Adoption and Impacts of Improved Winter and Spring Wheat Varieties in Turkey

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Introduction

Wheat is one of the most important agricultural commodities in Turkey, and the country ranks among the top ten producers in the world. It is a staple and strategic crop, and an essential food in the Turkish diet, consumed mostly as bread, but also as bulgur, yufka (flat bread) and cookies. Total annual wheat production is estimated at 17.7 million tonnes, valued at approximately US$5 billion in 2006/07 (FAO, 2009). Value addition via processing make the wheat industry one of the major sectors in the economy. Wheat production increased in the late 1970s, enabling the country to become a wheat exporter, though production declined in the 1980s.

With its research infrastructure and a core of well-trained scientists, Turkey has also made a significant contribution to international efforts to improve winter wheat production. In 1986, the government of Turkey and CIMMYT, joined by ICARDA in 1990, established the International Winter Wheat Improvement Program (IWWIP). Several improved wheat varieties have since been jointly developed, disseminated and grown by producers both in Turkey and elsewhere in the world. Other varieties were also introduced into the country, particularly with the implementation of new agricultural policies in the 1980s, and both private companies and public agencies introduced new varieties at an accelerated rate.

However, there has been no systematic monitoring of the adoption of these varieties, and economic impacts on producers were not evaluated. Key socio-economic research questions remain unanswered, especially whether these improved varieties have effectively contributed to achieving their intended impacts.

Objectives

The objective of this study was to document the adoption of five new winter and spring wheat cultivars in Turkey, and to assess their economic impacts under rainfed and irrigated conditions in different agricultural zones in selected provinces. These varieties were developed by the national breeding program and through international collaboration over the past 10-15 years.

Specifically, the study evaluated the technical, economic, and social impacts of the monitored varieties on the livelihoods of producers, and whether the new varieties increased wheat productivity, profitability, household income, and whether they thus improved household poverty status.

Results of this study were deemed to be important in establishing whether research efforts are generating the expected positive impacts at the household level, and will therefore demonstrate to different stakeholders the actual impacts of the national and international breeding program on rural livelihoods.

1. BACKGROUND TO WHEAT IN TURKEY

1.1 Characteristics of wheat varieties monitored through the study

a) Ceyhan-99

Ceyhan-99 is a spring wheat variety released in 1999. It was developed by Cukurova Agricultural Research Institute in Adana from germplasm provided by CIMMYT (pedigree: BJY"S"/ COC; cross ID and selection history: CM55651-4Y-2Y-1M-4Y-0M). The variety was recommended for cultivation in rainfed areas and has been grown in Cukurova region since 1999, and in other spring wheat growing regions of Turkey. Ceyhan-99 is medium early maturing with good resistance to lodging, cold and drought in the region where it is grown. Ceyhan-99 is resistant to yellow rust, and septoria, and is also moderately resistant to leaf rust. It is suitable for growing on fertile and less fertile soils, and the grain yield is 5000-8000 kg/ha. It has good grain and bread-making qualities. The thousand kernel weight is 32-34 g, test weight 77-78 kg/hl. Other quality characteristics include: protein 14-15 %, sedimentation 42-44 ml, and a softening value of 60.

b) Demir-2000

Demir-2000 is a winter wheat variety released for use by producers in 2000. This variety was developed by the Central Field Crop Research Institute in Ankara (pedigree: 21031/ CO6552142/ MARA/SUT/3/PTP; cross ID and selection history YA19673-0A-0A-2A-0A). It has a medium late growth cycle. The spike is white, with awn and compact, and the plant height is 110-120 cm. The variety has high productive tillering with high winter hardiness, to be grown in winter wheat areas of the Central Anatolian Plateau, with a medium tolerance to drought. It is resistant to leaf rust and root rot. Given its height, Demir-2000 also has medium resistance to lodging. The grain yield potential is high, about 2000-3000 kg/ha even in drought conditions, and 3800-6000 kg/ha in irrigated areas of Central Anatolia. It is suitable for growing on fertile and less fertile soils. The planting rate is between 450-500 g seeds/m2 and recommended nitrogen fertilization rate is 80-100 kg/ha pure N under rainfed conditions, and 100-150 kg/ha pure N, under irrigated system. The grain is oval, hard-red, large, and has good milling and baking qualities. The thousand kernel weight is 35-40 g and test weight is 78-82 kg. Some quality characteristics are: protein 12-15 %, sedimentation 30-44 ml, gluten 35-45%, gluten index 60-68%, absorption 60-65%, and energy value 150-200.

c) Karahan-99

Karahan-99 is a medium early winter wheat developed by Bahri Dagdas International Agricultural Research Center in Konya (pedigree: C12615/COFN"S"/3/ N10B11/ P14// SEL101/4/KRC; cross ID and selection his-

tory: YE 2957-4E-1E-1E-0E) and released in 1999. It is generally suggested for growing in the rainfed areas, and has been grown in the Central Anatolian Plateau since its release. The winter hardiness and tolerance to drought is very good, and it has high productive tillering. The plant height is medium-high, so it has medium resistance to lodging. The grain yield is 2000-5000 kg/ha depending on the growing conditions. The planting rate is between 450-500 g seeds/m2 and the recommended nitrogen fertilization is 80-90 kg/ha of pure N. The grain quality is good, having desired milling and baking qualities. The thousand kernel weight is 32-38 g and test weight 76-81 kg. Some quality characteristics include: protein 11-14%, sedimentation 16-12.5 ml, and gluten 12-9.65%. Karahan-99 planting started with 135 ha in Konya province in 2004 and reached 11,370 ha in 2007 (Küçükçongar *et al.*, 2006).

d) Pehlivan

Pehlivan is a winter wheat variety released in 1998. The variety developed by the Trakia Agricultural Research Institute (pedigree: Bez /Tvr/5/Cfn/Bez// Suw92/ CI13645/ 3/ Nai60/ 4/Emu"S", cross ID and selection history - TE2376-6T-1T-3T-0T). It has a medium early growth cycle. The spike is white, smooth, awnless and compact, and the plant height is 95-100 cm. The variety has high productive tillering with high winter hardiness to be grown in winter wheat areas of the Central Anatolian Plateau, with a medium tolerance to drought. It has medium resistance to powdery mildew but is susceptible to leaf rust and root rot. Given its height, Pehlivan also has medium resistance to lodging. The grain yield potential is high, about 5000-7000 kg/ha. It is suitable for growing on fertile and less fertile soils, and is grown in most wheat producing regions of Turkey. The planting rate is between 450-500 g seeds/m2 and recommended nitrogen fertilization rate is 120-150 kg/ha pure N. The grain is oval, hard-red, very large, and has good milling and baking qualities. The thousand kernel weight is 38-42 g, and test weight is 78-82 kg. Some quality characteristics include: protein 12-14%, sedimentation 35-45 ml, gluten 35-45%, gluten index 60-70%, absorption 60-65% and energy value 190-220.

e) Saricanak-98

Saricanak-98 is a spring durum wheat variety developed by the South East Anatolia Agricultural Research Institute in Diyarbakir from germplasm provided by ICARDA and CIMMYT (pedigree: DAKI=DACK/GEDIZ//USPA575; cross ID: CD19606) for spring planting and is early maturing with high productive tillering. It was released in 1998 and has been grown in the south-east Anatolia wheat region of Turkey since 2000. The plant height is medium-tall, so the variety has resistance to lodging. The resistance to drought is good and the grain yield potential high, about 7000-10000 kg/ha in irrigated systems and 3500-5000 kg/ha in rainfed areas. The variety is generally suggested for cultivation in rainfed and

supplementally irrigated areas, but it gives exceptionally high yields under irrigation. The recommended planting rate is between 400-450 seeds/m2 and nitrogen fertilization is 120-160 kg/ha (of pure N) under irrigated conditions. The grain quality is good with protein content up to 13.6%, mini sedimentation 6-8 ml, and grain color is desirable for macaroni producers. The thousand kernel weight is 40.6 g and the test weight 80 kg. An estimated 334.5 ha and 1767 ha were cultivated in 2005 and 2006, respectively, in the province of Diyarbakir.

Detailed physical and quality characteristics of the varieties are presented in Table 2. The average yields recorded in a good, normal and dry seasons are also summarized in Table 1. Among all the varieties, Saricanak-98 is the most productive in good years; however, yield data is not available for other years. Pehlivan and Ceyhan-99 are the highest yielding varieties on average across the three types of growing years, followed by Karahan-99.

Table 1. Potential yields by different wheat varieties (kg/ha)

Variety name	Good season	Normal season	Dry season
Ceyhan-99	7360	6320	5280
Demir-2000	6000	4000	2500
Karahan-99	5000	3500	2000
Pehlivan	7680	6740	4540
Saricanak-98	8380	5000	2800

Source: MARA Variety Registration and Seed Certification Center, Agricultural Research Institutions (2008).

Table 2. Characteristics of monitored wheat varieties

Variety Name		Test weight	1000 seed weight (g)	Sedime-ntation	Protein Content %	UV %	Absorption %	Alveograph Energy value	Hardness PSI	Softening Degree
Ceyhan 99	average	78.0	35.2	38	12.0	66.7	57.8	216	64.6	72
	min.	69.7	26.6	29	9.5	55.4	53.6	122	40.4	25
	max.	83.3	45.0	61	15.9	73.7	62.1	501	86.9	145
Karahan-99	average	78.8	33.7	38	12.7	66.4	55.7	178	75.3	129
	min.	74.9	27.8	25	10.4	61.0	51.3	101	60.8	60
	max	81.3	43.4	67	15.7	74.5	60.8	266	99.6	235
Demir-2000	average	77.7	33.2	37	12.4	68.0	61.7	187	62.8	141
	min.	72.6	26.8	27	10.3	61.4	51.5	103	28.4	35
	max	82.2	46.6	57	15.2	78.9	68.1	261	78.1	245
Pehlivan	average	78.5	37.1	35	12.1	69.2	60.8	185	65.1	114
	min.	70.7	23.0	22	9.0	52.5	54.1	70	35.6	20
	max	83.4	49.7	67	15.9	77.8	68.7	304	90.7	220

Variety Name		Test weight	1000 seed weight (g)	Sedime ntation	PRT(%)	IVU (%)	IV (%)	CT (%)	b value*
Saricanak-98	average	80.5	35.4	16	13.3	70.0	58.9	89.4	22.7
	min.	71.0	19.40	7	9.2	61.9	52.4	8.0	20.4
	max	84.9	46.3	27	18.0	75.5	65.8	100.0	25.2

* 'b' value = semolina b yellowness value

Source: The Central Research Institute for Field Crops, Quality and Technology Laboratory, Ankara, Turkey

1.2 Rural poverty in Turkey

Although rural poverty has declined in Turkey over the past decade, extreme disparities of income and poverty levels persist across the country. In 2007, it was estimated that 0.63% of the Turkish population lived below the poverty line (US$2.15 per day) (Turkish Statistical Institute, 2008). In poor rural areas, family sizes are nearly twice the national average, adult literacy rates are far lower than the national average, there are fewer doctors, agricultural production per capita is lower, and fewer women are employed. More rural people live in poverty than urban people. The overall poverty rate in rural households is 35%, however, the margin between rural and urban households is diminishing as more rural people migrate to urban areas, mainly in the more prosperous western parts of the country.

The poorest rural people are self-employed and unpaid family workers. They include small-scale farmers and their households, and people who live in remote and isolated areas. Women and unemployed young people are particularly disadvantaged. The common causes of poverty among disadvantaged people in Turkey's rural areas include large family size and the small landholding size, long-term environmental problems such as overgrazing and soil erosion, a lack of infrastructure such as roads and markets in remote areas, and the lack of an effective welfare safety net (for more information, see related pages at the website: http://www.ruralpovertyportal.org/english/regions/asia/tur/index.htm).

1.3 Government policies towards increasing wheat production

In Turkey, the government stimulates agricultural production through crop subsidies, low taxation, price supports, credit with subsidized interest rates, research and education programs, and the establishment of model farms. It also controls the conditions under which farm products can be traded and for some products such as grain, the government is the sole exporter. For nearly all crops, the government provides support for the use of certified seeds. The largest support is in the form of a direct rural income support of US$88.33/ha. Drought Support was added in 2007, for example, when US$125/ha was paid to producers in 40 provinces as part of relief from a severe drought.

Wheat producers in 2007 received US$24/ha (28.8 TL/ha) toward the cost of fuel, US$17.8/ha (21.3 TL/ha) for fertilizer, US$8.3/ha (10 TL/ha) for soil analysis, US$83.3/ha (100 TL/ha) as direct income support, US$41.7/ha (50 TL/ha) for certificated wheat seed support, and US$25/ha (30 TL/ha) to promote organic production. It is estimated that together, all subsidies to wheat production amount to US$200/ha (TL 240/ha), excluding price support, or US$37.5/t (45 TL/t) (MARA, 2008). Relating to credit; there is about a 60% reduction for agricultural credit distributed by agriculture banks and agricultural credit cooperatives, and about 50% of agricultural insurance payments are to be paid back by the government. In

addition, agricultural cooperatives and some farmer organizations provide long term loans to meet the needs of wheat producers.

Between 1938 and 2002, the wheat market has been state controlled through the Turkish Grain Board (TGB), which announces official prices and aims to purchases all wheat grain from producers. However, since 2002, the market has been slightly liberalized, and the TGB now only declares the buying prices. The purchasing price of wheat has since been determined by market forces, depending on the quality and quantity of the grain. In relation to producer price support, there is a direct subsidy, being US$0.0375/kg of wheat (0.045 TL/kg), paid to producers in 2007 (MARA, 2008).

2. METHODOLOGIES

2.1 Introduction

The first part of this evaluation was a review of previous studies related to adoption and impact of wheat production in Turkey. Field visits and rapid rural appraisal (RRA) were then made to the target study areas to gain a good understanding of farmers' circumstances and farming systems dominated. Later, formal surveys were carried out, and farm level data were collected using questionnaires. Several methods were used for data analysis including descriptive analysis and econometric models.

