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Designing an Incentive Scheme for the Adoption of Crop Rotation in the Harran Plain, Turkey

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Abstract: Between 1997 and 2004, the land lost to salinization in the Harran Plain of Turkey almost doubled. A key reason was the continuous production of cotton, which uses large amounts of irrigation water. Although research has found that some crop rotation systems can be more profitable and Turkey has implemented an extension program to promote these rotations, adoption has been limited. A common policy recommendation in this situation is to offer farmers a government incentive payment to adopt a crop rotation system. Using contingent valuation methods, the average willingness to accept incentive is estimated at 27.8 Turkish Lira per dekar. The only statistically significant variables associated with WTA are the level of the incentive payment and the salinity level of a farmer's soils.

Key words: Incentive scheme, designing, crop rotation, irrigation water, salinity level

INTRODUCTION

Ancient Mesopotamia owed its prominence to its agricultural productivity, which was largely based on irrigation water obtained from the Euphrates and Tigris Rivers. In the 1970s, Turkey, home of the headwaters of these two rivers, launched the South Eastern Anatolian Project (with Turkish acronym GAP). The goals of GAP are to stimulate economic development by generating cheap hydroelectric power and to improve food security through the use of irrigation water.

A major destination for the irrigation water is the Harran Plain, an area totaling 225,109 hectares. Irrigation water from the Ataturk Dam began flowing to the Harran Plain in 1993. As a consequence, the land planted to cotton in the Harran Plain expanded from 21% of cropped land in beginning of irrigation to 83% of cropped land today (GAP, 2005).

The large amount of irrigation water needed by cotton, along with an inefficient furrow irrigation system, substantially increased the amount of water entering the ground water systems. A rising water table combined with the high salinity of the irrigation water increased the discharge of salt into streams and the relocation of salt in the soil profile to the surface. Even though GAP is not yet completed, the area in the Harran Plain that can no longer be used to grow crops due to its salinity doubled from 7,498 hectares in 1997 to 14,805 hectares in 2004 (Cullu *et al*., 2002 and Cullu, 2006).

To address this problem, Turkey's Extension Directory created a program to promote rotations that include crops which use less water than cotton. This effort emphasizes the findings of research by the Research Institute for Rural Area which finds that the crop rotations being promoted generally are more profitable than continuous cotton (Çikman *et al*., 2005). Nevertheless, farmers have not adopted the crop rotations.

When a new practice or technology is not adopted even though it is potentially more profitable and has environmental benefits, a common public policy recommendation is to use incentive payments to encourage adoption (Cooper and Keim, 1996; Kline *et al*., 2000; Amigues *et al*., 2002; Isik and Khana, 2003). Such programs have been implemented in the United States and the European Union to encourage the adoption and use of production technologies that reduce soil erosion, protect water qualityand enhance the long term profitability of a forest.

Therefore the objective of this study is to estimate the level of incentive payment that will induce farmers to switch from continuous cotton production to a crop rotation that uses less water. An analysis also is conducted to determine if characteristics of the farm and farmer are associated with the size of the incentive payment. Results of this study should be of interest to policy makers, farmers, agribusinessesand individuals concerned about the relationship between farming and environmental quality.

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The rest of the study is organized as follows. The methodology used in the study, the variables that influence the decision to adopt a crop rotation and thus the size of the incentive paymentand the data are described in the next parts. A discussion of the results follows. The study closes with conclusions and implications.

MATERIALS AND METHODS

Research has established that the incentive payment needed to encourage adoption of a farming practice involves more than calculating the difference in profitability between alternative production technologies (Cooper and Keim, 1996; Kline *et al*., 2000; Amigues *et al*., 2002; Lynch *et al*., 2002; Isik and Khanna, 2003). Consequently, direct revelation techniques are commonly used to discover a farmer's probability of adaptation at different incentive payment levels. This study uses the dichotomous Choice contingent Valuation (CV) approach to determine the Willingness To Accept (WTA) amount (Cooper and Kim, 1996; Hubel *et al*., 2000; Kline *et al*., 2000; Qaim and Janvry, 2003; Haab and McConnell, 2003). Three other methods are the open ended, biding gameand payment card methods. They all have been criticized for having an incentive compatibility problem (Haab and McConnell, 2003).

