Farmers’ willingness to adopt salt-tolerant forage in south-eastern of Tunisia

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Abstract

This paper analyzed the factors that affect farmers' willingness to adopt salt-tolerant forage as forage source for livestock using a Tobit model. The data used for the empirical analysis has been obtained from a survey of 97 farmers in south-eastern Tunisia. The results of this study show that variables related to age, education level, salinity level of water and membership in a farmers’ associations do not significantly influence adoption degree of salt-tolerant forage production. However, a positive relationship between off-farm income availability and adoption is found. Finally, the flock size variable, expressed in Standard Livestock Unit, has a significant and positive relationship with adoption. This indicates the need of farmers to cover their forages deficit.

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1. Introduction

Salinity in groundwater and soil has sharply increased in the arid areas of south-eastern Tunisia. It is a major constraint to crop and forage production. Therefore, forage production was always insufficient to meet livestock demands, whereas livestock production is the main source of livelihood for rural population in these areas. Feed scarcity and poor feed quality are the major constraints to improve livestock productivity in south of Tunisia.

The over-utilization of rangelands for livestock production has caused severe degradation in the target areas. Use of saline water and marginal lands, when they are relatively abundant in these areas can provide a useful forage source for livestock, improves livelihoods of poor farmers and significantly contributes to control rangeland degradation. Farmers have become increasingly dependent on saline or slightly water irrigation. The use of saline water to produce non-conventional crops is of particular importance. Among crops and farming systems that are highly appropriate for salt-tolerant environments are the forage production systems.

During the last decades, great effort has been realized in Tunisia to evaluate and select new varieties of forage that will have a better salt-tolerance, land and water treatments that will reduce salinity, etc. (Nasr, 2001; CFPA, 2006) but factors affecting adoption of salt-tolerant forages have not been investigated with sufficient attention. The main objective of this paper is to identify and analyze the factors affecting adoption decisions of salt-tolerant forages by farmers in south-eastern Tunisia.

The remainder of this paper is organised as follows. Section 2 presents the study area and the data collection. Section 3 specifies the model and the variables employed in the analysis. Section 4 reports and discusses the empirical results. Finally, section 5 presents conclusions.
2. Study area and data collection

The study concerns an area of south-eastern Tunisia (Gabes, Medenine and Tataouine Governorates). This area, with irregular rainfall of 100 to 200 mm per year, is characterized by its aridity. Therefore, no sustainable agricultural production is possible without irrigation. In this area, the saline groundwater is the major source of water supply. It has a total area of 5,522,200 ha (approximately 33% of the area of Tunisia), with 3,031,300 ha agricultural land (arable, rangeland and forest lands), and 2,490,900 ha non-agricultural areas. About 2,500,000 ha or 82% of agricultural area is rangeland. The arable land is 525,000 ha and it occupies 17% of agricultural land. This means that only 9% of total area contributes to agricultural production. Practicing annual fallow on a high percentage of arable land has always been an important aspect of the farming system.

The total cultivated land occupation amounts to 428,810 ha in 2004, of which cereals occupy 21.3%, fruits tree lands 74%, vegetables 2.2%, legumes 1.3%, forage crops 1.2%, and others 0.2% (Ministry of agriculture, 2006).

Irrigated areas of forage crops are limited, since farmers prefer high return vegetable crops to forage, if irrigation is possible. Some of the land (5,220 ha) is used for forage production but animal feed is constant short supply. The main forage species used in the study areas are alfalfa and green barley.

The area suffers severe land degradation, including desertification, salinisation and loss of agrobiodiversity. Livestock production is the main source of livelihood for the local population. Based on the latest surveys of Ministry of agriculture (2006), farm numbers in the three governorates (Gabes, Medenine and Tataouine) of Tunisia is estimated about 54,000. The farming structure is characterised by the predominance of small-size farms and land fragmentation. Most (80%) of the farming households consist of small-and medium (less than 20 ha).
A baseline survey of 30, 33 and 34 farmers were conducted in Tataouine, Medenine and Gabes regions, respectively. The selected sample of farms was based on the two criterions: availability of saline water and livestock. Single visits to farmers to solicit answers to a standardized questionnaire covering qualitative and quantitative information about the farming system, socio-economic indicators, practice and perception about the use of saline water for irrigation and feeding patterns of livestock reared took place in December 2005 - January 2006.