2.2 Planning and development of tools

A planning meeting was organized in Ankara on 2-3 July 2007, between representatives from ICARDA, CIMMYT and TAGEM. This meeting discussed research objectives, agreed on the main impact indicators of interest, and helped to identify and agree on the new wheat varieties to be evaluated. It also discussed the scope of the study in terms of geographic coverage, and the resources required. Accordingly, the following improved varieties: Ceyhan-99, Demir-2000, Karahan-99, Pehlivan and Saricanak-98, developed jointly through collaborative efforts between agricultural research institutes in Turkey, CIMMYT and ICARDA, were selected for the adoption and impact assessment study. These varieties are referred to together in this report as the 'monitored varieties'.

The terms of reference and the workplan were jointly developed, and. a workshop was organized in Konya on 27-30 November 2007, to develop, pre-test and finalize the survey questionnaire to be used for data collection. The survey was implemented between January and May 2008, followed by data entry, and a workshop at ICARDA headquarters in Aleppo, Syria for data cleaning and preliminary analysis. Subsequently, the data was analyzed in August 2008 and reporting initiated jointly.

2.3 Agro-ecological zones

Turkey is characterized by diversified agro-ecologies which permit the production of a wide range of crops and livestock. The State Institute of Statistics recognizes nine agricultural zones (AZ) (Figure 1). Each of the five provinces covered in this study falls within one specific agricultural zone, having the following main characteristics, with large farms are concentrated mainly in the Konya and Adana regions.

- Ankara is within the Central North Zone (AZ 1) with a continental climate and annual rainfall of 375 mm. The production system for cereals, food and forage legumes is predominantly rainfed with extensive rearing of small ruminants, and intensive dairy cattle.

- Edirne is in the Marmara and Thrace Zone AZ 3) with an average rainfall of 700 mm per year. Wheat and other cereals are produced, also sunflower, and vegetables.
- Adana is part of the Mediterranean Agricultural Zone (AZ 4) in the western coastal area of the country, with average rainfall up to 700 mm per year. Cereals are produced under rainfed conditions or irrigation.
- Diyarbakir is in the South East Zone (AZ 6) with large fertile plains in the southern part. The production system is mainly rainfed, although the GAP project has invested in one of the biggest irrigation scheme in the zone.
- Konya is part of the Central South Zone (AZ 9) having an average rainfall of 350 mm per year and 80-100 days of frost. Crop production is mainly under rainfed cultivation

2.4 Sampling

Multi-stage stratified random sampling was applied to five provinces, and dominant production systems by district or cluster of districts, communities, and wheat producing households. The provinces of Adana, Ankara, Diyarbakir, Edirne and Konya were selected, based on information about the distribution and use of improved varieties being monitored. These also have diverse agro-ecologies, and represent the largest wheat production provinces, accounting for 1.9 million hectares of the national total of 8.6 million hectares of cultivated wheat in 2007, with Konya leading (623,000 ha) followed by Ankara (512,000 ha), Diyarbakir (302,000 ha), Adana (263,000 ha) and Edirne (190,000 ha) (Turkish Statistical Institute, 2009).

Fig. 1. Agricultural zones of Turkey

Table 3. Distribution of sampled household by province and production system

Province	Districts	Communities	Sampled households		
			Irrigated	Rainfed	Total
Adana	7	27	30	100	130
Ankara	6	27	17	113	130
Diyarbakir	7	49	38	92	130
Edirne	8	15	-	90	90
Konya	10	52	143	158	301
Total	**38**	**170**	**228**	**553**	**781**

Within each province, districts were classified into two predominant wheat production systems (rainfed and irrigated) and to the two types of wheat (bread or durum) predominantly cultivated. Rural communities and farmers were randomly selected in the respective systems using lists obtained from census offices, with distribution of farm households across production systems proportional to their relative importance in terms of area of wheat cultivated. The survey was implemented between January and May 2008, and a total of 781 questionnaires were completed from direct interviews of producers. The distribution of the sampled households across province and production systems is presented in Table 3 below.

2.5 Variety classifications

A total of 45 different wheat varieties were encountered during the survey. The five monitored varieties (Ceyhan-99, Demir-2000, Karahan-99, Pehlivan, and Saricanak-98) were released a relatively short time ago compared to other cultivars grown, and these are the most promising in much of their target areas.

There were 13 wheat varieties released before 1995 that are classified as 'old improved varieties' (Table 4), and 27 released during or after 1995 are classified as 'other new varieties' (Table 5).

Pehlivan has the broadest geographic range, being the only variety grown in four of the five sampled provinces (with the exception of Adana), whereas Ceyhan-99 is grown in three provinces (Adana, Diyarbakir, and Konya) and Demir-2000 in two provinces (Ankara and Konya). Saricanak-98 and Karahan-99 are grown only in Diyarbakir and Konya respectively.

The monitored varieties represent only 11% of all varieties grown by the sampled producers, however. From the sample, five different varieties were reported in Adana province, six in Edirne, 11 in Ankara, 21 in Diyarbakir, and 24 in Konya. The number of wheat varieties follows the order of importance of the respective provinces in their share of total wheat area cultivated in Turkey.

Table 4. Variety classification: old improved varieties

Variety Name	Release date	No of growers in the sample	%
Aydin-93	1993	7	1.4
Bezostaja-1	1968	245	48.0
Cesit-1252	1991	30	5.9
Dagdas-94	1994	4	0.8
Diyarbakir-81	1987	6	1.2
Ege-88	1988	3	0.6
Firat-93	1993	16	3.1
Gerek-79	1979	103	20.2
Gun-91	1991	2	0.4
Katea 1	1988	13	2.5
Kiraç-66	1970	2	0.4
Kiziltan-91	1991	55	10.8
Yuregir-89	1989	12	2.4
Zerun	Local land race	1	0.2
Other varieties	-	11	2.1
Total		**510**	**100.0**

Table 5. Variety classification: other new varieties

Variety Name	Release date	No of growers in the sample	% v
Adana-99	1999	56	13.9
Ahmetaga	2004	3	0.7
Altay-2000	2000	7	1.7
Amanos-97	1997	2	0.5
Bayraktar-2000	2000	3	0.7
Dariel	2002	5	1.2
Ekiz	2004	2	0.5
Flamura	1999	43	10.7
Gelibolu	2005	33	8.2
Golia	1999	7	1.7
Gönen	1998	5	1.2
Guadolope	2007	2	0.5
Kirgiz-95	1995	4	1.0
Konya-2002	2002	27	6.7
Nurkent	2001	33	8.2
Pamukova-97	1997	4	1.0
Pandas	2001	36	8.9
Prostar	1999	1	0.2
Sagettario	2001	61	15.1
Svevo	2001	19	4.7
Tekirdag	2005	5	1.2
Tosunbey	2004	1	0.2
Zenit	2001	1	0.2
Ukrayna*	-	27	6.7
Toros*	-	15	3.7
Ispanyol*	-	1	0.2
Total		**403**	**100.0**

* Varieties not registered officially, names are given by farmers

2.6 Modeling the diffusion of monitored varieties

Diffusion of new technologies is directly linked to adoption process. According to most theories on the adoption and diffusion of new agricultural technologies, the adoption of a new technology is not a single sudden event, but is a process. The diffusion of an innovation has been defined as a process by which the innovation is communicated through certain channels over time among the members of a social system (Rogers, 1983). A social system is defined by Rogers (1983) as "a population of individuals who are functionally differentiated and engaged in collective problem-solving behavior". In the context of this study the social system consists of the potential adopters, or the farming communities, in the target areas.

The time dimension is essential in the diffusion process; it is an important aspect of any communication process. Researchers (Rogers, 1983; Mahajan and Peterson, 1985; CIMMYT, 1993) have shown that adoption of an innovation when plotted against time often follows a normal distribution curve. If the cumulative number of adopters is plotted over time the resulting distribution is an S-shaped curve, in which there is slow initial growth in the use of the new technology, followed by a more rapid increase, and then a slowing down as the cumulative percentage of adoption approaches its maximum. Early research on the diffusion process focused on describing the observed diffusion patterns in terms of prespecified distributions (Mahajan and Peterson, 1985).

Subsequent research has attempted to develop more theory-based models. Diffusion models have been developed to represent the spread of an innovation amongst a given population of prospective adopters in terms of a simple mathematical function of the time that has elapsed from the introduction of the innovation. The objective of such a diffusion model is to show the successive increase in the number of adopters over time. This provides valuable information about trends and prospects for a new technology, by providing an estimate of the rate of adoption, from which predictions about future progress and demand for inputs can be made. In addition it allows extension services to quantify the change in the number of technology users over time in order to evaluate the impact of an agricultural technology (CIMMYT, 1993).

Logistic function has been used in this research, a well-known function in determining the diffusion of new technologies. The function is S shaped and is expressed as follows (CIMMYT, 1993):

$$Y_t = K / (1+ e^{-z - b t}),$$

where Y_t is cumulative share of the adopter in time t, K is the maximum adoption rate, and z is a constant related to the time when adoption begins, and b is a constants related to the rate of adoption. The above function could also be written as follows:

$$\ln \quad \frac{Y_t}{K - Y_t} = z + b\,t$$

By using ordinary linear regression, it is possible to estimate coefficients of z and b. Based on the time-series data (i.e. year since variety is being used) and the number of yearly adopters of the monitored wheat varieties which were gathered in this study, the coefficient values of the logistic function which gave the best fit for the data was estimated.

2.7 Assessing productivity impacts

Fundamental to economic analysis is the idea of a production function, which describes the maximum output obtainable at the existing state of technological knowledge and with given amounts of factor inputs. Production function analysis provides a theoretical framework to estimate the comparative productivity of inputs used in a production process. The most straightforward approach to formally link notions of technical change with measured rates of productivity growth is to assume that an index of the state of technology can be incorporated directly in a production function. Hence technological progress is perceived as an upward shift in production function.

Many functional forms have been defined in the literature for the analytic study of production process (e.g. Griffin *et al.,* 1987), however, economic theory provides mainly generic conditions of specification and provides little guidance for specifying a function. Any attempt to fit a production function immediately confronts the specification problem, i.e. choosing arguments, and the algebraic form of the function. Satisfactory specification must consider the technological conditions governing each production process.

The Cobb-Douglas function is by far the most widely used in agricultural economics because of its simplicity and ease of estimation. Its specification satisfies theoretical properties of strict monotonicity, quasi-concavity, strict essentiality, non-empty input requirement sets, continuity, differentiability, and homogeneity. Aside from being easy to estimate, it owes some of its popularity to the straightforward and transparent way in which the estimated parameters can be used to quantify the economic effects of interest. The Cobb-Douglas function permits the calculation of returns to scale and embodies the entire marginal productivity theory of distribution. The general form for the Cobb-Douglas function is:

$$Y = A \prod_{i=1}^{n} X_i^{ß_i}, \quad ß_i > 0 \qquad i = 1,2 \ldots n$$

where Y is the output, and X a vector of essential inputs used in production, and n is number of inputs used. The parameter A is the combined effects on the produc-

tion function of all inputs (rainfall, weather, disease outbreaks, etc.) that are not under the strict control of the farmer. Empirically, a logarithmic transformation in the following format was made, and dummy variables included to distinguishing the impact of the improved varieties being monitored on crop productivity:

$$\ln(Y) = \ln(A) + \sum_{i=1}^{n} ß_i \ln(X_i) + \sum_{j=1}^{J} \delta_j D_j + \varepsilon \qquad ß_i > 0 \quad i = 1,2,....n \qquad j = 1,2,... J$$

where Y is the output measured per unit land area, X_i are variable inputs such as seeds and fertilizers used per unit of land; D_j are dummy variables for varieties, production system, and variety type, which take the value of 1 for monitored varieties, irrigated system, or durum wheat variety, and zero otherwise; and ε is the error term of the regression equation. A significantly positive (negative) coefficient estimated on the dummy variable representing the improved variety reflects an upward (downward) shift in the intercept of the production function due to the new technology. Alternatively, it means an increase (decrease) in total factor productivity as a result of variety adoption. The same interpretation is valid for other dummies included in the model. After the estimation of the log-linear form above, the anti-log of the intercept term ln(A) gives the actual value of A when one is interested in the contribution of factors not controlled by the farmer.

2.8 Adoption and impact indicators

Several indicators which encompass the notions of adoption, productivity, efficiency, economic, and social impacts are used in this study to assess and evaluate the advantages being derived from the monitored improved wheat varieties.

Adoption is first measured by the rate defined as the percentage of farmers using these varieties. This indicator is largely subject to the convenience of the new varieties, their profitability, the degree of risk regarding adaptability to drought and other climatic conditions, resistance to diseases and pests, the policy environment, and socio-economic characteristics of producers. Although the adoption rate is an important indicator in measuring technology uptake, other indicators are used to better assess comprehensively the adoption. These include adoption degree, as measured by the proportion of land under the new wheat varieties compared to the total area of wheat cultivated, and the intensity of adoption, which represents the product of adoption rate multiplied by the adoption degree. It defines on average the overall proportion of wheat area cultivated with the improved varieties and may be quantified in terms of seed quantity of these varieties compared to total wheat seed sown using the appropriate seeding rates applied by producers.

Technical and economic indicators of impacts include crop productivity as measured in terms of yields. Yield stability is assessed by comparing average yield in

normal, good and dry years, and by comparing the standard deviation (or coefficient of variation) of yields by variety, and within the same cropping year. Water use efficiency is measured by the amount of physical output per unit of rainfall obtained over the growing season in rainfed systems. Profitability is measured by the gross margin generated per unit of land by wheat variety; since farmers produce several varieties and other crops on their farms, this is an appropriate measure of the contribution of each variety to the overall farm profitability in the presence of fixed production costs. Household income from wheat and from all economic activities are estimated and compared between adopters and non-adopters.

'Poverty' is defined as an economic condition of lacking both money and basic necessities needed to live successfully, such as food, water, education, healthcare, and shelter. There are many working definitions of 'poverty' with considerable debate on how to best define the term. Income security, economic stability and the predictability of one's continued means to meet basic needs all serve as absolute indicators of poverty. Poverty may therefore also be defined as the economic condition of lacking predictable and stable means of meeting basic life needs.

Poverty levels are estimated by comparing the percentage of households which fall below, within, or above the reference poverty line which was defined as $0.99 and $1.2 per capita per day between adopters and non-adopters. The population living below $2 a day was 27% in 2002 and 18.7% in 2003, as estimated by the World Bank. However, the Turkish Statistical Institute (2009) indicated that the poverty line in Turkey is $2.15 per capita per day, but that only 0.63% of the Turkish populations live below this.