A farmer's decision to adopt crop rotation system is modeled using a random utility model (Hanemann, 1984; Cooper and Keim,1996; Hubbell *et al*., 2000). The farmer will be willing to accept an incentive payment of q Turkish Lira/per dekar to adopt a crop rotation system if the utility derived from net income generated by the crop rotation system plus the incentive payment of "q" Turkish Lira/per dekar is at least as high as utility derived from net income generated from the continuous production of cotton.

Formally, a farmer chooses the crop rotation system if

$$U(1, y_1 + q; \mathbf{z}) \geq U(0, y_0; \mathbf{z}) \qquad (1)$$

Where 1 indicates the crop rotation system and 0 indicates continuous cotton production y_0 and y_1 are net income of crop rotation system and continuous cotton production respectively, is the offered incentive payment and $\mathbf{z}$ is a vector of farm and farmer attributes that may affect the farmer's decision to accept the crop rotation system.

Because utility is only partially observable to the investigator,

$$U = V(i, y_i; \mathbf{z}) + \varepsilon, \qquad (2)$$

where i is the state or condition (equals 1 if crop rotation is accepted, 0 for the status quo); V(.) is the observable component of utility, called indirect utility; and ε is the unobservable component of utility.

Equation 2 implies the following decision rule for adopting a new practice or technology in the presence of an incentive payment:

$$V(1, y_1 + q; \mathbf{z}) + \varepsilon_1 \geq V(0, y_0; \mathbf{z}) + \varepsilon_0 \qquad (3)$$

where y_1 y_0, q and z are the arguments as defined above and ε_1 and ε_0 are the error terms of the utility derived from the crop rotation system and continuous production of cotton, respectively, by the farmer.

As is common in CV studies (Cooper, 1997; Hubbell *et al*., 2000; Qaim and de Janvry, 2003; Haab and Mc Connell, 2003) we assume that the observable indirect utility function, V(.) is liner. That is,

$$V_i = \mathbf{ß}_{\mathbf{i}}'\mathbf{z} + \alpha(y_i + \delta_{i1} q) \qquad (4)$$

where i = 0,1 , α is the marginal utility of income and isδ_{i1} a Kronecker delta that takes the value of one when i = 1and zero otherwise.
Equation 4 can be written as

$$\mathbf{ß}'\mathbf{z} + \alpha(\Delta y + q) \geq \varepsilon \qquad (5)$$

where $\mathbf{ß}'\mathbf{z} = \mathbf{ß}_{\mathbf{1}}'\mathbf{z} - \mathbf{ß}_{\mathbf{0}}'\mathbf{z}$, $\Delta y = y_1 - y_0$ and$\epsilon = \epsilon_0 - \epsilon_1$. Unfortunately, the expected net income changes per dekar between the crop rotation system and the continuous production of cotton can not be observed. However, it can be explained by other farm and farmer characteristics, so that is implicitly included in the vector. In this contextα takes a value of one, as V is measured in monetary units.

Assuming that ϵ is Independently and Identically Distributed (IID) with mean zero, two widely used distributions are the normal and the logistic (Haab and McConnell, 2003). Given the closed form solution for the cumulative distribution, previous studies commonly have used the logistic distribution for the error term (Cooper and Keim, 1996; Haab and McConnell, 2003.

Given the logistic distribution, the probability that a farmer will accept the incentive payment and adopt the crop-rotation system is:

$$\Pr(\text{yes}) = \left[1 + \exp\left(-\left(\mathbf{ß}'\mathbf{z}/\sigma + \alpha q/\sigma\right)\right)\right]^{-1} \qquad (6)$$

To estimate the parameters, the following log-likelihood function is maximized:

$$\ln L = \sum_{j=1}^{T} I_j \ln\left[\left(1+e^{-\left(\beta' z/\sigma+\alpha q/\sigma\right)}\right)^{-1}\right] + (1-I_j) \ln\left[1-\left(1+e^{-\left(\beta' z/\sigma+\alpha q/\sigma\right)}\right)^{-1}\right] \quad (7)$$

where ln *L* denotes the log-likelihood function, T is the sample size (158 farmers in this study), I_J denotes the binary indicator variable which takes the value of 1 if farmer j answers yes for the offered incentive payment and 0 otherwise.

