therefore, strength of the present study lies in ability to determine the factors that significantly influenced the sheep owners to adopt the feed block technology on their farm.

Table (2): Analyses of response profile of the sheep owners to adopt the feed block technology and maximum likelihood estimates using Chi-Square test.

<table>
<thead>
<tr>
<th>Analysis of Response profile</th>
<th>Analysis of Maximum Likelihood Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adoption Response</td>
<td>Total</td>
</tr>
<tr>
<td>Yes</td>
<td>34</td>
</tr>
<tr>
<td>No</td>
<td>17</td>
</tr>
</tbody>
</table>
Factors Influencing the Adoption

The significant factors were only the education level and flock mobility (Table 3). However, other studied factors (flock size, home type and source of information) were not significant in the present study. Anyhow, the key question here is how each factor of those two significantly influenced owner types for potentially adopting the technology. As a consequence, the question was answered by finding the odds ratio using multiple-logistic regression. The value of odds ratio means adoption rate by sheep owners as influenced by education level and production system. The logistic regression provided the adoption rates in form of odds ratios as described in Table 4.

Table (3): Summary of stepwise selection of significant factors on adoption of feed block technology by sheep owners.

<table>
<thead>
<tr>
<th>Factor</th>
<th>DF</th>
<th>Chi-Square</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education Level</td>
<td>4</td>
<td>22.92</td>
<td>0.0001</td>
</tr>
<tr>
<td>Flock Mobility</td>
<td>2</td>
<td>9.65</td>
<td>0.008</td>
</tr>
</tbody>
</table>

Table (4): Odds ratios and their confidence intervals of logistic regression analysis for the factors which significantly enhanced the adoption rate of feed block technology by sheep owners.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Odds Ratio (95% confidence interval)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education level of owner</td>
<td></td>
</tr>
<tr>
<td>Graduate</td>
<td>9.98 (2.9-20)</td>
</tr>
<tr>
<td>Secondary</td>
<td>5.5 (2.83-7.9)</td>
</tr>
<tr>
<td>Primary</td>
<td>3.66 (1.36-6.04)</td>
</tr>
<tr>
<td>Elementary</td>
<td>1.87 (1.1-2.9)</td>
</tr>
<tr>
<td>Illiterate</td>
<td>1</td>
</tr>
<tr>
<td>Flock mobility of production system</td>
<td></td>
</tr>
<tr>
<td>Intensive</td>
<td>2.92 (1.86-3.84)</td>
</tr>
<tr>
<td>Semi-Intensive</td>
<td>2.05 (1.6-2.36)</td>
</tr>
<tr>
<td>Extensive</td>
<td>1</td>
</tr>
</tbody>
</table>

Education Level

Figure 1 shows the adoption rate expressed in the odds ratio of elementary, primary, secondary and graduate owners in relation to illiterate ones. The maximum adoption was in graduate owners when compared with illiterate owners (Table 4). In general, owners’ education was related to faster technology adoption in this study. On other hand, lack of education (illiterate) seemed to be a limiting factor against technology adoption. Similar results of extensive researches have shown that varying degrees of adoption technology in sustainable manner were due to varying degrees of owners’ education (Rabbani et al., 2004; Sabyasachi and Rangnekar, 2006). In accordance, the result of the current research shows that the higher educated owners have the more adoption rate of feed technology (Figure 1). It also shows that secondary educated owners come after graduated owners in their rate of adoption, then come primary educated owners and finally elementary educated owners. Such results were reported by many researchers in different livestock industries. For example, Sabyasachi and Rangnekar (2006) reported that higher educated owners are better adopters with sustainable...
manner of feed block technology in dairy enterprises. Generally, the results can be explained in details as the sheep owners of higher education were mostly willing to adopt and disseminate the technology. Furthermore, this might be a result of appropriateness and adaptability of the technology to those owners' conditions and benefits of the technology. The latter could be the main reason why educated owners were more aware of the feasibility of using feed block technology for feeding their flocks as well as the production status outcomes. Thus, this case confirms the observation that educated owners get fully convinced about a new technology after benefiting from it, and therefore they are more able to spread over the technology. Such observations were reported by Haddad et al. (2005) on a technology adoption level by barely growing owners in Jordan. Furthermore, educated owners might help and play a successful role in the extension to other owners in easily and quickly disseminating the technology.