3. RESULTS

3.1 Farmers' characteristics and household assets

Households usually use a variety of resources as inputs into their production. These can be classified into human, financial, physical, natural and social capital, as has been popularized in the sustainable livelihoods approach (Carney, 1998), and these have been used here to ensure that all the components of livelihood assets were addressed, summarized in Table 6.

Natural capital is very important for rural communities because they derive all or part of their livelihoods from resource-based activities. Farm size is a major determinant of the financial status of farmers, plays an important role in family labor employment and income, and may influence production per unit area. Mean farm size in the target areas was 27.4 hectares, with a range from 0.5 to 620 ha, but generally most households in the sample were small farmers and 50% of those samples had less than 19 ha. Mean farm size varies between provinces, being 16.6 ha in Adana but 369 ha in Diyarbakir. Irrigated land represents on average 23% of survey farmland, being only 10% in Ankara and Edirne, and 40% in Adana and Konya. Farmers owned 55% of farmland, 20% was sharecropped and 25% was rented.

Physical capital plays a vital role, as it comprises basic infrastructure and producer goods supporting livelihoods. Many assessments have found that a lack of certain infrastructure is a core dimension of poverty. Without adequate access to public services such as water and energy, human health deteriorates and long periods are spent in non-productive activities (DFID, 2001). Livestock, tractors, and other ownership all affect household welfare.

Human capital represents skills, knowledge, availability of labor and health status that together enable people to pursue different livelihood strategies. The household head remains the main driving force behind any household livelihood strategy, and their education, experience and age had a strong influence on decisions regarding crops, livestock management and farm investments. Household endowments of different livelihood assets were included in the analysis, and most farmers classified themselves as moderately well-off whereas only a small proportion classed themselves as poor or very poor.

Financial capital is the availability of money or equivalents that enables people to adopt different livelihood strategies. Available stock and savings may not be cash, and is sometimes livestock in dry areas. Livestock are considered a stand-by asset as part of a strategy to reduce vulnerability, and alternative sources of income, especially from non-farm activities, also have poverty reducing effect. Facilitating

Table 6. Household assets

	Adana	Ankara	Edirne	Diyar-bakir	Konya	Mean	Sig
Natural capital							
Total land holding (ha)	16.6	31.7	20.0	38.9	29.6	27.4	***
Arable land (ha)	16.3	31.5	20.0	38.6	29.4	27.2	***
Non-arable land (ha)	0.3	0.2	0	0.3	0.2	0.2	n.s.
Total irrigated area (ha)	6.7	3.1	2.0	8.6	11.7	6.4	***
Own land (ha)	8.3	12.4	12.5	20.6	22.6	15.3	***
Sharecropping land (ha)	3.3	10.3	2.6	8.0	3.1	5.5	***
Rented land (ha)	5.0	9.0	4.9	10.3	3.9	6.6	n.s.
Physical capital (% of farmers)							
Having a tractor	82	73	82	65	78	76	(*)
Having a combine harvester	2	2	2	1	7	4	*
Having shop	7	2	8	1	6	5	n.s.
Having car	35	30	32	14	38	32	**
Having cattle	51	39	61	52	26	41	***
Having sheep and/or goats	4	14	6	2	24	13	***
Having telephone	77	78	78	89	79	80	n.s.
Having satellite dish	69	82	86	61	64	70	***
Human capital							
Family size (persons)	6.16	6.82	4.63	9.3	6.57	6.78	***
Size of family labor (persons)	1.8	1.52	2.22	2.84	3.11	2.48	***
Permanent hired labor (persons)	0.22	0.62	0.09	0.3	0.23	0.29	***
Age of household head (years)	51.72	53.58	52.7	47.18	49.68	50.6	***
Agricultural experience (years)	32.1	30.24	33.33	27.28	30.96	30.69	**
- none	1.5	1.5	1.1	11.5	3	3.7	***
- can read and write	3.8	2.3	1.1	0.8	2	2	
- preliminary	76.9	84.6	86.7	74.6	85	82.1	
- secondary	16.2	11.5	11.1	9.2	10	11.3	
- university	1.5			3.8		0.9	
Householders studied agriculture	10	4	1	3	2	4	
Farmers' own wealth classification (%)							***
- very poor	5	2	0	7	1	3	
- Poor	24	12	19	19	24	20	
- moderately well-off	70	84	74	71	73	74	
- well off	2	2	7	3	3	3	
Financial capital							
Mean annual household income (TL)	43893	43109	56152	62265	51486	51160	n.s.
% of income from wheat	49.1	49.4	28.9	69.8	33.2	44.6	***
% off-farm income	1.7	6.7	3.1	0.5	5.2	3.7	***
Saving money last year (%)	9	7	14	5	8	8	n.s.
Access to credit (2006/07)	50	49	56	22	51	46	***
Social capital (% of farmers)							
Cooperative in village	57	43	81	23	65	55	***
Cooperative membership (%)	48	48	82	14	66	53	***
Information exchange with others	95	98	98	96	93	95	***
Active in community action							
- Leader	13	13	13	6	5	9	***
- Very active	22	24	26	19	33	26	
- Somewhat active	52	52	56	59	44	50	
- Not active	14	12	6	16	19	15	
Trust in lending and borrowing							***
- Do trust	57	83	78	56	63	65	
- Trust sometimes	31	10	19	31	22	23	
- Do not trust	12	7	3	15	15	12	

(*) significant among provinces at the level of 0.1
* significant among provinces at the level of 0,05
** significant among provinces at the level of 0,01
*** significant among provinces at the level of 0,001

finance to farmers and intermediary agencies is important in improving livelihoods in rural areas, by improving the delivery of inputs to farmers and introducing liquidity into output marketing. Moreover, delivery of credit can be linked to savings as the other important element in rural finance. The percentage of households who saved money in the previous year was notably low, farmer access to credit was 46%, and income from non-farm activities was 6% only.

The social capital of any society is very important, as mutual trust and connectedness helps to cope with shocks and vulnerability, particularly for the poor. However, in this study, due to the availability of agricultural cooperatives, farmers had the potential to cooperate in commonly beneficial development schemes. There is a strong need to develop mutual trust and organization of the community to develop and utilize available resources for sustainable livelihoods. Cooperatives are available in 55% of the villages and 53% of farmers are members in these cooperatives. Exchange of information among farmers is very high (95%), and most farmers see themselves as active in any collective action in their community.

3.2 The wealth index

Wealth index, based on the status of household assets, was calculated using factor analysis and was used for ranking households in the sample. In the wealth ranking, variables important in distinguishing households from each other were identified by using principal components analysis and wealth quartiles have were used to explore patterns of household income distribution. In factor analysis, sets of variables are grouped by their correlations, thus each group represents a single underlying construct or factor, though it is subjective, and factors must be interpreted relying on previous knowledge and intuition about underlying relationships. Five elements were used to represent household well-being; being human, natural, financial, physical, and social capitals and several variables were selected as indices for assessing welfare status (Table 7).

Table 7. Households characteristics by wealth quartiles

	Wealth quartiles			
Variables	**Lowest 25%**	**25%-50%**	**50%-75%**	**Highest 25%**
Total holding area (da)	144	198	275	511
Number of cars	0.0	0.2	0.4	0.6
Sheep and goats number	7	7	12	17
Total irrigated area in the farm (ha)	29	52	61	171
Area of land planted with trees (ha)	0.0	0.2	0.6	2.2
Number of tractors	0.4	0.8	0.9	1.3
No. of rooms in the house	2.9	3.5	3.9	5
Years of agricultural experience	23	31	33	36
Having university degree (%)	0	1	3	6
Years of education	0	0	3	4
Having a satellite dish (%)	49	68	78	85

3.3 Reasons for preferring the varieties

Producers' preferences for certain characteristics are critical for variety adoption. Therefore, understanding the criteria used by producers to evaluate new crop varieties allows breeders to effectively set priorities and target different breeding strategies to different communities. Producers' evaluations of new varieties are also useful to determine whether they have maintained their intrinsic characteristics, and if their agronomic as well as quality and price performances are satisfactory from the view of the end users. The characteristic which scored highest among producers was high yield, reported by 65-100% of producers depending on the variety (Table 8).

Other varieties also scored highly among producers. For high yields, Adana-99, Bezostaja-1, Cesit-1252, Firat-93, Gelibolu, Flamura-85, Gerek-79, Kiziltan-91, Konya-2002, Nurkent, Sagettario, and Ukrayna scored highly. For disease resistance, 28-50% of producers preferred Adana-99, Golia, Cesit-1252, Guadelope, Konya-2002 and Sagettario. For resistance to waterlogging, 38-80% listed Adana-99, Diyarbakir-81, Golia, Pandas and Sagettario. For fetching a good market price, 60-100% listed Aydin-93, Bezostaja-1, Dariel, Ekiz, Flamura, Gonen, Kiziltan-91, Pandas, Sagettario, and Tekirdag. For drought resistance, 60-100% preferred Altay-2000, Dagdas-94 and Gerek-79. In short, producers have the choice between diverse wheat germplasm, some of which are as good as the monitored varieties.

Table 8. Characteristics of wheat varieties preferred by producers (% of respondents)

Traits	Ceyhan-99	Karahan-99	Pehlivan	Saricanak-98
Better yields	91.1	81.8	65.8	100.0
Good market price	53.3	18.2	45.6	33.3
Locally adapted	31.1	18.2	22.8	66.7
Frost resistant	6.7	18.2	39.2	-
Good bread quality	37.8	-	17.7	-
Drought resistant	17.8	100.0	8.9	-

Table 9. Reasons for not preferring the varieties (% of respondents)

Traits	Ceyhan-99	Pehlivan	Saricanak-98
Improved seed is expensive	13.3	3.8	-
Susceptible to diseases	-	11.4	-
Yield declines over time	4.4	7.6	66.7
Susceptible to waterlogging	-	10.1	-
Susceptible to cold/frost	26.7	1.3	-
Number of respondents	45	79	3

Some reasons were mentioned by producers for their dislike of the monitored wheat varieties. The majority (67%) perceived Saricanak-98 yields to decline over time, 27% said that Ceyhan-99 was susceptible to cold or frost, 13% said its seed was expensive, and 11% perceived Pehlivan as susceptible to diseases (Table 9). Among other varieties, significant numbers of producers disliked Bezostaja-1 for seed unavailability, Guadolope, Pandas, Sagettario for the high price of their seed, Sagettario and Pandas for yield decline over time, and Flamura-85, Gerek-79, Ukrayna, Besostaja-1, Konya-2002, Pandas for waterlogging, and Toros, Cesit-1252, Firat-93 and Kiziltan-91 were disliked for susceptibility to cold and frost.

3.4 Variety adoption (rate, degree, intensity)

a) Variety diversity at household level

Given the high diversity of wheat varieties available for producers in the study areas, their distribution according to the number grown during the 2006/07 crop year was investigated. Results show that from the sample of 781 households surveyed, 69% of producers reported growing distinct varieties cultivated on a total of 1059 wheat plots (fields), and 31% used mixed wheat varieties. The majority of producers grew a single variety, 26% cultivated two varieties on a fifth of these fields, and the number of producers declines sharply as the number of varieties increases (Table 10), with only 0.4% of the sampled producers cultivated 5 different wheat varieties during that cropping year.

Regardless of the pool of different improved varieties, providing a great opportunity for selection and on-farm genetic diversification in the study area, results show a tendency of producers to specialize with respect to varieties and to stick to the most preferred one. This pattern is observed equally across provinces and regions (Table 11), rainfed and irrigated systems covered in the study areas (Tables 12 and 13), though the proportion of producers who cultivated more than one variety during the season is slightly higher on irrigated land compared to rainfed production. Thus, wheat biodiversity, although very high at country level, is very low at the household level. A possible reason is that producers may be minimizing the risks of on-farm grain mixing, and the potential of loosing market value for their harvest because they are priced according to strict purity and other quality characteristics. Therefore, the rate of adoption of the monitored varieties on the sample level as measured by the percentage of wheat fields on which they were cultivated, is 13.8% against 38.1% for other new varieties, and 48.2% for the old-improved varieties.

Table 10. Distribution of producers by number and type of wheat varieties grown

Number of varieties used	Number of farmers	Producers (%)	Distribution by variety type (% of plots)		
			Monitored	Other new	Old improved
1	549	70.3	8.6	37.2	54.3
2	199	25.5	18.8	37.7	43.5
3	23	2.9	21.7	46.4	31.9
4	7	0.9	25.0	25.0	50.0
5	3	0.4	13.3	66.6	20.0
Total	781	100.0	13.8	38.1	48.2
	Count	781	146	403	510

Table 11. Distribution of producers by number of varieties grown and by province (% of farmers)

No. of varieties	Province					Region	
	Adana	Ankara	Edirne	Diyarbakir	Konya	Plateau (Ankara, Konya)	Lowland (Adana,Edirne, Diyarbakir)
1	81.5	81.5	62.2	63.8	65.8	70.5	70.0
2	15.4	18.5	33.3	30.0	28.6	25.5	25.4
3	3.1	0.0	2.2	3.8	4.0	2.8	3.1
4	0.0	0.0	1.1	2.3	1.0	0.7	1.1
5	0.0	0.0	1.1	0.0	0.7	0.5	0.3

Table 12. Distribution of producers by number of variety grown in rainfed system

Number of varieties	Number of farmers	Producers (%)	Variety classification (% of plots)		
			Monitored	Other new	Old improved
1	412	74.4	9.0	36.2	54.9
2	125	22.6	20.9	39.8	39.4
3	12	2.2	16.2	48.6	35.1
4	4	0.7	33.3	20.0	46.7
5	1	0.2	20.0	80.0	0.0
Total	554	100.0	14.1	38.0	47.9

Table 13. Distribution of producers by number of variety grown in irrigated systems

Number of varieties	Number of farmers	Producers (%)	Variety classification (% of plots)		
			Monitored	Other new	Old improved
1	137	60.2	7.3	40.1	52.6
2	74	32.8	15.4	34.2	50.3
3	11	4.7	28.1	43.8	28.1
4	3	1.4	15.4	30.8	53.8
5	2	0.9	10.0	60.0	30.0
Total	227	100.0	13.2	38.1	48.7

b) Diffusion of the monitored varieties

As diffusion processes of the monitored varieties varied between plateau and lowland regions, two diffusion models were estimated, and results of the estimated logistic models are summarized in Table 14. The coefficient on the time variable is positive and significantly different from zero, thus there a positive propensity of wheat producers to adopt the monitored varieties over time, and adoption is projected to increase over time.

