Wheat Landrace Cultivation in Turkey: Household Land-use Determinants and Implications for On-Farm Conservation of Crop Genetic Resources

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Introduction

The continued cultivation of landraces by household farms in centers of domestication and diversity is considered to be an *in situ* means of conservation of crop genetic resources. Landraces, or traditional varieties, are defined as crop varieties whose morphological and genetic composition is shaped by household crop management practices and natural selection pressure over generations of cultivation (Smale et al. 2001), while modern varieties refer to varieties that have been improved scientifically, usually by professional breeders.

However, because *in situ* conservation has continued into the present does not ensure that this de facto strategy for conserving crop genetic resources will continue into the future. Whether or not traditional varieties continue to be cultivated rests primarily on factors influencing the crop decisions of these household farms.

This paper focuses on two questions: 1) what are the significant determinants influencing the household cultivation of traditional wheat varieties; and 2) how do those determinants affect on-farm levels of diversity? To address these questions, we incorporate socioeconomic characteristics at the household level, as well as information on agroecological heterogeneity, market access, and perceptions of variety attributes into a household land-use decision model that examines plot-level decisions to cultivate wheat landraces.

The results of this research have policy implications at several levels. If policy makers support *in situ* conservation, information on the households most likely to continue to cultivate landraces, as well as the landraces cultivated by those households, can provide an indication of the likelihood of maintaining *in situ* conservation of crop genetic resources without intervention. Information on these households and on the significant determinants of their landrace cultivation can also provide guidance on the types and levels of intervention necessary, as well as the potential costs.

The paper proceeds as follows: The next section provides the conceptual framework for the empirical analysis outlined in the third section of the paper. In the fourth section, we provide a brief description of the data utilized. Results of the empirical analysis are examined in Section 5, and implications are discussed in the final section.

Conceptual Framework

As crop variety choice decisions take place at the level of the household farm, the conceptual framework underlying our analysis is the household farm model (Singh, Squire and Strauss, 1986) in which the household is simultaneously the producer and consumer of goods. With perfect markets and information, a household farm maximizes utility over a set of consumption goods subject to constraints on income, time, and technology. However, with the existence of any combination of transactions costs, missing markets, and asymmetric information, the household farm's decisions are no longer separable, and its consumption and production decisions cannot be modeled recursively. Household decisions on consumption and production thus take place simultaneously and must be modeled as such.

Previous research on technology adoption and crop variety choice related to diversity have demonstrated the significance of household production and consumption risk aversion (Just and Zilberman 1983, Feder *et al.* 1985, Finkelshtain and Chalfant 1991, Fafchamps 1992); agroecological constraints (Bellon and Taylor 1993); transactions costs and market access (Omamo 1998); and most recently, crop variety characteristics (Smale *et al.*, Hintze 2002, Edmeades 2003). The empirical model used in this paper considers all of these as determinants of land-use decisions.

Empirical Model

The estimation equation takes the following reduced form:

$$\Pr\left(Landrace_j = 1\right) = \Phi(\mathrm{b}_0 + \mathrm{b}_1 SE + \mathrm{b}_2 PC + \mathrm{b}_3 MA + \mathrm{b}_4 VC + \mathrm{b}_5 P + \mathrm{b}_6 AZ + \mathrm{e}) \qquad \textbf{(1)}$$

where the dependent variable is a binary indicator representing the household's choice to cultivate a landrace on plot *j*. The decision is a function of socioeconomic factors at the household level (*SE*), plot level characteristics (*PC*), market access (*MA*), crop variety characteristics (*VC*), provincial indicators (*P*), and agroecological zone (*AZ*).

Socioeconomic Factors

Decision makers with more farming experience may be more reluctant to give up tried and true practices, relative to others, while those with higher levels of education have been shown to be more willing to accept new technologies, including modern varieties (Meng et al. 1998a). A larger overall household size relative to household labor supply could indicate the need to utilize household labor supply efficiently on the production side as well as the importance of sufficient and stable output for household members on the consumption side.