3. Model specification and variables description

To study the adoption behaviour, limited dependent variable provides a good framework. In the present study, tobit model is used. The advantage of this model is that not only measures the probability of adoption of improved variety, but takes care of the degree of its adoption.

The tobit model supposes that there is a latent unobservable variable \( y_i^* \). This variable linearly depends on \( x_i \) via a parameter vector \( \beta \). In addition, there is a normally distributed error term \( u_i \) to capture random influence on this relationship. The observable variable \( y_i \) is defined to be equal to the latent variable whenever the latent variable is above zero and zero else.

\[
y_i = \begin{cases} 
y_i^* & \text{if } y_i^* > 0 \\
0 & \text{if } y_i^* \leq 0
\end{cases} \tag{1}
\]

Where \( y_i^* \) is a latent variable

\[
y_i^* = \beta x_i + u_i, \quad u_i \sim N(0, \sigma^2)
\]
If the relationship parameter $\beta$ is estimated by regressing the observed $y_i$ on $x_i$, the resulting ordinary least squares estimator is inconsistent. Maddala (1983) has proven that the likelihood estimator suggested by Tobin for this model is consistent.

The likelihood function of the model (1) is given by

$$L = \prod_0 F_i(y_{yi}) \prod_i f_i(y_i)$$

(2)

$$L = \prod_0 \left[1 - F(x_i, \beta / \sigma)\right] \prod_i \sigma^{-1} f \left[\left(y_i - x_i, \beta / \sigma\right)\right]$$

where $f, F$ are the standard normal density and cumulative distribution functions.

Then we can write the log-likelihood function as:

$$\log L = \sum_0 \log(1 - F(x_i, \beta / \sigma)) + \sum_i \log\left(\frac{1}{(2\Pi\sigma^2)^{1/2}}\right) - \sum_i \frac{1}{2\sigma^2}(y_i - \beta x_i)^2$$

(3)

The parameters $\beta$ and $\sigma$ are estimated by maximizing the log likelihood function

$$\begin{align*}
\frac{\partial \log L}{\partial \beta} &= -\sum_0 x_i f(x_i, \beta / \sigma) + \frac{1}{\sigma^2} \sum_i (y_i - \beta x_i) x_i = 0 \\
\frac{\partial \log L}{\partial \sigma^2} &= \frac{1}{2\sigma^2} \sum_0 1 - F(x_i, \beta / \sigma) - \frac{n_i}{2\sigma^4} + \frac{1}{2\sigma^4} \sum_i (y_i - \beta x_i)^2 = 0
\end{align*}$$

(4)

Since the equations (4) are non-linear, the maximum likelihood estimators must obtained by an iterative process, such as the Newton-Raphson algorithm, Davidson-Flecher-Powell (DFP), Berndt, Hall-Hausman, (Greene, 2003).

To study the explanatory power of the model, statistic based on likelihood ratio (LR) is the appropriate.

$$LR = -2(\log L_r - \log L_u)$$
Where $\log L_u$ is the log-likelihood for the unrestricted model and $\log L_r$ is the log-likelihood for the model with $k$ parametric restrictions imposed. The likelihood ratio statistic follows a chi-square distribution $\chi^2$ with $k$ degrees of freedom.

The variable used in the analysis are in Table 1. The dependent variable indicating the willingness to adopt salt-tolerant forage, measured by the area to be cultivated with the salt-tolerant forage. Average willingness to cultivate salt-tolerant forage is about 1.3 ha. It’s varies between 0 and 12 ha. The explanatory variables are age of farmer, educational level of farmer, farm size, salinity level of water, (flock) livestock size, main activity of farmer and membership of farmer’s association.