The actual and predicted cumulative percentages of adopters are shown in Figure 2, with adoption increasing at an accelerating rate and is expected that the maximum (90%) will be reached by 2020 under the same conditions. Current adoption of the monitored varieties is greater in lowlands since the diffusion process started earlier and these varieties have been used by farmers since 1995. Given the diversity of wheat varieties, whether the 90% maximum adoption can be reached is an empirical question, and the actual outcome will depend on the mobilization of extension services, seed multiplication and distribution, and other efforts and resources put in place to provide incentives to adopt these varieties.

Table 14. Results of the logistic variety diffusion model

	Coefficient	Standard error	t
Lowland(1)			
(Constant)	-4.152	0.297	-13.991
Time	0.271***	0.037	7.240
Plateau(2)			
(Constant)	-8.597	0.644	-13.339
Time	0.441***	0.075	5.886

(1) Adjusted R-squared equals 0.81. F-statistic (1) = 52.4 significant at 0.01% probability level.
(2) Adjusted R-squared equals 0.77. F-statistic (1) = 34.6 significant at 0.01% probability level.

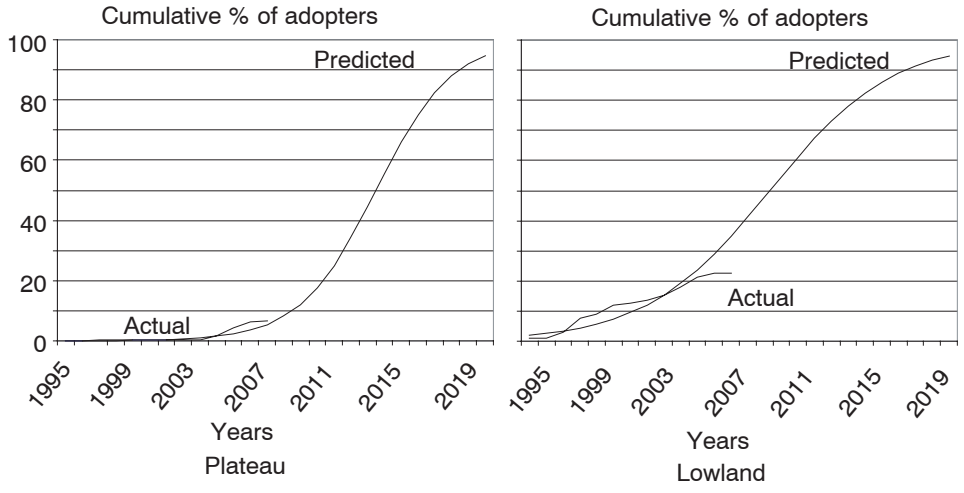

Fig. 2. Diffusion of wheat monitored varieties

Poor farmers, i.e. the first wealth quartile, tend to use one wheat varieties (81%) (Table 15), whereas the more wealthy farmers use a higher number of wheat varieties, for example 46% used two varieties or more. Adoption intensity of the monitored varieties is also highest among the well-off farmers, but followed by the poor farmers, then the other wealth groups. Thus, the monitored varieties are reaching the poor as well as the well-off farmers (Table 16).

c) Adoption rates of wheat varieties by group classification

The adoption rate is commonly measured as the proportion of producers using the improved variety being studied. In the context of the present study where producers used more than one variety, some of these producers simultaneously used a monitored variety and other varieties that fall in other classifications. Taking advantage of the fact that different varieties are rarely grown together in the same field, the proportion of fields cultivated with each type of variety is used as a measure for adoption rate.

Table 15. Distribution of producers by varieties number and livelihood level

No. of varieties	No. farmers	Type of varieties (%)		
		Monitored	Other new	Old improved
		First wealth quartile		
1	158	10.8	37.3	51.9
2	35	14.3	42.9	42.9
3	1		33.3	66.7
4	1	75.0	25.0	
Total	195	12.8	38.7	48.5
		First wealth quartile		
1	148	8.8	33.8	57.4
2	41	19.5	29.3	51.2
3	4	8.3	50.0	41.7
4	1		25.0	75.0
5	1	20.0	80.0	
Total	195	12.4	33.9	53.8
		Third wealth quartile		
1	138	5.8	42.0	52.2
2	53	17.9	40.6	41.5
3	5	6.7	60.0	33.3
Total	196	10.8	42.5	46.7
		Fourth wealth quartile		
1	105	8.6	35.2	56.2
2	70	21.4	37.9	40.7
3	13	33.3	41.0	25.6
4	5	20.0	25.0	55.0
5	2	10.0	60.0	30.0
Total	195	18.2	37.3	44.6

Table 16. Adoption (rate, degree, and intensity) by wealth quartiles (%)

Wealth quartiles	Variety classification	Adoption rate	Adoption degree	Adoption intensity
Lowest 25%	Monitored varieties	12.8	17.4	2.2
	Other new varieties	38.7	36.9	14.3
	Old improved varieties	48.5	45.8	22.2
25-50%	Monitored varieties	12.4	9.3	1.2
	Other new varieties	33.9	38.8	13.1
	Old improved varieties	53.8	51.9	27.9
50-75%	Monitored varieties	10.8	8.9	1.0
	Other new varieties	42.5	35.4	15.1
	Old improved varieties	46.7	55.6	26.0
Top 25%	Monitored varieties	18.2	21.1	3.8
	Other new varieties	37.3	33.7	12.6
	Old improved varieties	44.6	45.2	20.1
Total	Monitored varieties	13.8	15.4	2.1
	Other new varieties	38.1	35.5	13.5
	Old improved varieties	48.2	49.1	23.6

F = 16.083** between wheat planted area and 4 wealth quartiles.

Among all varieties cultivated by the sampled producers, Pehlivan specifically ranks third in terms of adoption rate (8.2%), after Bezostaja-1 (23%) and Gerek-79 (10%). The adoption rate is 3.5% for Ceyhan-99, 0.9% for Karahan-99, 0.7% for Demir-2000, and 0.5% for Saricanak-98. Among all 45 different varieties recorded in the survey, the variety ranking according to adoption rate is 8th position for Ceyhan-99, 20th for Karahan-99, 21st for Demir-2000, and 28th for Saricanak-98. The adoption degrees and intensities for individual varieties follow a similar trend and are presented in Table 17.

Adoption of the monitored varieties differs substantially across provinces, with the highest adoption rate in Edirne (32%) and Diyarbakir (28%) and the lowest in Ankara (Table 18), whereas adoption is nearly the same across rainfed and irrigated production systems (13-14%). Other new varieties were widely adopted in some provinces, highest for Adana (92%), followed by Edirne (63%) and Diyarbakir (44%), and similarly, old-improved varieties are widely used in Ankara (86%) and in Konya (74%). Therefore, there is much competition between the monitored varieties and others available, particularly in Ankara and Konya (plateau region), and also in Adana where adoption rates are very low (below 10%). Several factors may explain this, particularly the criteria used by producers to define their preferences, such as low income of farmers, residency outside the village, and having off-farm activity.

Table 17. Adoption rates of wheat varieties

Variety	Year of variety release	Adoption (%)		
		Rate	Degree	Intensity
Bezostaja-1	1968	23.1	28.0	6.5
Gerek-79	1979	9.7	9.1	0.9
Pehlivan	1998	8.2	9.4	0.8
Sagettario	2001	5.7	5.1	0.3
Adana-99	1999	5.4	4.2	0.2
Kiziltan-91	1991	5.2	3.3	0.2
Flamura	1999	4.1	2.0	0.1
Ceyhan-99	1999	3.5	4.0	0.1
Karahan-99	1999	0.9	1.0	0.01
Demir-2000	2000	0.7	0.5	0.003
Saricanak-98	1998	0.5	0.5	0.003

Table 18. Adoption rates of wheat varieties by province and production system

	No. of wheat plots	Variety classification (% of plots)		
		Monitored	Other new	Old improved
Province				
Adana	158	8.2	91.8	0.0
Ankara	154	5.2	8.4	86.4
Edirne	131	32.1	62.6	5.3
Diyarbakir	188	27.7	43.6	28.7
Konya	428	7.2	18.9	73.8
Production System				
Rainfed	718	14.1	38.0	47.9
Irrigated	341	13.2	38.1	48.7
Region				
Plateau	582	6.7	16.2	77.1
Lowland	477	22.4	64.8	12.8

d) Adoption degree

Adoption degree measures the proportion of land under the new wheat varieties compared to the total area of wheat cultivated. In aggregate, the monitored varieties were cultivated on 15% of total area of wheat, whereas other improved varieties and old varieties accounted for 36% and 49% respectively (Table 19). Although the monitored varieties have the lowest adoption degree, they are only five of them, compared to 26 and 15 varieties in the other two groups, and the monitored varieties were only released relatively recently.

Table 19. Adoption degree of improved wheat varieties by province

	Total wheat area (ha) in the sample	Adoption degree by variety type (%)		
		Monitored	Other new	Old improved
Province				
Adana	1790	16.8	83.2	0.0
Ankara	3037	1.8	10.3	87.8
Edirne	885	35.7	60.0	4.4
Diyarbakir	3769	30.0	49.6	20.4
Konya	4598	8.1	17.3	74.7
Production System				
Rainfed	9414	16.3	33.5	50.1
Irrigated	4665	13.6	39.4	46.9
Region				
Plateau	7635	5.6	14.5	79.9
Lowland	6444	27.1	60.4	12.5
Total	**14079**	**15.4**	**35.5**	**49.1**

Table 20. Adoption intensity of wheat varieties

	Adoption intensity by variety type (%)		
	Monitored	Other new	Old improved
Province			
Adana	1.4	76.4	0.0
Ankara	0.1	0.9	75.9
Edirne	11.5	37.6	0.2
Diyarbakir	8.3	21.6	5.9
Konya	0.6	3.3	55.1
Production System			
Rainfed	2.3	12.7	24.0
Irrigated	1.8	15.0	22.8
Region			
Plateau	0.4	2.3	61.6
Lowland	6.1	39.1	1.6
Total sample	**2.1**	**13.5**	**23.7**

e) Adoption intensity

Adoption intensity multiplies adoption rate and adoption degree, and Table 20 show that the monitored new varieties occupy a very small share of the total wheat production area.

3.5 Impact of the new varieties on productivity

a) Comparison of wheat yields

The impact of different varieties on productivity is assessed through a comparison of average yields between variety groupings (using data provided by farmers). In the rainfed system, the average yield obtained from the monitored varieties is 3541 kg/ha compared to 3685 kg/ha for other new varieties and 1654 kg/ha for old-improved varieties (Table 21). Under irrigation, monitored and other new varieties gave average yields of 4137 kg/ha and 4431 kg/ha, respectively, and old-improved varieties is 3736 kg/ha (Table 21). There was no statistical difference

Table 21. Comparison of yield and standard deviations by variety type and production system

System	Indicator	Monitored varieties	Other new varieties	Old improved varieties	Mean
Rainfed	Yield (kg/ha)	3541	3685	1654	2692
	Standard deviation	993	1175	1014	1465
	CV (%)	28	32	61	54
Irrigated	Yield (kg/ha)	4137	4431	3736	4054
	Std. Deviation	1160	1371	1507	1447
	CV (%)	28	31	40	36
Test of effects	Source of effect	System	Variety	System x variety	
	F-Statistic (df)	305 (1) ***	224(2)***	38 (2)***	

Note: F-statistics derived from univariate analysis of variance; *** yield differences are significant at 1% level.

Table 22. Average yields obtained by farmers in 2006/2007 season (kg/ha)

				% increase over old improved varieties	
	Monitored varieties	Other new varieties	Old improved varieties	Monitored varieties	Other new varieties
Plateau					
Rainfed	2407	1342	1394	72.7	-
Irrigated	3850	4171	3657	5.3	14.1
Lowland					
Rainfed	3739	3932	3302	13.2	19.1
Irrigated	4464	4716	4589	-	2.8

between the monitored varieties and the other new varieties under either rainfed or irrigated conditions, but both gave higher yields that the old improved varieties. However, if divided by region and irrigation regime, results indicated that monitored varieties were superior in the plateau region under rainfed conditions (Table 22 and Figure 3).

b) Comparative yield stability

Achieving high and stable yields is an important selection criterion in wheat breeding programs. Stability may be reached over time or across several production locations. Presuming that wheat varieties are grown in areas where they are adapted to soil and climatic conditions, the use of such an indicator of stability is justified, measured by absolute or relative standard deviations, or variance. Following Barkley and Porter (1996), yield stability is measured by the coefficient of variation of yields calculated across producers who use the respective varieties.

The monitored wheat varieties have the lowest coefficients of variation among all wheat varieties under both rainfed (28%) and irrigated (28%) production systems (Figure 4). Thus, they provided more stable yields compared to other groups, and irrigation contributes to lower yield variability and therefore to achieving greater stability.