Previous research has demonstrated a positive relationship between farm size and the adoption of modern varieties (Perrin and Winkelmann 1976; Feder *et al.* 1985). Larger farmers may benefit from economies of scale, be able to dedicate some proportion of land to experimenting with modern varieties, or face lower information costs relative to small farmers. Household land fragmentation has also been significant in land use decisions, likely due to larger time demands on labor and the probability of increased environmental heterogeneity.

Other factors likely to play an important role in variety selection are those that affect the household's perception of wealth and their resulting levels of risk aversion. With higher levels of wealth, both the ability of the household to accept and its access to new technology may increase (Feder *et al.* 1985; Brush, *et al.* 1992; Meng et al., 1998). However, wealthy households may also be more willing to trade off higher expected yields for the consumption attributes often associated with traditional varieties. Livestock assets may help the household mitigate risk through market sales or on-farm livestock consumption. However, because landraces are often preferred over modern varieties for the texture and abundance of the biomass for feed, livestock ownership could also increase a household's demand for landraces (et al. 1998).

Plot level Characteristics

Plot level characteristics provide another set of potentially important explanatory variables influencing the household decision to cultivate landraces. High quality land, *ceteris paribus*, is more likely to be planted to modern varieties due to their higher expected yields under optimal agroecological conditions. Irrigation availability reduces the risk of weather variability in production conditions. Finally, a larger plot area may indicate economies of scale in production and result in a lower probability of landrace cultivation.

Market Access

Previous theoretical and empirical research on household farms has reinforced the significance of a household's access to inputs, information, and output markets (de Janvry *et al.* 1991, Omamo 1998). Higher transactions costs to access markets will negatively affect participation and increase self sufficiency in consumption. As landraces are often associated with consumption quality, we expect households producing for their own consumption to be more likely to cultivate landraces as market participation becomes more expensive or as information is less available. As technical information, such as knowledge of recommended varieties, becomes available more readily, we expect household familiarity and access to improved varieties to increase. However, information and access can also apply to landraces. A larger available local supply of wheat varieties could indicate better local seed flows and improved access to landraces (Lipper et al. 2005).

Variety Characteristics

Variety characteristics play an important role in the household's variety choice decision and diversity outcomes (Hintze 2002, Edmeades 2003). In Turkey, the higher the expected yield of modern varieties relative to traditional varieties in a given plot, the less likely households are to cultivate landraces. However, expected stability of yields was positively associated with landraces (Meng et al. 1998a). Landraces are preferred in environmentally stressful conditions, such as cold temperature Meng et al. 1998a), and have been associated with greater adaptability to a range of soil types (Bellon and Taylor 1993). Landraces are often preferred for consumption traits, such as bread making quality, and are recognized as providing a greater quantity and more palatable form of livestock feed, an important consideration for households (Meng et al. 1998a). Resistance to biotic stresses such as diseases and insects, however, are likely to be more associated with modern varieties as a result of targeted breeding priorities.

Provincial and Agroecological Zone Indicators

Fixed factors representing regional differences not controlled for by other variables, such as availability of off-farm opportunities and local prioritization of agriculture may also be significant in plot-level variety choice decisions. Household location in mountainous agroecological zones has also been a significant factor in the cultivation of landraces.

Table 1 summarizes information on the variables used in the empirical analysis.

Table 1: Variables Determining Plot-level Land-Use

Variable Name	Description of Variable	Expected Sign
Socioeconomic		
Characteristics		
Farm Experience	Years of farming experience of decision maker	+
Education	Years of education of decision maker	-
Dependency	Ratio of number of children under 13 and number	+/-
Ratio	of adults over 60 to total number living in	
Total Farm Area	household	-
Fragmentation	Total farm area (hectares)	+/-
Index	Ratio of number of cultivated plots to total area	
Off-Farm	cultivated	+/-
Property	Indicator variable indicating household	
# of Rooms	ownership of off-farm property	+/-
# of Buildings	Number of rooms in the house	+/-
Car Ownership	Number of buildings on household farm	+/-
Livestock	Indicator variable indicating household car	+/-
Holdings	ownership	
Livestock	Three variables indicating household number of	-