Once the parameters are estimated and assuming a linear CV model, the value of the expected WTA can be calculated as follows (Haab and McConnell, 2003):

$$E_{\varepsilon}(WTA \setminus \alpha,\beta,\bar{z}) = \left[(\beta/\sigma)/(\alpha/\sigma)\right]\bar{z} \quad (8)$$

where β is the vector of the coefficients of the explanatory variables, α is the coefficient of the offered incentive payment, q and $\bar{z}$ is the vector of the mean values of the explanatory variables.

FACTORS INFLUENCING FARMER ADOPTION OF CROP ROTATION

Besides the level of the incentive payment, a key factor expected to influence a farmer's WTA for switching from continuous cotton to a crop rotation system is the farm's soil salinity. A common measure of soil salinity is Electrical Conductivity. Denoted EC[3], its unit of measurement is deciseimens per meter ($dS\ m^{-1}$). Yields of many crops, including wheat, sugarbeets, soybean, cotton and paddy rice, are not affected by soil salinity in the range of 0-4 $dS\ m^{-1}$ (Datta and de Jong, 2002; Cardon *et al*., 2003). As salinity increase above 4 $dS\ m^{-1}$, yields of these crops gradually decline. Once salinity exceeds 12 $dS\ m^{-1}$, a farmer has no choice but to plant cotton because it is the only crop planted in the Harran Plain that can grow in severely salinised soil. However, continuing to plant continuous cotton increases the likelihood that the land will eventually become too saline to produce any crops.

Therefore, a complex, nonlinear relationship exists between soil salinity and the likelihood that farmers will accept an offered bid level. As soil salinity increases above 4 $dS\ m^{-1}$, a farmer's likelihood of accepting a given incentive payment is expected to increase because the crop rotation system reduces soil salinity. However, if soil salinity exceeds 12 $dS\ m^{-1}$, a farmer is unlikely to accept an incentive payment to switch from continuous cotton production.

Previous research (Akinola, 1987; Polson and Spencer, 1991; Cooper and Keim, 1996; Amigues *et al*., 2002) has found that farm size is positively related to the adoption of new technology. The hypothesized rationale is that, relative to smaller farmers, larger farmers have more income and thus a greater ability to finance the adoption of new technology. Larger farmers also may be more willing to assume the risk associated with adopting a new technology. Their higher income means that the failure of a new technology is less likely to undermine their long-term ability to survive as well as their long-term level of consumption. Because larger farmers are more likely to accept a lower incentive payment to adopt crop rotations, farm size is hypothesized to be negatively associated with WTA.

Most adaptation studies have found that new technological practices are positively related to the farm operator's education level (Hubbell *et al*., 2000; Lynch *et al*., 2002; Qaim and de Janvry 2003; Lapar and Ehui, 2004. However, some studies have found no statistically significant relationship between a farmer's education level and adaptation of new technology (Foltz, 2003; Qaim *et al*., 2006). It is commonly assumed that a higher level of education is associated with a willingness to acquire new information and to learn from it. This argument implies that more educated farmers are likely to accept a lower incentive payment to adopt a crop rotation system.

Two other variables, age of the farmer and contact with an extension agent, are included in this analysis because they are commonly examined in studies of willingness to adopt. However, the empirical evidence for both variables is mixed.

Bultena and Hoiberg (1983), Polson and Spencer (1991), Adesina and Zinnah (1993), Qaim and de Janvry (2003) have shown that, relative to older farmers, younger farmers are more knowledgeable about new practices and may be more willing to bear risk due to their longer planning horizons. However, Adesina and Zinnah (1993), Hubbell *et al*. (2000), Qaim and de Janvry (2003) found no statistically significant relationship between a farmer's age and adoption of new technology.