![Figure 1](image1.png)

**Figure (1): Adoption rate expressed in odds ratio estimates and 95% CI for sheep owner adopters of different education levels compared to illiterate owners.**

**Flock Mobility of Production System**

The result in Figure 2 shows the odds ratio of owners of intensive and extensive systems compared to owners of semi-extensive system. The maximum adoption rate was for owners of intensive system when compared with owners of extensive production system (Table 4). Since the beginning, there has been a strong support to introduce the technology into sheep industry (Mohammed et al., 1997). In particular, the intensive sheep owners visualized the potential of the technology in improving the nutritional status and fattening of the animals earlier than other owners. This is because those owners have fixed farm locations and in-door kept flocks, and they witnessed on-farm demonstrations on the utilization of the technology arranged by NCARTT promoters. As a result, they took up the introduction of technology in a program mode. Besides, in the beginning, NCARTT provided incentives, in the form of basic materials of the technology, to those owners who agreed for demonstration of the technology on their fields (Mashreq/Magreb Project, Annual Report, 1998). All these together enhanced the owners of intensive industry to adopt the feed block technology in faster long run mode on their farms than other owners. In contrast, researchers reported that intensive system owners tried to conduct the technology.
throughout the world, but only a few owners have adopted the technology on a continuous basis (Birthal and Parthasarathy, 2002; Nguyen Xuan Trach, 2004; Rabbani et al., 2004). This might be because feed block treatment is not used on a wide scale by such owners who use concentrated feed instead. Non-availability of sufficient raw materials for their large flocks limited storage availability and inadequate extension efforts to popularize the technology (Nguyen Xuan Trach, 2004).

In Jordan, major share of meat and milk is produced by small and medium owners with the semi-extensive production (mixed crop-livestock) system as the dominant system. Increasing demand for meat and milk offers the possibility of scope to improve their income. So, the semi-extensive system is mainly based on the use of agricultural by-products and crop residues as feed resource (FAO, 1994). Therefore, it was assumed that extensive system owners would adopt the technology at higher rates. But the results showed that the adoption rate was less than that of intensive system owners and higher than that of extensive system ones (Figure 2). Nevertheless, the same technology has been well adopted by semi-extensive system owners in many countries, and the owners seemed to be satisfied to use it on a continuous basis (Maarse et al., 1998). In this latter context, it is relevant to pay attention to important conditions for application of the technology under extensive system conditions. Such conditions are: availability of raw materials, size of farm, season and type of animal production (milk, fattening, dry season feeding and growth) and then suitable extension program. Unfortunately, the overall results showed that the extensive system owners were generally not adopting the technology. It is particularly important to find out why - from the owners’ perspective – they are not willing to adopt the technology. It is known that those owners have no right to cultivate the land grazed by their sheep. Therefore, the owners had scarce amounts of straw and crop byproducts for making feed blocks. Furthermore, before owners will be prepared to invest in new technologies, they have to be assured of their rights to the land they cultivate and long run availability of necessary raw materials. It has been implied that secure land rights and raw material availability are important conditions for uptake of technologies by owners (Dolberg, 1992).

![Figure (2): Adoption rate expressed in odds ratio estimates and 95% CI for sheep owner adopters of intensive and semi-extensive production system compared to extensive production system.](image)

**Figure (2):** Adoption rate expressed in odds ratio estimates and 95% CI for sheep owner adopters of intensive and semi-extensive production system compared to extensive production system.

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CONCLUSIONS AND RECOMMENDATIONS

This study provides indications that technology of feed blocks is likely to be highly adopted by sheep owners provided that they have higher education. The educated owners seem to benefit more from up-taking and adopting the technology in terms of improving flock productivity, reproductivity and health status. Furthermore, owners of the intensive production system were adopting the technology in more than a double rate compared to other systems owners. Apart from low price, these owners might find feed blocks nutritionally as good as concentrated feed, and a consequence saving more of expenditure on business. There might be other factors which are not considered in the present study and can be studied in future research. Moreover, these results should be considered in coming future technology adoption programs for livestock owners.

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The evaluation of multi-purpose and slaughter hog fattening systems in the Jordanian West Bank

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The objective of this study was to estimate the productivity and efficiency of fattening multi-purpose and slaughter hog fattening systems in the Jordanian West Bank. Two fattening systems were investigated: the standard fattening system and the fattening system with a slaughter hog fattening system. The data were collected from 20 farms in the Jordanian West Bank during the 2002-2003 period. The results showed that the multi-purpose fattening system had a higher productivity than the slaughter fattening system. The Odds Ratio (9.98, 95% CI 2.92-30.87) was significant in the analysis of the influence of the fattening system on the productivity. The results indicate that the multi-purpose fattening system is more efficient and productive than the slaughter fattening system. Furthermore, the results suggest that the multi-purpose fattening system is more suitable for the Jordanian West Bank conditions.