Holdings Squared	head of sheep, goats, and cattle Three variables indicating the squared number of head of sheep, goats, and cattle	
Plot-level Characteristics		
Irrigation	Indicator variable for irrigation availability on plot	-
Land Quality	Variable indicating household perception (high, medium, low, or extra low quality	+ as quality decreases
Plot Area	Area of the plot (hectares)	-
Market Access		
Distance	Distance to mill (kilometers)	+
Recommended Varieties	Indicator variable representing household knowledge of varieties recommended for district	-
Variety Supply	Number of varieties available at the district level	+/-
Variety Characteristics	Indicator variables representing household ranking of characteristic as one of the three most important in selecting a wheat variety:	
Yield	High yield	-
Drought	Drought tolerance	+
Cold	Cold tolerance	+
Soil	Suitability for soil type	+
Disease	Disease resistance	-
Bread	Quality of bread	+
Residue	Wheat residue for feed	+
Province	Indicator variables for province (default Eskisehir)	-
Agroecozone	Indicator variables for agroecological zone (valley, hill, mountain (default valley))	+

Data

Data were collected in 1999 in seven provinces in Turkey using a stratified random sampling strategy. Within each province, two districts were selected with contrasting levels of infrastructural and market development. Within each district, one village was randomly selected to represent each of three agroecological zones: valley, hill, and mountain, with a fourth village randomly selected from the most prevalent of the agroecological zones in the district. An average of ten households per village were chosen as randomly as possible to be interviewed for the household surveys.

Of the 486 households originally surveyed, 416 were included in the empirical analysis.

Table 2 presents an overview of the surveyed households.

Table 2: Selected Household Characteristics

	N	Total Land (Ha)	Total Land Planted to Wheat (%)	Total Parcels	% Parcels Planted to Wheat	Fragmentation Index	Modern Variety Only (%)	Traditional Variety Only (%)	Modern and Traditional Varieties (%)
All Households	416	12.1	49.6	7.8	52.6	13.0	47.6	35.8	16.6
Province									
Eskisehir	73	13.8	68.8	8.2	62.8	9.5	87.7	6.8	5.5
Kutahya	69	9.8	59.2	11.2	58.9	16.8	26.1	31.9	42.0
Kastamonu	59	5.7	56.1	7.8	55.1	18.7	40.7	25.4	33.9
Malatya	75	10.7	42.1	5.9	44.1	8.0	58.7	38.7	2.6
Sivas/Kayseri	68	25.7	40.5	9.1	41.8	5.3	45.6	39.7	14.7
Erzurum	72	6.7	35.8	4.9	44.9	20.3	23.6	70.8	5.6
Agroecotype									
Valley	128	13.1	54.2	7.7	57.1	12.2	59.4	24.2	16.4
Hilly	178	14.3	45.5	8.6	48.8	10.5	52.3	30.9	16.8
Mountain	110	7.4	51.4	6.6	54.5	19.0	26.4	57.3	16.3

Table 3 summarizes plot-level agroecological characteristics of land cultivated by the surveyed households. On average, 20.7 percent of the plots were judged by the households to be of high quality. The majority of land was of medium quality, with less than 10 percent of the plots considered to be of low or extra low quality. 22 percent of plots cultivated by surveyed households were irrigated, although there is a high variation depending on the province and agroecological zone. Erzurum and Eskisehir exhibited high levels of irrigation, while plots cultivated to wheat in Sivas/Kayseri were rarely irrigated.