Age measures the age of the farmer (continuous variable). It was hypothesized that AGE is negatively related to adoption. Bagi (1983) was found that younger farmers had greater likelihood of adopting improved varieties.

The level of farmers’ education (dummy variable) is measured as 1 for farmer has more than primary education level and 0 otherwise. The level of farms’ education is hypothesized to be positively related with the adoption of new varieties (Adesina and Seidi, 1995; Kebede et al., 1990).

Farm size was expected to have a positive relationship with the adoption of improved varieties (Bagi, 1983; Kebede et al. 1990; Sarab and Vashid, 1994).

SAL is a continuous variable that measures the salinity level of water. It was hypothesized that SAL is positively related to adoption. Since if the level of water salinity is low the farmers cultivate classical (conventional) crops. SLU variable represents the flock size of livestock and was expected positively related with the adoption. ACTIV is a dummy variable, which takes the value 1 if the farmer has only agricultural income and 0 with off-farm income. Some studies have shown that non-farm income positively influence adoption of
new technologies (Adesina, 1996; Savadogo et al., 1994). FAS is a dummy variable. It takes the value of 1 if the farmer belonging to farmers’ associations and 0 otherwise. It was hypothesized that Membership of farmers’ groups is positively related to adoption of salt-tolerant forage.

Table 1: Description of variables used in Analysis of farm-level adoption of salt-tolerant forage in south-eastern of Tunisia

<table>
<thead>
<tr>
<th>Variable acronym</th>
<th>Variable name</th>
<th>Variable definition</th>
<th>Expected sign</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent variable</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SURF</td>
<td>willingness to adopt salt-tolerant forages</td>
<td>Number of hectare</td>
<td></td>
<td>1.30</td>
</tr>
<tr>
<td>Independent variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B₀</td>
<td>Constant</td>
<td>Unitary vector</td>
<td>-</td>
<td>53.46</td>
</tr>
<tr>
<td>AGE</td>
<td>Farmer’s age</td>
<td>Number of Years</td>
<td>+</td>
<td>0.29</td>
</tr>
<tr>
<td>EDUC</td>
<td>Educational level of farmer</td>
<td>1 if farmer has more than primary education level, 0 otherwise</td>
<td>+</td>
<td>0.29</td>
</tr>
<tr>
<td>SIZE</td>
<td>Farm size</td>
<td>Number of hectare</td>
<td>+</td>
<td>23.36</td>
</tr>
<tr>
<td>SAL</td>
<td>Salinity level of water</td>
<td>Grame per litre</td>
<td>-</td>
<td>4.76</td>
</tr>
<tr>
<td>SLU</td>
<td>Standard Livestock Unit*</td>
<td>Number of SLU</td>
<td>+</td>
<td>17.02</td>
</tr>
<tr>
<td>ACTIV</td>
<td>Activity</td>
<td>1 if farmer has only farm income, 0 otherwise</td>
<td>-</td>
<td>0.85</td>
</tr>
<tr>
<td>FAS</td>
<td>Membership of farmers’ associations</td>
<td>1 if the farmer is a member, 0 otherwise</td>
<td>+</td>
<td>0.09</td>
</tr>
</tbody>
</table>

*Standard Livestock Unit (SLU) = 1 cattle = 5 sheeps = 6 goats = 1 camel.
4. RESULTS AND DISCUSSION

The iterative method of Newton-Raphson algorithm from the least squares solution has been used for the estimation of the coefficients, using the data processing program Eviews. The solution has been reached after 6 iterations. The maximum likelihood estimates for the tobit model is exhibited in Table 2. It may be noted that the estimated model has explanatory power. In fact, the likelihood ration (LR) of the tobit model was significant at the 1% level. The effect of certain variables on the adoption decision shows the additional information gained once model is used.

The empirical results of the tobit run indicate that five of the seven variables tested had the hypothesized signs. However, only the two variables (SLU and ACTIV) were found to significantly affect farmer’s decision to adopt salt-tolerant forage production. The signs of the estimated coefficients of AGE and EDUC variables are not consistent with our expectation. The coefficients signs of Size, SAL and FAS variables are consistent with our expectation but are not statistically significant. These variables not have any significant influence on adoption.