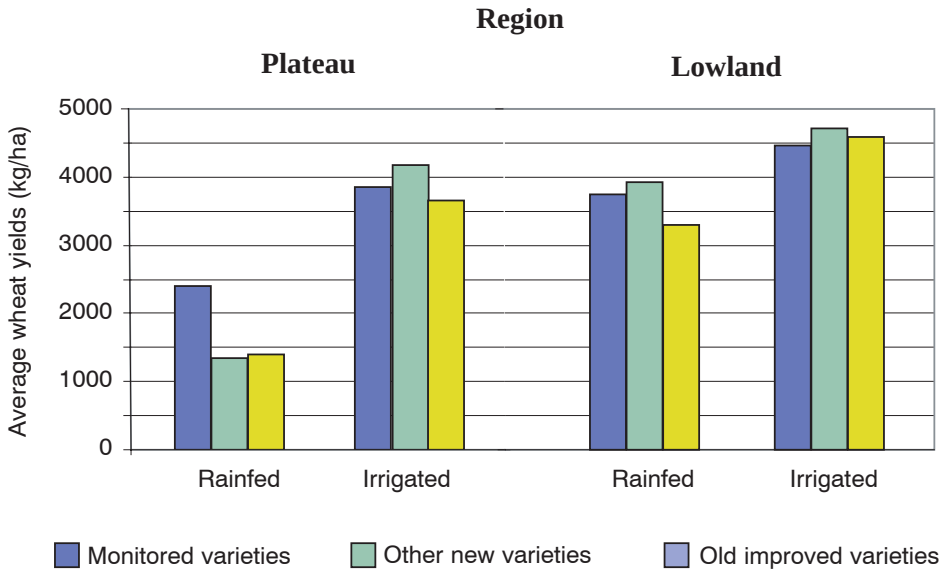

Fig. 3. Average yields obtain by farmers by region and wheat production system

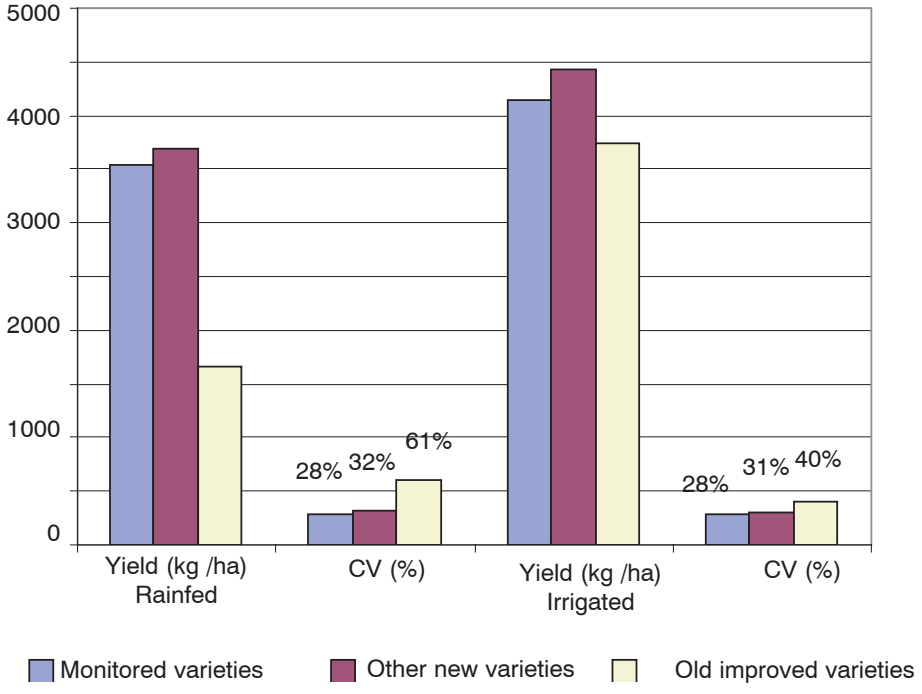

Fig. 4. Average yields and coefficient of variance by variety type and production system

3.6 Production function analysis

a) Cobb-Douglas production function

Results of the Cobb-Douglas production function are presented in Table 23. Estimated coefficients on the continuous variables represent elasticities measuring the percentage increase in yield in response to increases in the respective inputs. The impact of the monitored varieties of wheat was estimated by adding a dummy variable which took a value of one if the variety is of interest, and zero for other new varieties and old-improved varieties. The estimated coefficient on the dummy variable measured the shift in the intercept of the production function resulting from the new technology, and this shift captured the impact of the monitored varieties on total factor productivity. The coefficient for monitored varieties is positive (0.164) and significantly different at the 1% level. This implies that with the same levels of other farm inputs, the monitored varieties do indeed increase wheat yield compared to other varieties. Based on this coefficient, the magnitude of the net increase in productivity following the use of the monitored varieties is 18%.

Other inputs significantly contribute to increased productivity in wheat production in Turkey, being the amount of water available to the crop through rainfall or irrigation, and the quantity of seed, manure and/or nitrogen fertilizer. The most important is water, which increases wheat production by 11.5% for a 10% increase in its level, or productivity may decline by 11.5% following a 10% reduction in rainfall as a result of drought. The importance of water is additionally stressed by the positive and significant coefficient estimate associated with the number of irrigations provided by producers. There is also a net increase of productivity by 10% for durum wheat varieties over the bread types.

However, wheat shows a negative response to phosphorus fertilizer application, because in many parts of the country, the soil is naturally rich in this mineral and so application of this nutrient is counter-productive. In addition, wheat productivity

Table 23. Parameter estimates for determinants of wheat yield using the Cobb-Douglas function

Variable	Coefficient	Standard error	t-statistic
LN-Rainfall	1.150***	.060	19.045
LN-Seed quantity	0.235*	.103	2.290
LN-Manure	0.020***	.005	3.796
LN-N fertilizer	0.029*	.013	2.250
LN-P fertilizer	-0.019(*)	.011	-1.754
LN- No. irrigations	0.063***	.004	17.742
Wealth index	0.148***	.038	3.903
Monitored varieties	0.164***	.052	3.187
Durum wheat	0.097*	.051	1.902

Note: Adj R-squared equals 0.394. Coefficient is statistically different from zero at 0 (***), 1 (**), 5 (*), and 10 ((*)) probability levels respectively.

increases with the wealth level of the producer as indicated by the positive and significant coefficient on the wealth index. Given that the use of external inputs and mechanization is encouraged through government programs, it is not surprising that producers who can afford these inputs are more likely to increase productivity over those who cannot do so. The sum of all the main inputs is 1.45, thus suggesting there is potential for wheat production to increase more than the proportionate increase in these inputs.

b) Multiple linear production function

The multiple linear production function was also applied in this study, used to measure the impact of a given innovation (Shideed and El Mourid, 2005). This approach relates yield per unit area to a set of variables, such as levels of input use, type of technology, and environmental factors. The dependent variable used in this production function was grain yield in 2007. The independent variables included rainfall, nitrogen fertilizer added, number of irrigations, wheat area, variety type, and if using durum wheat varieties. All these variables positively and significantly affected the yield (Table 24). In terms of productivity effect, adopting monitored varieties is statistically different at the 5% level. The multiple regression analysis indicates that each 1 mm of rainfall increases wheat yield by 54.7 kg/ha. The use of 1 kg of elemental nitrogen increases yield by about 9.6 kg/ha. Using the monitored varieties may increase the yield by 231 kg/ha compared to other varieties, and growing durum wheat varieties increases yield by about 268 kg/ha.

3.7 Profitability of wheat production

Net return is one measure of profitability commonly used by analysts, being the gross revenue minus operational costs and asset depreciation. Gross margin is a useful tool in farm management for selecting crop varieties or new technologies,

Table 24. Estimated coefficients of wheat yield using a multiple linear production function

Variable	Coefficient	Standard error	t-statistic
(Constant)	-741.178***	154.087	-4.810
Rainfall 2006/07 (mm)	5.474***	0.401	13.638
Nitrogen added (kg/ha)	9.642***	0.790	12.201
Number of irrigation (times)	502.137***	32.532	15.435
Wheat area (ha)	0.299**	0.105	2.847
Monitored varieties (1=Yes) (0= otherwise)	231.453*	109.113	2.121
Durum wheat variety (1=Yes) (0= otherwise)	268.652*	109.835	2.446

Dependent variable: wheat grain yields (kg/ha)

Adj R-squared = 0.49. Coefficient is statistically different from zero at 0 (***), 1 (**), and 5(*) probability levels respectively.

measuring returns over variables costs, and determining the contribution of each production activity to the profitability of the whole farm. It indicates likely returns or losses of a particular crop, but does not account for fixed costs relating to buildings, machinery or equipment depreciation.

Table 25 shows the estimated gross revenues, variable production costs, government support received by producers, and the resulting gross margins per hectare before and after such government support. On average, the gross margin per unit area for both the monitored varieties and other new varieties was 1030 TL/ha, and for old improved varieties was 474 TL/ha. The same ranking is maintained when comparing gross margins before government support, and the monitored varieties are associated with the highest profitability per unit area. However, results show that Demir-2000 is being produced at an economic loss of 68 TL/ha if government support is not considered and has the lowest gross margin even with support. Saricanak-98 and Ceyhan-99 generate the highest margins before government support, with Pehlivan and Ceyhan-99 being the most profitable varieties with government support. The detailed revenue, variable costs, government support and gross margins for each variety is presented in Table A-8 in the appendix.

In terms of the profitability of each variety, only Ceyhan-99 and Saricanak-98 performed better than all other varieties, whereas other new varieties generated a higher gross margin than Demir-2000, Karahan-99, and Pehlivan. Similarly, the old improved varieties on average generated higher gross margins than Demir-2000.

In rainfed wheat production systems, the monitored varieties are more profitable than other varieties, with gross margins of 1010 TL/ha. In both rainfed and irrigated systems, the old improved varieties are the least profitable, thus creating an economic incentive and opportunity for their replacement with new wheat varieties. Gross margins for the monitored varieties are highest in Ankara, Adana, and Konya compared to other varieties, with the reverse observed in Edirne and Diyarbakir (Table 26).

Thus, results provide evidence that Ceyhan-99, Pehlivan and Saricanak-98 outperform all other wheat varieties in terms of profitability, whereas Demir-2000 is the least profitable. The monitored varieties contribute more than all other wheat varieties to increasing household income from wheat production in Ankara, Adana, and Konya provinces, and in both rainfed and irrigated systems.

3.8 Income sources

Producers' incomes were estimated from all reported household activities including the production of wheat and other crops, livestock rearing, agricultural labor

Table 25. Estimated revenues, costs and gross margin of wheat varieties (TL/ha)

	Monitored varieties							
Item	**Ceyhan-99**	**Demir-2000**	**Karahan-99**	**Pehlivan**	**Saricanak-98**	**Mean**	**Other new**	**Old improved**
Revenue[1]	2067	1102	1152	1542	1841	1637	1687	1161
Total cost	1175	1170	885	896	926	980	1025	986
Gross margin[2]	892	-68	267	646	915	657	662	175
Gov. support	390	304	293	355	381	370	367	299
Gross margin[3]	1282	236	561	1000	1296	1027	1029	474

1. includes revenues from grain and straw; 2. before government supports; 3. after government support.

Table 26. Estimated gross margins by province and production system (TL/ha)

	Variety classification			
Province[1]	**Monitored new**	**Other new**	**Old improved**	**Average**
Adana	1373	1063	-	1088
Ankara	633	620	228	274
Edirne	1157	1300	1448	122
Diyarbakir	982	1042	1026	1020
Konya	828	748	466	545
System[2]				
Rainfed	1010	1004	330	681
Irrigated	1037	1082	772	925
Average	**1027**	**1029**	**474**	**760**

Gross margins are estimates after accounting for government support.
[1]Across provinces: F-statistic = 71.5 with 4 degrees of freedom; the difference is significant at 0.1 level.
[2]Across production systems: F-statistic = 26.7 with 1 degree of freedom; the difference is significant at 0.1 level.

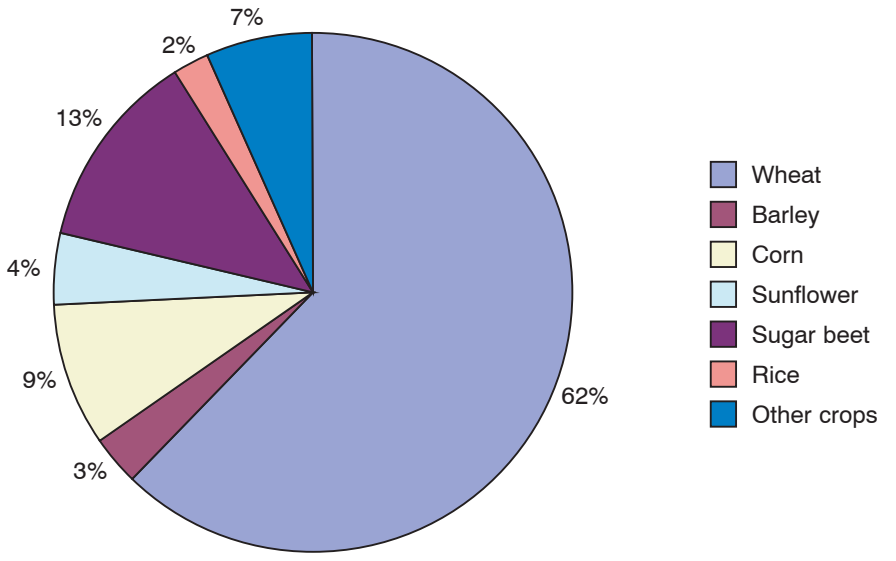

Fig. 5. Income by crops

wage, revenues from share-cropping, renting farm machinery and other assets, off-farm incomes, and amount of government support received. The distribution of total household income by source is presented in Figure 5. For the sampled producers, wheat accounts for the largest share (62%) of household income. This underlines the importance wheat in the production systems and income generating activities of the households. Wheat is followed in decreasing order of importance by sugar beet (12.6%) and maize (9%).

The distribution of household incomes by source and the type of varieties grown is summarized in Table 27. Across the alternative sources and three classifications of varieties, wheat leads over other crops, followed by payments received from government support and livestock production, for adopters of the monitored varieties or other new varieties. The order of importance of the latter sources is reversed for non-adopters of new varieties as they received relatively less income from government support.

Estimated income for adopters of the monitored varieties is the highest (TL 78,772), statistically different with that of non-adopters at the 1% level. The contribution of wheat to their income is 54%, compared to 46% for adopters of other new varieties, and 37% for non-adopters. Wheat and other crops are relatively more important sources of income for adopters of new wheat varieties, whereas livestock, labor wage and non-agricultural incomes, transfers and other incomes are relatively more important for farmers using old-improved varieties (Figures 6 and 7).