Table 3: Plot-Level Agroecological Conditions					
	N	% of Plots Ranked as High Quality Land	% of Plots Ranked as Medium Quality Land	% of Plots Ranked as Low or Extra Low Quality Land	% of Plots with Irrigation
All Plots	1669	20.7	69.4	9.9	22.0
Province					
Eskisehir	368	29.1	64.1	6.8	38.0
Kutahya	454	19.4	70.5	10.1	16.1
Kastamonu	243	14.4	67.1	18.5	12.8
Malatya	192	14.1	80.2	5.7	14.1
Sivas/Kayseri	254	18.5	74.0	7.5	3.5
Erzurum	158	25.9	62.1	12	55.1
Agroec otype					
Valley	550	33.8	60.2	6	39.1
Hilly	732	14.5	76.1	9.4	13.1
Mountain	387	13.7	70.0	16.3	14.5

As Table 4 illustrates, the district level wheat variety supply varies widely between provinces surveyed with Kutahya and Kastamonu being the provinces with the highest number of wheat varieties available in a surveyed district. In Erzurum, only two varieties were available to households in each district.

Table 4: District Level Wheat Variety Supply			
	N		Number of Varieties
All Households	416		6.2
Province			
Eskisehir	73		7.0
Kutahya	69		11.5
Kastamonu	59		10.0
Malatya	75		4.0
Sivas/Kayseri	68		3.5
Erzurum	72		2.0

Table 5 presents summary data on household rankings of the three most important attributes for the household in any wheat variety, independent of any specific wheat variety cultivated. All households overwhelmingly ranked yield as the most important characteristic, with resistance to cold, disease, and drought as other major attributes of importance. Bread making quality was an important consumption characteristic for many households. Marketability of a variety was also a characteristic highly valued by households.

Table 5: Top Three Most Important Characteristics of Wheat				
	Modern Variety Only (N=198)	Traditional Variety Only (N=149)	Both Modern and Traditional Varieties (N=69)	All Households (N=416)
Variety Characteristic	**% of hhlds**	**% of hhlds**	**% of hhlds**	**% of hhlds**
Yield	95.5	94.6	100.0	95.9
Drought Resistance	25.8	22.8	34.8	26.2
Cold Tolerance	35.4	37.6	49.3	38.5
Disease Resistance	34.3	33.6	36.2	34.4
Suitability for Soiltype	19.7	21.5	10.1	18.8
Good Bread Making Quality	22.2	40.3	15.9	27.6
Good Market Price	21.2	8.1	18.8	16.1

Estimation Results

Equation 1 was estimated using maximum likelihood probit estimation. To account for suspected heteroskedasticity, the Huber-White estimator of variance was used to calculate robust standard errors in order to minimize non-constant variance of the independent variables on the dependent variable (Rogers 1993).

The results confirm the significance of many of the hypothesized determinants of land-use decisions. When jointly tested, the estimated coefficients on all sets of exogenous variables except for variety attributes are jointly different from zero at the 1 percent level. Table 6 presents the change in the marginal probability of landrace cultivation given a small change in the mean of the continuous independent variables or a change from zero to one for dummy variables.

Socioeconomic/Household Indicators

As expected, a household decision maker with more years of farming experience is more likely to cultivate traditional varieties, while more education results in a significantly lower probability of landrace cultivation. The probability of cultivating a landrace is also significantly reduced as total landholdings of the household increase, although the marginal impact is very small. These results are consistent with previous empirical studies.

Wealthier households as identified by off-farm property and car ownership, are significantly more likely to cultivate landraces. This result suggests that as wealth increases, households may be more willing and able to trade off potentially larger expected yields of modern varieties for landrace attributes that they value.

The probability of landrace cultivation also increases with household ownership of sheep and cattle. This result is likely explained by the superior quality and quantity of residues for feed from traditional varieties. However, the sign on the estimated coefficient of the squared cattle term is negative and significant, indicating that as herd size increases, households may view livestock as a more substantive source of alternative income and rely increasingly on feed sources other than wheat straw.