Polson and Spencer (1991), Kebede *et al*. (1990), Koundari *et al*. (2005) found that contact with an extension agent during the previous year was positively related to the likelihood of adopting an innovation. On the other hand, Qaim and Janvry (2003), Lynch *et al*. (2002) found no relationship between contact with extension agents and the adoption of technology.

RESULTS AND DISCUSSION

The Harran University, College of Agriculture, Department of Soil Science has constructed a soil salinity map for the Harran Plain based on soil samples collected duirng field trips to farms located there. Using Electrical Conductivity as a measure of soil salinity and a common classification scheme (Datta and de Jong, 2002; Asten *et al*., 2003; Katerji *et al*., 2003) soil salinity is recorded as being one of four categories: normal (soil salinity of 0-4 dS m^{-1}), marginally affected (soil salinity of 4.1-8 dS m^{-1}), moderately affected (soil salinity of 8.1-12 dS m^{-1}) and severely affected (soil salinity of 12.1 dS m^{-1} and above).

For the regression analysis, this classification system was transformed into three dummy variables:

$$SD_1 = \begin{cases} 1 & \text{if soil salinity level is } 4-8 \text{ dSm}^{-1} \\ 0 & \text{Otherwise} \end{cases} \quad (9)$$

$$SD_2 = \begin{cases} 1 & \text{if soil salinity level is } 8.1-12 \text{ dSm}^{-1} \\ 0 & \text{Otherwise} \end{cases} \quad (10)$$

$$SD_3 = \begin{cases} 1 & \text{if soil salinity level is } 12.1 \text{ dSm}^{-1} \text{ and above} \\ 0 & \text{Otherwise} \end{cases} \quad (11)$$

The other variables were collected via personal interviews in 2004 with 160 farmers located in Harran Plain, Sanliurfa Province, Turkey. The farmers were selected using a two stage sampling process. In stage one, a random sample of 25 villages was selected from a population of 153 villages. In stage two, 160 farmers living in these 25 villages were chosen for interviews using a random sampling design. Two surveys were excluded from the analysis because they were incomplete. Thus, 158 surveys composed the data set for this study.

The WTA measure of the incentive payment farmers would need to adopt a crop rotation system was elicited during the interview using a two-step dichotomous choice method. First, the farmers were asked if they used a crop rotation system. If the answer was no, they were asked if they would be interested in using a crop rotation system if the government provided an incentive payment. If this answer was yes, they were asked to choose from among the three crop rotation systems listed in Table 1.

Table 1: Crop rotation systems offered to farmers participating in a willingness to adopt experiment, harran plain, Turkey, 2004

First year	Second year
Cotton	Wheat plus maize*
Cotton	Wheat plus soybean*
Common vetch plus cotton*	Wheat plus maize*

Notes: (1) *designates the second crop in a rotation for the year and (2) Source: farmer survey instrument used in harran plain, Turkey, 2004

In each of the three rotations, cotton was planted every other year. Conversations with farmers revealed that they would be unlikely to adopt a rotation in which cotton was not planted every other year. Besides its profitability, farmers know its production function since they have grown it for years. Furthermore, both the marketing system and genetics industry are well established for cotton. The other crops in the rotations were selected based on the advice of extension agents and farmers, the crops currently grown in the study area, the availability of marketing outlets and the production techniques and equipment currently used by farmers in the study area.

Following Cooper (1993), Cooper and Keim (1996), each farmer was given an incentive payment randomly drawn from this set: 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55 and 60 TL per dekar. Each payment had an equal probability of being selected. The range of payments was based on a preliminary analysis involving 18 farmers who lived in the study area. These farmers were asked an open ended question regarding how much the government would have to pay them to switch from continuous cotton to the crop rotation systems listed in Table 1. Their responses ranged from 10 to 50 TL. The range was increased to 5 to 60 TL in recognition of the small number of farmers included in the preliminary analysis.