Table 27. Income sources by adoption (TL /household)

Variety	Adopters of monitored varieties		Adopters of other new varieties		Non-adopters (using old improved varieties		Mean		F-stat (df=2)
class	TL	%	TL	%	TL	%	TL	%	
Wheat	42309	54	22753	46	15698	37	22824	45	16.9 ***
Other crops	18870	24	15475	31	10779	26	13785	27	3.5 *
Livestock	7038	9	4462	9	5878	14	5621	11	1.7 n.s.
Labor wage	92	0	233	0	625	1	400	1	4.9 **
Off-farm income	1021	1	1287	3	2603	6	1885	4	10.9 ***
Land rental /receipts	206	0	143	0	66	0	117	0	0.5 n.s.
Money transfer	117	0	122	0	256	1	187	0	0.8 n.s.
Other income sources	475	1	347	1	1137	3	757	1	1.4 n.s.
Gov. support	8645	11	4760	10	5010	12	5584	11	22.9 ***
Total household income	78,772	100	49,582	100	42,053	100	51,160	100	15.2 ***

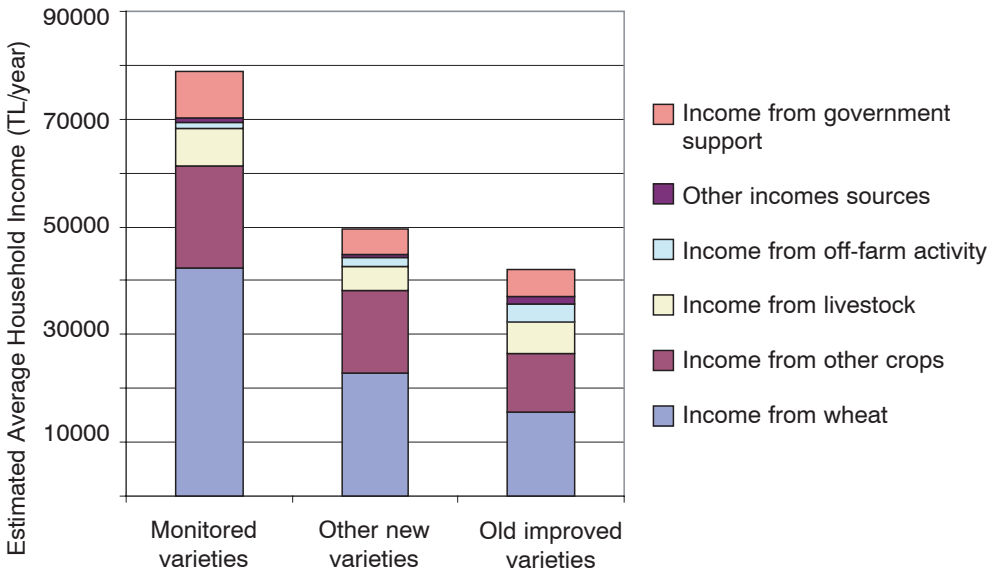

Fig. 6. Estimated income by sources and variety classification

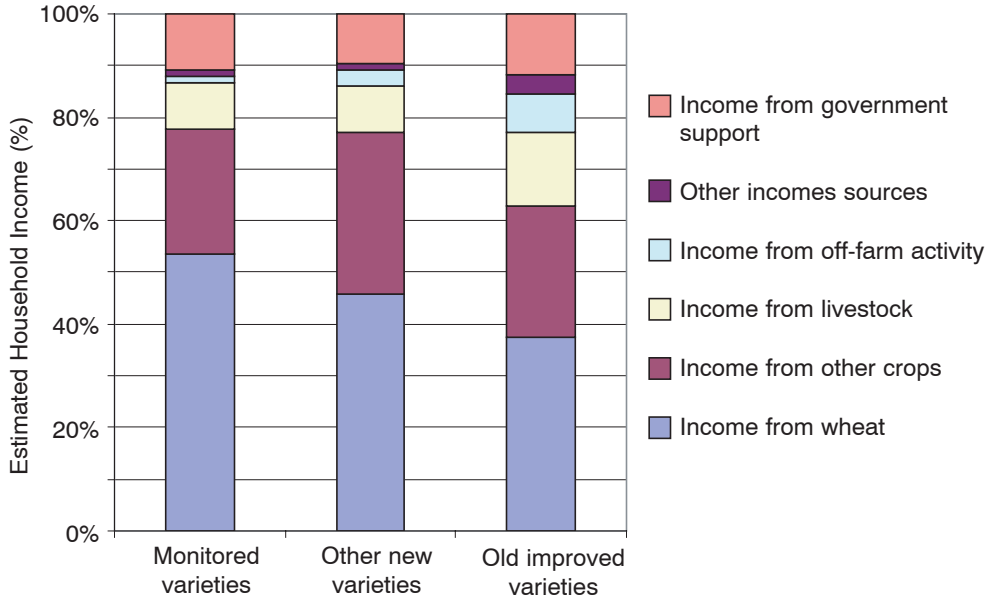

Fig. 7. Estimated percentage of income by source and variety classification

Results suggest that non-adopters of new wheat varieties are more dependent on other sources of income and at the same time generate the lowest level of income across the classifications. It can be concluded that adoption of the monitored varieties significantly contributes to increased household incomes.

The importance of wheat in household incomes across the five provinces is presented in Tables 28 and 29, and Figure 8. Wheat is relatively very important in Diyarbakir, equally important in Adana and Ankara, and less important in Konya and Edirne. In reverse order, other crops were more important in the respective provinces. Income from livestock activities is particularly high in Edirne and Ankara compared to other provinces. The analysis of variance shows there is statistically significant difference in incomes from wheat, other crops, livestock, and from government programs across the three provinces. However, there is no statistically significant difference in total household income across the provinces, with the likelihood that there is some form of compensation effect.

3.9 Impact on poverty

On average, the per capita income per day is estimated at $18.7 for the whole sample; and higher for households who adopted the monitored varieties or other new varieties, and across the provinces the highest per capita per day income was obtained in Edirne ($25.90), Konya ($19.10), and Diyarbakir ($18.50) (Table 30).

Table 28. Income sources by adoption and provinces (TL /household)

Province	Adoption status	Wheat	Other crops	Livestock	Govt support	*Total household income
Adana	Adopters of monitored varieties	42705	11827	1563	7104	63289
	Adopters of other new varieties	19387	13398	4527	2710	41921
	Non-adopters	-	-	-	-	-
Ankara	Adopters of monitored varieties	15814	9410	2888	5073	41478
	Adopters of other new varieties	4966	1497	-	763	12642
	Non-adopters	22063	4996	8014	4189	43987
Edirne	Adopters of monitored varieties	18415	20847	12391	7983	61973
	Adopters of other new varieties	14164	19590	6440	7027	49631
	Non-adopters	18415	31950	24800	8721	83886
Diyarbakir	Adopters of monitored varieties	55095	9654	5641	7049	78081
	Adopters of other new varieties	45090	7409	1618	6706	61033
	Non-adopters	24513	5494	5523	4855	40770
Konya	Adopters of monitored varieties	62263	38411	5084	14223	122521
	Adopters of other new varieties	19769	25313	5326	6152	60640
	Non-adopters	10979	14440	4646	5431	40869
Average	Adopters of monitored varieties	42309	18870	7038	8645	78772
	Adopters of other new varieties	22753	15475	4462	4760	49582
	Non-adopters	15698	10779	5878	5010	42053
	Average	22824	13785	5621	5584	51160
		8.08	5.59	3.51	11.61	1.77
F-stat (4)		***	***	**	***	ns

* "Total household incomes" include the other income sources (off-farm, labor wages, etc.)

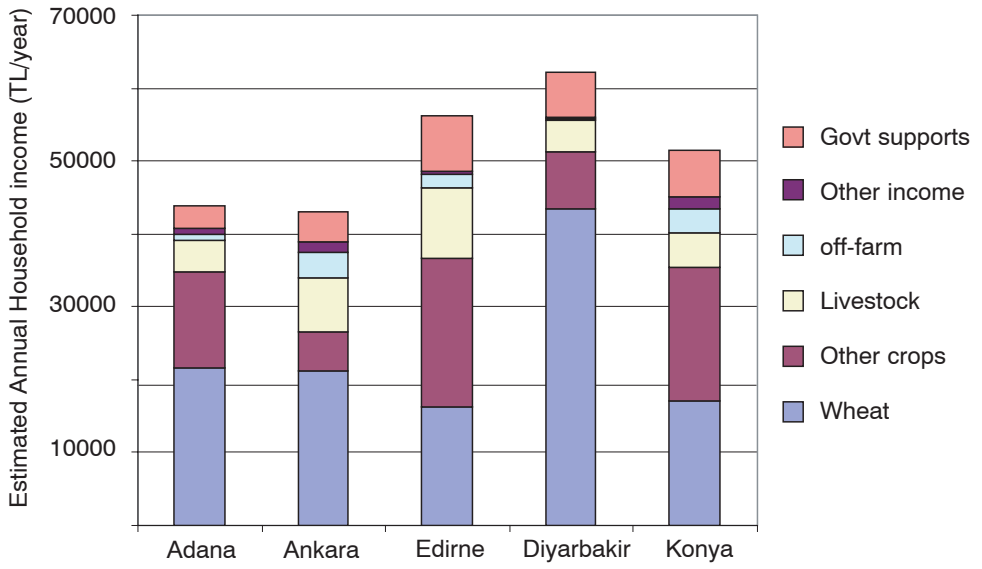

Fig. 8. Estimates of income sources by provinces

Table 29. Average household income by sources and provinces (TL)

Province		Wheat	Other crops	Livestock	Labor wage	Off-farm	Shared cropping	Transfers	Other income	Govt supports
Adana	Mean	21539	13253	4253	120	756	240	142	473	3116
	CV (%)	118	310	215	815	271	1069	678	396	137
Ankara	Mean	21284	5187	7514	710	2878	89	238	1045	4164
	CV (%)	414	344	306	453	130	811	520	392	116
Edirne	Mean	16242	20451	9625	122	1723	0	0	478	7511
	CV (%)	103	186	151	762	153			412	110
Diyarbakir	Mean	43475	7774	4248	0	281	50	77	18	6342
	CV (%)	117	273	278		368	825	819	1140	91
Konya	Mean	17093	18331	4791	643	2684	138	288	1159	6359
	CV (%)	164	201	203	363	221	1085	718	828	98
Average	Mean	22824	13785	5621	400	1885	117	187	757	5584
	CV (%)	207	243	244	509	228	1237	780	829	109

Table 30. Household income by varieties adoption, provinces and regions ($)

	Variety classification	Per capita income US$/person/yr	Per capita income US$/person/day
Total (all areas)	Monitored varieties	9,329	25.9
	Other new varieties	6,559	18.2
	Old improved varieties	5,876	16.3
	Mean	6,723	18.7
Province			
Adana	Monitored varieties	7,575	21.0
	Other new varieties	5,623	15.6
	Old improved varieties	-	-
	Mean	5,806	16.1
Ankara	Monitored varieties	4,935	13.7
	Other new varieties	2,266	6.3
	Old improved varieties	5,752	16.0
	Mean	5,620	15.6
Edirne	Monitored varieties	9,861	27.4
	Other new varieties	8,706	24.2
	Old improved varieties	11,333	31.5
	Mean	9,311	25.9
Diyarbakir	Monitored varieties	8,160	22.7
	Other new varieties	6,394	17.8
	Old improved varieties	4,814	13.4
	Mean	6,662	18.5
Konya	Monitored varieties	12,686	35.2
	Other new varieties	7,301	20.3
	Old improved varieties	6,056	16.8
	Mean	6,863	19.1
Region			
Plateau	Monitored varieties	10,964	30.5
	Other new varieties	6,993	19.4
	Old improved varieties	5,952	16.5
	Mean	6,490	18.0
Lowland	Monitored varieties	8,763	24.3
	Other new varieties	6,454	17.9
	Old improved varieties	5,167	14.4
	Mean	7,012	19.5

Analysis by wealth quartiles and variety classification (Table 31) shows that the poorest households increased their per capita income to $14.90 by adopting monitored varieties as compared to those in the same wealth quartile using other new varieties ($12.60) or old improved varieties ($10.60). Better-off farmers derived the highest per capita income per day in each variety classification or adoption

Table 31. Household income by varieties and adoption by wealth quartiles

Variety classification	Wealth quartiles	Per capita income US$/person/yr	Per capita income US$/person/day
Monitored varieties	Lowest 25%	5,363	14.9
	25-50%	8,160	22.7
	50-75%	8,188	22.7
	Top 25%	12,852	35.7
	Mean	9,329	25.9
Other new varieties	Lowest 25%	4,543	12.6
	25-50%	6,471	18.0
	50-75%	7,387	20.5
	Top 25%	8,226	22.8
	Mean	6,559	18.2
Old improved varieties	Lowest 25%	3,824	10.6
	25-50%	5,544	15.4
	50-75%	7,129	19.8
	Top 25%	7,168	19.9
	Mean	5,876	16.3
Total sample	Lowest 25%	4,311	12.0
	25-50%	6,245	17.3
	50-75%	7,376	20.5
	Top 25%	8,999	25.0
	Mean	6,723	18.7

Table 32. Comparison of Kolmogorov-Smirnov statistics of per capita income distribution by variety adoption

Variety adoption groups	KS-statistic
Monitored varieties x Other new varieties	1.479*
Monitored varieties x Old improved varieties	2.385***
Other new varieties x Old improved varieties	1.312(*)

(*) significant at 6% level

group. There is no significant difference in per capita income per day between adopters of the monitored varieties and other new varieties, but there is between these groups and farmers who used the old-improved varieties. Similarly, the distribution of per capita income based on the Kolmogorov-Smirnov test is nearly the same for adopters of monitored varieties and other new varieties. On the contrary, there is a statistically significant difference in the distribution of per capita income between these two groups and the group of farmers using old-improved varieties (Table 32 and Figure 9).