Table 6: Plot-level Land-use Determinant Regression Results (N=1669)			
Dependent Variable: Landrace Cultivation (1=yes, 0=no)			
Independent Variables	**% Change in Probability from Small Change in Mean**		**Robust Standard Error**
Socioeconomic Indicators			
Farm Experience (Years)	0.0031	***	0.0011
Education (Years)	-0.0158	**	0.0074
Dependency Ratio	-0.0629		0.0601
Total Farm Area (Hectares)	-0.0005	***	0.0002
Land Fragmentation	0.1408		0.1946
Off-farm Property Holdings (1=yes, 0=no)	0.0579	*	0.0319
Number of Rooms in House	-0.0078		0.0093
Number of Buildings on Farm	-0.0097		0.0160
Car Ownership (1=yes, 0=no)	0.1246	***	0.0416
Cattle (Head)	0.0260	***	0.0056
Sheep (Head)	0.0023	**	0.0010
Goats (Head)	0.0047		0.0035
Cattle^2	-0.0008	***	0.0002
Sheep^2	0.0000		0.0000
Goats^2	0.0000		0.0000
Plot-level Characteristics			
Medium Quality Land (1=yes, 0=no)	0.1434	***	0.0338
Low Quality Land (1=yes, 0=no)	0.1503	***	0.0614
Extra Low Quality Land (1=yes, 0=no)	0.5850	***	0.0983
Irrigation (1=yes, 0=no)	-0.0915	**	0.0376
Plot Area (Hectares)	-0.0012		0.0012
Market Access			
Distance to Mill (Kilometers)	-0.0019		0.0014
Knowledge of Recommended Varieties (1=yes, 0=no)	-0.1046	***	0.0297
District Supply of Varieties (Number)	0.0269	*	0.0162
Variety Characteristics (1=one of 3 most important to household, 0=not one of 3 most important)			
Yield	-0.0959		0.0787
Drought Tolerance	0.0228		0.0340
Cold Tolerance	0.0686	**	0.0320
Disease Resistance	0.0059		0.0357
Soil Adaptability	0.0860	**	0.0449
Bread Quality	0.0448		0.0397
Residue Quality	0.0571		0.0672
Region (1=yes, 0=no)			
Sivas/Kayseri	0.6869	***	0.0473
Kutahya	0.5072	***	0.0843
Malatya	0.7120	***	0.0343
Kastamonu	0.4308	***	0.0804
Erzurum	0.7411	***	0.0304
Agroecozone (1=yes, 0=no)			
Hill	0.0134		0.0319
Mountain	0.2454	***	0.0438
Pseudo R-Squared = .29			
***denotes significance at the 10% level, ** at the 5% level, *** at the 1% level**			

Plot Level Characteristics

All land quality coefficients are positive and increase in marginal impact on landrace cultivation, suggesting that as land quality decreases, landrace cultivation is preferred. Landraces are expected to perform better than modern varieties on land of lower quality, both in terms of expected yields and stability of yields. The estimated coefficient of irrigation on the plot is negative and significant, implying that modern varieties are preferred over landraces in more optimal growing conditions.

Market Access

Increased knowledge of recommended varieties within a region has a negative, significant impact on the probability of landrace cultivation. This result suggests that access to information may be a constraining factor in the adoption of modern varieties. However, the probability of landrace cultivation by the households within a district increases with the number of varieties available at the district level. This result could imply that households otherwise willing to cultivate landraces are prevented from doing so due to the absence of a market for specific traditional landraces and resulting search and transactions costs.

Variety Characteristics

The estimated coefficients on variety characteristics do not jointly impact landrace cultivation. However, households prioritizing specific traits, such as cold tolerance, are more likely to cultivate landraces than modern varieties. Likewise, households that value varieties for their adaptability to heterogeneous soil types demonstrate a higher probability of landrace cultivation. Interestingly, we did not see the expected significant and positive effect on landrace cultivation of bread quality and residue quantity for feed.

Provincial and Agroecological Zone Indicators

Estimated coefficients of the province indicator variables are all positive and significant. This result was expected based on the prevalence of modern variety cultivation in the default province, Eskisehir, relative to the other provinces. Also, as expected, the probability of landrace cultivation is significantly increased for households located in mountainous agroecological zones, confirming results from previous studies suggesting that landraces likely adapt better to marginal agroecological conditions.