Once the incentive payment was selected, the farmer had to answer yes or no to whether they would accept it for the crop rotation that they had chosen. The farmers were told to assess the WTA only for the land that they owed.

On average, the surveyed farmers owned 122 dekar of land, with a minimum of 3 dekar and a maximum of 750 dekar (Table 2). Average age of the farmers was 40.1 years. Twenty four percent had earned a high school diploma. The farms were classified regarding soil the salinity as follows: 50.6% normal, 17.1% marginally affected, 15.8% moderately affected and 16.5% severely affected. The average value of the incentive payment offered to farmers was 27.8 TL with the range of 5 to 60 TL.

Table 2: Variables included in the analysis of willingness to accept bids for adoption of crop rotations, harran plain, Turkey, 2004

Variable name	Description	Mean	Standard deviation	Min.[1]	Max.[1]
Incentive value	Adoption incentive in Turkish lira per dekar[2] offered farmer	27.8	13.3	5	60
Farm size	Measured as number of dekar in the farm	122.0	334.0	3	750
Age	Measured in years	40.1	12.3	22	71
Working adults	Number of adults working in farm household	3.0	2.9	1	12
Dummy variables	Share of Surveyed Farmers Coded 1				
Education	Equals 1 if farmer earned high school degree; 0 otherwise	24.0%			
Extension	Equals 1 if farmer had contact with an extension agent during last year; 0 otherwise	55.1%			
Marginal salinity	See equation 6 for definition.	17.1%			
Moderate salinity	See equation 7 for definition	15.8%			
Severe salinity	See equation 8 for definition	16.5%			

Notes: (1) Min. is minimum; max. is maximum. (2) A dekar is a national measure of area used in Turkey. One dekar equals 0.1 hectare. (3) Source: farmer survey instrument used in Harran Plain, Turkey, 2004

RESULTS AND DISCUSSION

No farmer sampled in this study used any of the rotations listed in Table 1 at the time of the survey. When asked to choose a crop rotation, 135 selected cotton followed by a double crop planting of wheat and maize. Thirty five selected cotton followed by the double crop planting of wheat and soybean. Only five selected a double crop of fig and cotton followed by a double crop of wheat and maize. The farmers commonly cited inadequate information on growing soybean and fig and the lack of a well developed marketing system for these crops as reasons for not selecting the last two rotations. Results from the Logit analysis of the elicited WTAs are presented in Table 3. The incentive value offered to a farmer had the correct sign and is significant at the 5% level of statistical significance. Thus, the higher the incentive offered, the more likely the farmer was to adopt a crop rotation system.

The only other statistically significant variables are soils that were classified as having marginal salinity and moderate salinity. Both variables have a positive coefficient and are statistically significant at the 1% test level. Thus, given all other variables, in particular the incentive payment offered to a farmer; the farmer whose land is classified as having marginal and moderate salinity were more likely to adopt a crop rotation system relative to a farmer whose land is classified as having normal salinity. In contrast, the coefficient on the dummy variable for farms classified as having severe salinity was not statistically significant. Thus, given the other variables, the farmer whose land is classified as having severe salinity was no more likely to adopt a crop rotation system than a farmer whose land is classified as having normal salinity.

The parameters obtained from the regression can be used in conjunction with E (7) to estimate the marginal effects of the variable upon the willingness to accept the incentive payment and thus adopt a crop rotation system.

Table 3: Results from Logit Analysis of Willingness to Accept Bids for Adoption of Crop Rotations, Harran Plain, Turkey, 2004

Variable Name	Coefficient	Standard Error	t-statistic	p-value
Constant	-0.9600	0.751	-1.28	0.20
Incentive Value	0.0304*	0.014	2.25	0.02
Farm Size	0.0008	0.001	0.69	0.49
Education	0.2379	0.421	0.57	0.57
Age	-0.0199	0.017	-1.20	0.24
Extension Agent	-0.1142	0.363	-.32	0.77
Marginal Salinity	1.4179**	0.506	2.80	0.00
Moderate Salinity	1.7117**	0.560	3.06	0.00
Severe Salinity	0.5866	0.516	1.14	0.26