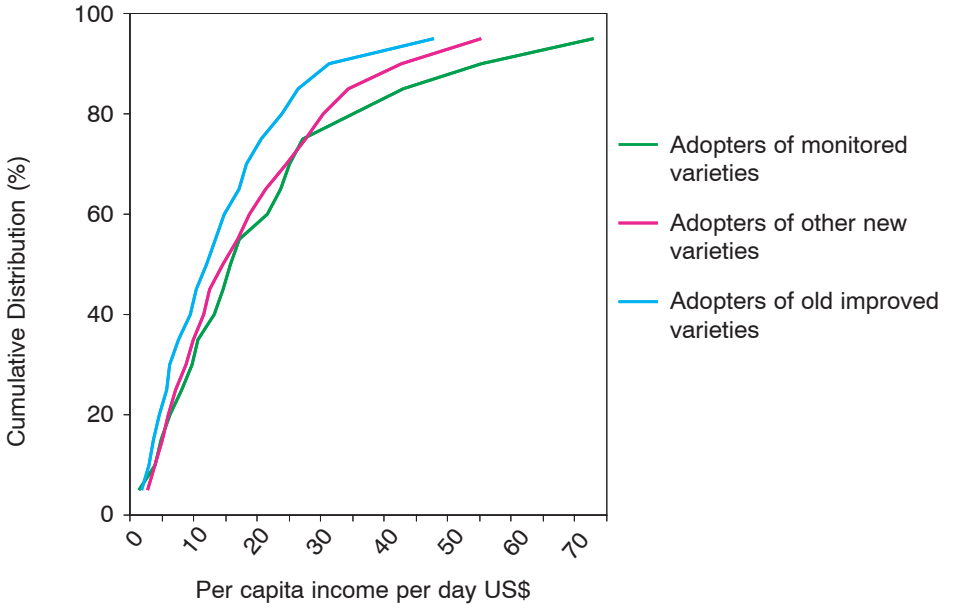

Fig. 9. Distribution per capita income per day by adoption

3.10 Estimated total increase in national income from adoption of new varieties

Based on the wheat gross margin analysis at the farm level, total increases from adopting monitored wheat varieties as well as adoption of other new varieties were estimated in the five provinces, and the increase in national income using the following formula:

Total increase = Σ Arj i* Aji * Xji

where Arji is the average area planted to wheat in province j under i production system, Aji is the adoption degree in province j under i production system, and Xji is the average gross-margin increase per unit obtained by farmers. The preliminary estimate was an increase in national income in 2007 of 28.8 million Turkish Lira (US$24 million) from adoption of monitored varieties in the target areas, with most (93%) of this increase from rainfed areas and only 7% from irrigated areas (Table 33). The contribution of Adana and Konya was essential in this increase (about 40% for each province), while there was no contribution from Edirne because using monitored varieties did not show any increase in gross margin over old improved varieties. The preliminary estimate also indicated an increase in national income in 2007 of 21 million Turkish Lira due to adoption of other new varieties in the target area (Table 33). Therefore, adoption of new improved wheat varieties released after 1995 has increased the national income in 2007 by about 50 million Turkish Lira in total, with 80% of this increase coming from rainfed areas.

Table 33. Estimated increase in national income due adoption of monitored varieties in 2007

Province	Harvested wheat area (ha) in 2007		Estimated cultivated area under new varieties (ha)		Estimated increase in gross margin over old varieties at province level (TL)		Increase in national income (TL)
	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Total
Monitored varieties							
Adana	160,872	102,328	26,576	17,950	11,321,468	0	11,321,4680
Ankara	510,305	2,193	8,866	457	3,227,238	249,421	3,476,659
Edirne	190,056	0	67,756	0	0	0	0
Diyarbakir	301,730	26,000	95,425	6,798	2,290,203	0	2,290,203
Konya	487,489	136,189	26,746	15,114	9,789,071	1,898,706	11,687,777
Total	1,650,452	266,710	225,369	40,319	26,627,980	2,148,127	28,776,107
Other new varieties							
Adana	160,872	102,328	134,296	84,378	0	0	0
Ankara	510,305	2,193	21,521	5,262	2,259,661	4,216,629	6,476,290
Edirne	190,056	0	113,943	0	0	0	0
Diyarbakir	3,017,300	26,000	144,002	14,040	8,208,105	0	8,208,105
Konya	487,489	136,189	33,225	39,954	2,558,349	3,780,663	6,339,012
Total	1,650,452	266,710	446,987	143,634	13,026,116	7,997,291	21,023,407

However, increases in the national income can be greater if new wheat varieties are adopted by the majority of farmers, though this is a constant and never-ending challenge. Adoption of agricultural technologies by farmers depends upon farmers and policy makers being aware of improved technologies, upon good linkage between research/extension work, and on farmers participating in on-farm trials and demonstrations. Human capacity building across all the stakeholder groups will be necessary if sustainable crop production is to be achieved.

3.11 Rates of return to research

In assessing the rates of return from agricultural research and extension, specifically the adoption of new varieties, data on the cost of research are needed, and this study generated primary indicators that can be used to estimate the rates of return to research. As a follow up, additional data need to be collected on the costs of research (labor, equipment, operations, etc.) incurred by all partners involved (CIMMYT, ICARDA, and the wheat research program in Turkey) over the years of variety development. This task will be completed jointly with all partners involved in this study.

4. CONCLUSION

This study assessed the impacts of five improved varieties developed under the national and international programs in both rainfed and irrigated production in five provinces in Turkey. It specifically evaluated the technical, economic, and social impacts of the varieties on the livelihoods of producers, and the main findings are summarized below.

1. The ability of varieties to produce high yields, and their resistance to drought, their ability to demand a good market price, adaptation to local conditions, frost resistance, and good bread or durum quality are the most important characteristics indicated by farmers (Table 8). Few constraints to the adoption of the monitored varieties were identified based on farmers' perceptions of these criteria, with the exception of Saricanak-98 which some farmers perceived to have a declining yield over time, Ceyhan-99 being susceptible to cold or frost and seed was expensive, and Pehlivan being susceptible to diseases. These perceptions may be specific to the study areas and need further investigation of the causes in order to increase their adoption rates.

2. Crop biodiversity of wheat, although very high at country or province levels, is relatively very low at the household level. The implication is that biodiversity may be important for the development of new varieties in breeding programs, but not necessarily at the farm level.

3. Among all varieties cultivated by the sampled producers, Pehlivan ranks third in terms of adoption rate (8.2%), after Bezostaja-1 (23%) and Gerek-79 (10%). Other adoption rates are 3.5% for Ceyhan-99, 0.9% for Karahan-99, 0.5% for Saricanak-98 and 0.7% for Demir-2000 (Table 17). Among all 45 different varieties analyzed in the survey, the variety ranking according to adoption rate is 8th for Ceyhan-99, 20th for Karahan-99, 21st for Demir-2000, and 28th for Saricanak-98. The adoption degrees and intensities for individual varieties follow a similar trend. There is a need for more extension efforts to disseminate, and increase the adoption rates of the monitored varieties in the respective provinces.

4. The adoption rate and degree are relatively high for Pehlivan and Ceyhan-99 varieties compared to other monitored varieties.

5. Adoption intensity of the monitored varieties is highest among more wealthy farmers (Table 16), followed by the poor farmers, and the other wealth groups. These varieties are reaching the poor as well as the more wealthy farmers. Given their high productivity levels compared to other varieties, they could contribute to poverty reduction better if promoted on a wider scale to reach more farmers and production systems.

6. Yield comparisons show that wheat productivity following the adoption of the monitored varieties was doubled under rainfed systems (Table 21) and increased by 11% in irrigated systems. The analysis by region indicated that monitored varieties were only superior in the plateau region under rainfed conditions, but other new varieties were superior in the lowlands and in the plateau region under irrigation conditions. However, the monitored varieties and other new varieties give higher yields, on average, compared to old improved varieties in most situations (Table 22). Overall, the adoption of the monitored varieties generated a net increase of 18% in total factor productivity of wheat among producers. The increase in productivity is also accompanied by a substantial improvement in yield stability in the respective production systems and across the provinces.

7. Ceyhan-99, Pehlivan and Saricanak-98 outperform all wheat varieties cultivated by farmers in terms of profitability, measured by gross margin per unit of land, while Demir-2000 is the least profitable. Estimated income for adopters of the monitored varieties is the highest (TL 78,772 per household, Table 28), and significantly different from that of non-adopters. The contribution of wheat to total household income is 54% for adopters of the monitored varieties as opposed to 46% for adopters of other new varieties, and 37% for adopters of old-improved varieties.

8. The monitored varieties contribute substantially to poverty reduction in the study area. The analysis by wealth quartiles and by variety classification shows that households which belong to the lowest wealth quartile (poor farmers) increased their per capita income to $14.90 per day through the adoption of the monitored varieties compared to those in the same wealth quartile using other new varieties ($12.60) or old-improved varieties ($10.60) (Table 31).

9. The distributions of per capita income from the monitored varieties and from the other new varieties dominate the distribution of income from old-improved varieties, providing evidence of poverty reduction through variety adoption. The policy implication is that if existing government programs to increase wheat production are targeted specifically to the monitored varieties, and/or other new varieties rural poverty reduction, could be achieved more rapidly.

10. Preliminary estimates show an increase in the national income in 2007 of 28.8 million TL from the adoption of the monitored varieties in the target areas of the sampled provinces (Table 33), and 21 million TL from the adoption of other new varieties. Therefore, adoption of new improved wheat varieties which were released after 1995, increased the national income in 2007 in the five provinces by about 50 million Turkish Lira; and about 80% of this increase came from rainfed areas. The increase in the national income could be greater if new wheat varieties are adopted by the majority of farmers. Adoption of agricultural technologies by farmers depends upon policy makers being aware of improved technologies, upon good linkages between research and extension work, and upon farmers participating in on-farm trials and demonstrations.

11. This study was conducted in five provinces for one year, but in order to confirm these findings it is recommended that additional studies are conducted in the same area as well as other wheat growing areas in other provinces.

12. A next step of this study would be to determine the economic impact of the monitored wheat varieties at the national level. This requires additional data collection on the research costs incurred by all partners involved (CIMMYT), ICARDA, and the Wheat research program in Turkey) over the years. Subsequently, the benefits could be estimated based on the results from this study, and the internal rate of return (IRR) from research and extension could be effectively calculated.

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APPENDIX

Table A-1. Wheat area, yield, and production in Turkey

Year	Area harvested (ha)	Yield (t/ha)	Total production (t)
1985	9,274,500	1.836	17,032,000
1986	9,355,932	2.034	19,032,000
1987	9,310,681	2.033	18,932,000
1988	9,387,855	2.186	20,523,008
1989	9,227,000	1.758	16,221,000
1990	9,432,309	2.123	20,022,000
1991	9,597,539	2.127	20,418,496
1992	9,473,387	2.039	19,318,000
1993	9,716,377	2.163	21,016,000
1994	9,800,000	1.787	17,514,000
1995	9,400,000	1.916	18,015,000
1996	9,350,000	1.980	18,515,000
1997	9,340,000	1.998	18,663,400
1998	9,400,000	2.235	21,011,000
1999	9,380,000	1.920	18,008,800
2000	9,400,000	2.235	21,008,600
2001	9,350,000	2.033	19,007,000
2002	9,300,000	2.098	19,508,000
2003	9,100,000	2.089	19,008,200
2004	9,300,000	2.258	21,000,000
2005	9,250,000	2.324	21,500,000
2006	9,300,000	2.152	20,010,000
2007	8,600,000	2.055	17,673,000

Source: Turkish Statistical Institute, 2009 (http://www.tuik.gov.tr)

Table A-2. Description of wheat varieties in Turkey

Variety Name	Year of release	Main advantage	Targeted areas
Monitored varieties			
Pehlivan	1998	Good quality, high yield	Rainfed area in Thrace region
Ceyhan-99	1999	High yield, good industrial quality	Rainfed area in Cukurova region as well as other regions where spring wheat varieties cultivated.
Karahan-99	1999	Drought tolerance	Rainfed area in Central Anatolian Plateau (CAP)
Saricanak-98	1998	Better pigment, high yield	Rainfed and irrigated area in SE Anatolia wheat region
Demir-2000	2000	High yield, drought tolerance	Rainfed area in CAP and other winter regions
Other new varieties			
Adana-99	1999	High yield	Rainfed area in Cukurova region as well as other regions where spring wheat varieties cultivated.
Ahmetaga	2004		Irrigated areas in CAP
Altay-2000	2000	High yield, drought tolerance	Rainfed area in CAP and other winter regions
Amanos-97	1997	Durum wheat high yield	Rainfed and irrigated area in SE Anatolia wheat region
Bayraktar-2000	2000	Drought tolerance	Rainfed area in CAP and other winter regions
Dariel	2002	High yield	Rainfed area in Cukurova region as well as other regions where spring wheat varieties cultivated.
Ekiz	2004	-	Irrigated areas in CAP
Flamura	1999	-	Rainfed area in Thrace region
Gelibolu	2005	High yield	Rainfed area in Thrace region
Golia	1999	-	Rainfed area in Cukurova region as well as other regions where spring wheat varieties cultivated.
Gönen	1998	quality	Rainfed area in Marmara and Aegean region
Guadolope	2007	High yield	-
Kirgiz	1995	Drought tolerance	Rainfed area in CAP and other winter regions
Konya-2002	2002	-	Irrigated areas in CAP
Nurkent	2001	High yield	Spring wheat area in SE Anatolia under irrigated condition
Pamukova	1997	High yield, good quality	Rainfed area in Marmara region, as well as spring wheat area in SE Anatolia under irrigated condition
Pandas	2001	High yield	Rainfed area in Cukurova region as well as other regions where spring wheat varieties cultivated.
Prostar	1999	High yield	Rainfed area in Thrace region
Sagettario	2001	Good quality	Rainfed area in Cukurova region as well as other regions where spring wheat varieties cultivated.
Svevo	2001	Good quality	Rainfed area in Cukurova region as well as other regions where spring wheat varieties cultivated.