The estimated coefficient of ACTIV variable is negative and statistically significant at 5%. The negative signs of this variable as expected suggests that farmers with off-farm incomes have greater likelihood of adoption of salt-tolerant forage.

The estimated coefficient of Livestock (Flock) size variable is positive and statistically significant at 1%, which indicates that this variable had a positive effect on the degree of adoption. It means that farmers with more SLU were more likely to adopt forage species than farmers. This variable had the greatest significant effect on the farmers’ decision to adopt of the salt-tolerant forage by its level of significance. This finding show the necessity of farmers to meet their necessity of livestock.
Table 2: Estimation results of Tobit model

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficients</th>
<th>t-statistic</th>
<th>Significance level</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>2.109</td>
<td>2.097</td>
<td>***</td>
</tr>
<tr>
<td>AGE</td>
<td>0.004</td>
<td>0.332</td>
<td></td>
</tr>
<tr>
<td>EDUC</td>
<td>-0.081</td>
<td>-0.209</td>
<td></td>
</tr>
<tr>
<td>SIZE</td>
<td>0.007</td>
<td>1.487</td>
<td></td>
</tr>
<tr>
<td>SAL</td>
<td>-0.155</td>
<td>-1.290</td>
<td></td>
</tr>
<tr>
<td>SLU</td>
<td>0.024</td>
<td>3.967</td>
<td>***</td>
</tr>
<tr>
<td>ACTIV</td>
<td>-1.082</td>
<td>-2.311</td>
<td>**</td>
</tr>
<tr>
<td>FAS</td>
<td>0.182</td>
<td>0.369</td>
<td></td>
</tr>
<tr>
<td>LogL_r</td>
<td>-186.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LogL_u</td>
<td>-165.53</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LR</td>
<td>41.24</td>
<td></td>
<td>***</td>
</tr>
<tr>
<td>Degrees of freedom</td>
<td>7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

LogL_r: Log-likelihood function
LogL_u: Restricted log-likelihood
LR: Likelihood ratio test

* Significant at the 10% level
** Significant at the 5% level
*** Significant at the 1% level

5. CONCLUSIONS

The fresh water resources in Tunisia are scare and their quality is degrading. The south region of this country is classified as one with the least amount of available renewable fresh water resources. Salinity in groundwater in the arid area of south-eastern Tunisia represents a major constraint to conventional crop species. Among crops and farming systems that are highly appropriate for salt-tolerant environments are the forage production systems. Hence,
use of saline water, relatively abundant in this region can provide a useful forage source for livestock and contribute to control rangeland degradation. In fact, on this area, forage production is insufficient to meet the demands of an increasing livestock population.

In this paper, we identified the factors that most strongly influenced farmers' willingness to adopt the salt-tolerant forage. A Tobit model was used for the analysis of data from a sample of 97 farms in south-eastern. The analysis of adoption of salt-tolerant forage leads to the following results. Age, education level, salinity level of water, farm size and membership in a farmers’ associations do not significantly influence willingness to adopt salt-tolerant forage production. Off-farm income availability and flock size variables were found to significantly affect farmer’s willingness to adopt salt-tolerant forage production. The Results indicate that the most significant variable for the adoption of salt-tolerant forage is the (flock) livestock size. This show the need of farmers to meet the demands of an increasing livestock population. In fact, the majority of surveyed farmers would like to increase their head of livestock.

For salt-tolerant forages adoption to be sustainable, availability of good quality seeds of salt-tolerant varieties and information about technology of biosaline agriculture, which combine a salt-tolerant variety with improved cultural practices, are required. This contribution aims at providing information with respect to the use of salt-tolerant forages as fodder for animal production in arid areas. This requires the concerted efforts of farmers, researchers, extension agents, seed companies, and other stakeholders in order to increase feed availability for livestock.
REFERENCES