Linkages between Plot-level Land-use Determinants and On-farm Diversity

Farmers in Turkey, as in many other areas of crop diversity, do not directly consider on-farm diversity as an important factor in land-use cultivation decisions.[1] Household diversity outcomes, therefore, are the result of the household's plot-level cultivation decisions and are determined sequentially. Thus, the significant factors influencing the set of plot level decisions made by the household provide the fundamental basis for the level of diversity observed at the household level. The households of primary interest with respect to *in situ* conservation of crop diversity are those cultivating traditional varieties only and those cultivating both modern and traditional varieties.

Table 7 presents the number of varieties each grew in 1998 for households cultivating modern varieties only, traditional varieties only, or cultivating both modern and traditional varieties. Qualitative survey responses from households that specialized in the sole production of landraces indicated the importance of both the yield potential from their chosen variety(ies) and ability to satisfy household consumption demands. Households cultivating only modern varieties focused more narrowly on satisfaction with yield potential. Households explained their choice of a combination of modern and traditional varieties with a need both to mitigate risk and to satisfy various production and consumption needs.

[1] Meng et al. (1998) makes this assertion for households surveyed in three regions of Turkey. Other on-farm diversity studies that treat diversity outcomes as recursive are Brush et al.(1992); Smale et al.(2001); and Gauchan et al. (2005).

Table 7: Number of Varieties Grown per Household by Specialization, 1998-99						
Specialization	N	Households Growing One Variety (%)	Growing Two Varieties (%)	Households Growing Three Varieties (%)	Households Growing Four Varieties (%)	Total (%)
Modern Variety Only	198	79.8	18.2	2.0	0.0	100.0
Traditional Variety Only	149	90.6	8.7	0.7	0.0	100.0
Modern and Traditional Varieties	69	0.0	66.7	27.5	5.8	100.0

Discussion and Implications

An improved understanding of technology adoption patterns and determinants in centers of crop domestication, as well as an understanding of levels of existing on-farm diversity, better inform policy makers on the future feasibility of *in situ* conservation as a means of ensuring the existence of crop genetic resources. Identifying significant factors in land-use decisions is a first step in informing the debate on whether the displacement of landraces by modern varieties decreases overall diversity and if so, to what extent. If landrace displacement by modern varieties does not decrease on-farm and/or aggregate levels of diversity, policy intervention will not be needed to ensure the on-farm conservation of crop genetic resources. However, if landrace displacement lowers the level of on-farm and/or aggregate diversity beyond a desired level, policy measures may be appropriate.

Our results provide several implications for the continued cultivation and in situ conservation of wheat landraces in Turkey. As household decisions in the future are taken over by younger decision makers and as education levels increase, the likelihood of cultivating traditional is likely to decrease. Similarly, the development of improved varieties with better adaptation to heterogeneous agroecological conditions may decrease household decisions in favor of landrace cultivation. However, our results also suggest that it is not the poorest households that are cultivating landraces, implying that there are perhaps consumption needs and niches that can be better exploited. Furthermore, our results suggest that improvements the local level supply and accessibility of traditional varieties may be a viable means of intervention.

Taking as an example the set of 231 plots predicted by the estimated model to have 75% or greater probability of being cultivated in landraces[2], we identify corresponding households to observe that this subset involves 4 households in Kastamonu province, 7 households in Sivas/Kayseri, 10 households each in Kutahya and Malatya provinces, and 36 households in Erzurum province. Among these households, a total of 12 landraces is cultivated, although in some cases, a landrace is cultivated by only one household. By further examining both the household characteristics and the diversity within each landrace and across the set of landraces for different probabilities of landrace cultivation, we can continue to improve both the targeting of households likely to continue landrace cultivation as well as the landraces most likely to be cultivated.

[2] The estimated model predicted correctly for 81% of the plots in the sample.

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