Table A-2. Continued

Variety Name	Year of release	Main advantage	Targeted areas
Tekirdag	2005	High yield	Rainfed area in Thrace region
Tosunbey	2004	Good quality, high yield	Rainfed area in CAP and other winter regions
Zenit	2001	DW, good pigmentation	Rainfed and irrigated area in SE Anatolia wheat region
Tekirdag	2005	High yield	Rainfed area in Thrace region
Toros*	-	High yield	-
Tosunbey	2004	Good quality, high yield	Rainfed area in CAP and other winter regions
Ukrayna*	-	High yield	Irrigated area in Central Anatolia
Other old varieties			
Aydin-93	1993	Durum wheat, high yield	Rainfed and irrigated area in SE Anatolia wheat region
Bezostaja-1	1968	Wide adaptation, good quality stability	Rainfed area in CAP and other winter regions and Supplemental irrigation
Cesit-1252	1991	DW, high yield, better quality when irrigated	Rainfed area in CAP and other winter regions and Supplemental irrigation
Dagdas-94	1994	Drought tolerance	Rainfed area in CAP and other winter regions
Diyarbakir-81	1987	DW, high yield	Rainfed and irrigated area in SE Anatolia wheat region
Ege-88	1988	DW, high yield	Rainfed and irrigated area in SE Anatolia wheat region
Firat-93	1993	DW, high yield	Rainfed and irrigated area in SE Anatolia wheat region
Gerek-79	1979	Drought tolerance, wide adaptation	Rainfed area in CAP and other winter regions
Gun-91	1991	Good quality, high yield	Rainfed area in CAP and other winter regions
Katea-1	1988	Drought tolerance, high yield	Rainfed area in CAP and other winter regions and Supplemental irrigation
Kiraç-66	1970	Drought tolerant, good quality	Rainfed area in CAP and other winter regions
Kiziltan-91	1991	DW, high yield, better quality when irrigated	Rainfed area in CAP and other winter regions and Supplemental irrigation
Yuregir-89	1989	High yield	Rainfed area in Cukurova region as well as other regions where spring wheat varieties cultivated.
Zerun	-	Local landrace	-

* Not released officially
CAP - Central Anatolia Plateau

Source: MARA Variety Registration and Seed Certification Center, Agricultural Research Institutions

Table A-3. Agro-ecological characteristics of the study areas

Province	Location	Rainfall	Dominated farming system
Adana	Lowland	High	Rainfed system for wheat following by irrigated cotton
Ankara	Plateau	Low	Rainfed, wheat-Fallow system
Diyarbakir	Lowland	Low	Rainfed, wheat-Lentil system
Edirne	Lowland	High	Rainfed system
Konya	Plateau	Low	Rainfed, wheat-Fallow system

Source: MARA Variety Registration and Seed Certification Center, Agricultural Research Institutions (2008)

Table A-4. Number of plots (fields) by varieties cultivated by province

Province /variety	Field Freq.	(%)	Province /variety	Field Freq.	(%)	Province /variety	Field Freq.	(%)
Adana			**Diyarbakir**			**Konya**		
Adana-99	55	34.8	Adana-99	1	.5	Ahmetaga	3	0.7
Ceyhan-99	**13**	**8.2**	Amanos-97	2	1.1	Altay-2000	7	1.6
Golia	5	3.2	Aydin-93	7	3.7	Bayraktar-2000	3	0.7
Pandas	26	16.5	Bezostaja-1	9	4.8	Bezostaja-1	126	29.4
Sagettario	59	37.3	**Ceyhan-99**	**8**	**4.3**	**Ceyhan-99**	**16**	**3.7**
Sub-total	***158***	***100.0***	Dariel	4	2.1	Cesit-1252	29	6.8
Ankara	Field Freq.	(%)	Diyarbakir-81	6	3.2	Dagdas-94	4	0.9
Bezostaja-1	110	71.4	Ege-88	3	1.6	Dariel	1	0.2
Cesit-1252	1	0.6	Firat-93	16	8.5	**Demir-2000**	**3**	**0.7**
Demir-2000	**4**	**2.6**	Golia	1	.5	Ekiz	2	0.5
Gerek-79	11	7.1	Gönen	5	2.7	Gerek-79	92	21.5
Gun-91	1	0.6	Nurkent	33	17.6	Golia	1	0.2
Kiraç-66	1	0.6	Pamukova	4	2.1	Guadolope	2	0.5
Kirgiz	1	0.6	Pandas	10	5.3	Gun-91	1	0.2
Kiziltan-91	5	3.2	**Pehlivan**	**39**	**20.7**	Ispanyol	1	0.2
Pehlivan	**4**	**2.6**	Sagettario	2	1.1	**Karahan-99**	**10**	**2.3**
Tosunbey	1	0.6	**Saricanak-98**	**5**	**2.7**	Katea 1	8	1.9
Ukrayna	11	7.1	Svevo	19	10.1	Kiraç-66	1	0.2
Other	4	2.5	Yuregir-89	12	6.4	Kirgiz	3	0.7
Sub-total	***154***	***100.0***	Zenit	1	.5	Kiziltan-91	50	11.7
			Zerun	1	.5	Konya-2002	27	6.3
EDIRNE								
	Field Freq.	(%)	***Sub-total***	***188***	***100.0***	**Pehlivan**	**2**	**0.5**
Flamura	43	32.8				Toros	15	3.5
Gelibolu	33	25.2				Ukrayna	16	3.7
Katea 1	5	3.8				Other	5	1.1
Pehlivan	**42**	**32.1**				***Sub-total***	***428***	***100.0***
Prostar	1	0.8						
Tekirdag	5	3.8						
Other	2	1.5						
Sub-total	***131***	***100.0***						

Table A-5. Average yields and total wheat areas by varieties cultivated by province

Province variety	Total area (ha)	Average yield (kg/ha)
Adana		
Adana-99	583	4465
Ceyhan-99	**300**	**4385**
Golia	60	4100
Pandas	167	3567
Sagettario	680	4172
	1790	**4189**
Ankara		
Bezostaja-1	2375	1700
Cesit-1252	1	3500
Demir-2000	**30**	**2370**
Gerek-79	158	1230
Gun-91	2	1700
Kiraç-66	1	2000
Kirgiz	40	2200
Kiziltan-91	96	3128
Pehlivan	**26**	**2708**
Tosunbey	1	2540
Ukrayna	273	2597
Other	35	1180
	3037	**1830**
Edirne		
Flamura	286	3824
Gelibolu	220	4786
Katea 1	23	4720
Pehlivan	315	3989
Prostar	15	4500
Tekirdag	9	4696
Other	16	3750
	885	**4191**

Province variety	Total area (ha)	Average yield (kg/ha)
Diyarbakir		
Adana-99	4	3500
Amanos-97	13	3550
Aydin-93	132	3779
Bezostaja-1	81	2956
Ceyhan-99	**75**	**4550**
Dariel	93	3375
Diyarbakir-81	39	2547
Ege-88	45	2860
Firat-93	199	4050
Golia	8	5500
Gönen	176	3732
Nurkent	789	3485
Pamukova	67	2788
Pandas	244	4165
Pehlivan	**982**	**3412**
Sagettario	36	3750
Saricanak-98	**72**	**4260**
Svevo	412	4179
Yuregir-89	260	3678
Zenit	30	5300
Zerun	15	2500
	3769	**3656**
Konya		
Ahmetaga	23	5667
Altay-2000	59	1058
Bayraktar-2000	21	1293
Bezostaja-1	1495	2401
Ceyhan-99	**186**	**4512**
Cesit-1252	259	3898
Dagdas-94	20	1498
Dariel	12	3435
Demir-2000	**44**	**2550**
Ekiz	8	6800
Gerek-79	1128	1325
Golia	3	4000
Guadolope	13	4638
Gun-91	11	670
Ispanyol	1	4000
Karahan-99	**139**	**2195**
Katea 1	109	1865
Kiraç-66	4	900
Kirgiz	38	1715
Kiziltan-91	366	3266
Konya-2002	329	3561
Pehlivan	**3**	**3200**
Toros	131	4011
Ukrayna	158	3825
Other	42	3660
	4598	**2652**

Table A-6. Rate, degree, and intensity of adoption by variety (in decreasing order of importance)

Variety	Rate (%)	Degree (%)	Intensity (%)	variety	Total area (%)	yield (%)	Intensity (%)
Bezostaja-1	23.1	28.0	6.468	Golia	0.7	0.5	0.004
Gerek-79	9.7	9.1	0.883	Diyarbakir-81	0.6	0.3	0.002
Pehlivan	**8.2**	**9.4**	**0.771**	Dariel	0.5	0.7	0.004
Sagettario	5.7	5.1	0.291	Gönen	0.5	1.2	0.006
Adana-99	5.4	4.2	0.227	**Saricanak-98**	**0.5**	**0.5**	**0.003**
Kiziltan-91	5.2	3.3	0.172	Tekirdag	0.5	0.1	0.001
Flamura-85	4.1	2.0	0.082	Dagdas-94	0.4	0.1	0.000
Ceyhan-99	**3.5**	**4**	**0.140**	Kirgiz	0.4	0.6	0.002
Pandas	3.4	2.9	0.099	Pamukova	0.4	0.5	0.002
Nurkent	3.2	5.7	0.182	Ahmetaga	0.3	0.2	0.001
Gelibolu	3.1	1.6	0.050	Bayraktar-2000	0.3	0.1	0.000
Cesit-1252	2.8	1.8	0.050	Ege-88	0.3	0.3	0.001
Konya-2002	2.5	2.3	0.058	Amanos-97	0.2	0.1	0.000
Ukrayna	2.5	3.1	0.078	Ekiz	0.2	0.1	0.000
Svevo	1.8	2.9	0.052	Guadolope	0.2	0.1	0.000
Firat-93	1.5	1.4	0.021	Gun-91	0.2	0.1	0.000
Toros	1.4	0.9	0.013	Kiraç-66	0.2	0.0	0.000
Katea 1	1.2	0.9	0.011	Ispanyol	0.1	0.0	0.000
Yuregir-89	1.1	1.8	0.020	Prostar	0.1	0.1	0.000
Karahan-99	**0.9**	**1.0**	**0.009**	Tosunbey	0.1	0.0	0.000
Altay-2000	0.7	0.4	0.003	Zenit	0.1	0.2	0.000
Aydin-93	0.7	0.9	0.006	Zerun	0.1	0.1	0.000
Demir-2000	**0.7**	**0.5**	**0.004**				

Table A-7. Rate and degree of adoption by province by variety

Province variety	Adoption rate (%)	Adoption degree (%)
Adana		
Adana-99	34.8	32.8
Ceyhan-99	**8.2**	**16.8**
Golia	3.2	3.3
Pandas	16.5	9.3
Sagettario	37.3	38.0
Ankara		
Bezostaja-1	71.4	78.2
Cesit-1252	0.6	0.0
Demir-2000	**2.6**	**1.0**
Gerek-79	7.1	5.2
Gun-91	0.6	0.1
Kiraç-66	0.6	0.0
Kirgiz	0.6	0.1
Kiziltan-91	3.2	3.2
Pehlivan	**2.6**	**0.9**
Tosunbey	0.6	0.0
Ukrayna	7.1	9.0
Other	2.5	1.2
Diyarbakir		
Adana-99	0.5	0.1
Amanos-97	1.1	0.4
Aydin-93	3.7	3.6
Bezostaja-1	4.8	2.2
Ceyhan-99	4.3	0.3
Dariel	2.1	2.5
Diyarbakir-81	3.2	1.0
Ege-88	1.6	1.2
Firat-93	8.5	5.4
Golia	0.5	0.2
Gönen	2.7	4.8
Nurkent	17.6	21.3
Pamukova	2.1	1.8
Pandas	5.3	6.6
Pehlivan	20.7	26.5
Sagettario	1.1	1.0
Saricanak-98	2.7	1.9
Svevo	10.1	11.1
Yuregir-89	6.4	7.0
Zenit	0.5	0.8
Zerun	0.5	0.4

Province variety	Adoption rate (%)	Adoption degree (%)
Konya		
Ahmetaga	0.7	0.5
Altay-2000	1.6	1.3
Bayraktar-2000	0.7	0.4
Bezostaja-1	29.4	32.5
Ceyhan-99	**3.7**	4.1
Cesit-1252	6.8	5.6
Dagdas-94	0.9	0.4
Dariel	0.2	0.3
Demir-2000	**0.7**	**1.0**
Ekiz	0.5	0.2
Gerek-79	21.5	24.5
Golia	0.2	0.1
Guadolope	0.5	0.3
Gun-91	0.2	0.2
Ispanyol	0.2	0.0
Karahan-99	**2.3**	3.0
Katea 1	1.9	2.4
Kiraç-66	0.2	0.1
Kirgiz	0.7	0.8
Kiziltan-91	11.7	8.0
Konya-2002	6.3	7.2
Pehlivan	**0.5**	0.1
Toros	3.5	2.8
Ukrayna	3.7	3.4
Other	1.1	0.9
Edirne		
Flamura	32.8	32.3
Gelibolu	25.2	24.9
Katea 1	3.8	2.6
Pehlivan	**32.1**	**35.7**
Prostar	0.8	1.7
Tekirdag	3.8	1.0
Other	1.5	1.8

Table A-8. Estimated revenues, costs and gross margin by wheat varieties (TL/ha)

Wheat variety	Revenue[1]	Variable costs	Gross margin[2]	Govt support	Gross margin[3]
Adana-99	1739	922	817	389	1206
Ahmetaga	2891	1505	1386	441	1827
Altay-2000	541	571	-29	245	216
Amanos-97	1605	665	939	351	1290
Aydin-93	1607	962	645	361	1005
Bayraktar-2000	651	621	30	255	285
Bezostaja-1	1064	1031	32	290	322
Ceyhan-99	2067	1176	892	390	1282
Cesit-1252	2019	1363	656	365	1021
Dagdas-94	717	675	42	264	306
Dariel	1614	1020	593	344	937
Demir-2000	1102	1170	-68	304	236
Diyarbakir-81	1053	789	263	308	572
Ege-88	1167	901	266	322	588
Ekiz	3587	2035	1552	489	2041
Firat-93	1873	870	1003	372	1375
Flamura-85	1614	861	753	363	1116
Gelibolu	2008	908	1100	403	1504
Gerek-79	677	653	24	256	279
Golia	1559	932	627	382	1009
Gönen	1457	819	638	359	997
Guadolope	2259	1516	743	397	1140
Gun-91	635	719	-84	250	167
Ispanyol	1737	2374	-637	370	-267
Karahan-99	1152	885	267	293	561
Katea 1	1436	837	598	326	924
Kiraç-66	1117	632	485	262	746
Kirgiz	1103	645	458	278	736
Kiziltan-91	1606	1311	295	338	633
Konya-2002	1890	1579	311	351	662
Nurkent	1396	930	466	348	815
Pamukova	1057	1187	-130	318	188
Pandas	1482	938	544	359	902
Pehlivan	1542	896	645	355	1001
Prostar	2021	964	1057	391	1448
Sagettario	1639	962	677	377	1053
Saricanak-98	1841	926	915	381	1296
Svevo	2044	911	1134	378	1511
Tekirdag	1954	836	1118	400	1517
Toros	2207	1720	487	370	857
Tosunbey	1027	654	372	308	680
Ukrayna	1626	1269	357	341	698
Yuregir-89	1755	922	833	356	1189
Zenit	2120	1388	732	425	1157
Zerun	950	907	43	306	349

1. includes revenues from grain and straw; 2. before government support; 3. after government support.