Log likelihood function: -98.90**; p-value = 0.012.Notes: (1) * (**) indicates significance at 5% (1%) level of statistical significance. (2) Original calculations using data from a farmer survey in Harran Plain, Turkey, 2004

Table 4: Mean Willingness to Accept (WTA) Bids to Adopt Crop Rotation on Sampled Farmers' Owned Land By Degree of Salinity, Harran Plain, Turkey, 2004

Salinity of farmer's owned land	Mean WTA per dekar
Normal	55.0 Turkish Lira
Marginal	15.3 Turkish Lira
Moderate	6.8 Turkish Lira
Severe salinity	38.1 Turkish Lira
All sampled farmers	27.4 Turkish Lira

Notes: (1) Original calculations using data from a farmer survey in Harran Plain, Turkey, 2004

These marginal effects are discussed only for the significant variables since the other the marginal effect of the other variables from a statistical perspective is zero. A one unit TL increase in the offered bid value leads to an increase of 0,0076% in the probability of saying yes to crop rotation system. Relative to have soil classified as having normal salinity, having soil classified as being marginally and moderately salinized leads to a 0.3544 and 0.4278% increase in the likelihood of a farmer saying yes to the offered bid value to adopt a crop rotation system.

Given the Logit regression results presented in Table 3, the value of the WTA for each surveyed farmer can be calculated using E 8. For all 158 farmers, the average WTA was 27.8 TL per dekar per year (Table 4). The average WTA is also presented by the level of salinity of the farmer's soil. A farmer with normal soil salinity had the highest WTA of 55.0 TL per dekar per year. In other words, farmers with normal soil salinity would have to be paid the highest incentive to move away from continuous cotton and adopt a crop rotation. This finding was expected because the level of soil salinity on these farms was not affecting yields. As noted earlier, continuous cotton is the most profiting cropping pattern in the Harran Plain under normal agronomic conditions. As expected, everything else constant, a farmer with moderate salinity had the lowest WTA, 6.8 TL per dekar per year. This level of salinity is associated with the highest negative impact on crop yields. Again, as expected, a farmer with severe salinity had a higher WTA than either a farmer with marginal or moderate salinity As noted earlier, among the main crops grown in the Harran Plain, the yield of cotton is the most insensitive to severe soil salinity.

CONCLUSION

Salinity is an important and growing problem in the Harran Plain of Turkey. Between 1997 and 2004, the land lost to salinization almost doubled. Primary causes are the high salinity of water used for irrigation and the continuous production of cotton, a crop that requires large amounts of irrigation water. Although research has found that some crop rotation systems can be more profitable than continuous cotton and Turkey has implemented an extension program to promote these rotation systems, adoption has been limited. A common policy recommendation in this type of situation is to offer farmers a government incentive payment to adopt a crop rotation system. Therefore, the objective of this study is to estimate the incentive payment that farmers in the Harran Plain would need to replaced continuous cotton with a crop rotation system.

Contingent Valuation Methods are used to elicit a farmer's Willingness To Accept (WTA) an offer for adopting crop rotations. The average WTA is 27.8 Turkish Lira per dekar. The only statistically significant variables associated with the level of WTA are the level of the incentive payment and whether the farmer's soil is classified as having marginal salinity or moderate salinity. The WTA for soils with marginal and moderate salinity is 15.3 Turkish Lira per dekar and 6.8 Turkish Lira per deka, respectively. In contrast, the WTA for soil with severe salinity did not differ significantly from the WTA for soil classified as having normal salinity. This finding was expected because, among the main crops grown in the Harran Plain, cotton is the most insensitive to severe soil salinity.

These findings suggest that Turkey's government should not adopt a program that pays the same incentive to all farmers to encourage them to replace continuous cotton production with a crop rotation system. Instead, the incentive program should be targeted at farmers whose lands have marginal and moderate salinity problems. This approach will reduce program cost. It also will help prevent land from becoming severely saline and ultimately too saline to produce any crop.

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