Chapter 6: Adoption and impacts of improved varieties and seed demand analysis

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6.1 Executive summary

There is very limited information about the national level adoption of improved wheat varieties in Morocco. With the exception of some estimates based on secondary data, the same is true for household, regional and national level seed use. Using a nationally representative sample of 1,230 farm households from 21 provinces distributed across 56 districts and 292 villages and a variety of methods including descriptive statistics, the Heckman selection model, duration analysis, propensity score matching and endogenous switching regression, this study attempted to provide: 1) accurate estimates of current national and provincial adoption levels of improved varieties with special attention to their release date; 2) analysis of factors influencing the decision and speed of adoption of improved wheat varieties; 3) estimates of impacts on livelihoods indicators particularly yield, wheat net income and wheat consumption; and 4) estimation of farm, provincial and national level seed demand.

Survey results show that there are 40 wheat varieties in farmers' hands out of which 19 have been identified to be bread wheat and another 15 to be durum wheat while the remaining 6 were not identified. Out of the 34 identified varieties, some of them were released as recently as 2010 but the vast majority (25) are more than 10 years old with 10 of them more than 20 years of age. Out of 27 varieties for which the breeding programs were identified, 18 come from the INRA breeding program. Out of all the varieties released by INRA, 94% have come from the joint INRA/ICARDA/CIMMYT program, showing strong collaboration between INRA and the CGIAR.

Out of the 40 wheat varieties that were found in farmers' hands, the top 10 varieties are being cultivated by more than 91% of wheat growers on 92% of total wheat area. Among the top 10 varieties, four which are all at least 24 years old cover 56% of the total wheat area - showing that old varieties still dominate the Moroccan wheat fields. The top two varieties in terms of number of growers are Karim and Achtar, which are being cultivated by 38.1% of Moroccan farmers. The 17 varieties that came out of the joint INRA/CGIAR breeding programs over the last 4 decades are being cultivated by 81.8% of the wheat growers in the country – showing that the joint INRA/CGIAR varieties are still dominant among Moroccan farms.

None of the INRA/CGIAR varieties released in the last 10 years are found in farmers' hands and varieties which are between 10 and 20 years old are being cultivated by only 15% of the farmers. This shows that the INRA/CGIAR varieties which were released over 20 years ago are still dominant in the Moroccan farmers' portfolios. The national adoption rates for more recent varieties generally stand at very low levels. Only 16% of Moroccan wheat growers cultivate varieties that were released 10 or less years ago, while 48% of the farmers cultivate varieties 20 or less years old on 41% of total wheat area. With an area-weighted national average varietal replacement rate of 22 years, very old varieties still dominate the Moroccan farmers' portfolios where more than 58% of the growers are still cultivating varieties that were released over 20 years ago. This raises a number of important questions: 1) whether there are new improved INRA/CGIAR varieties which are superior to these old varieties; 2) whether there are indeed new and better varieties from INRA/CGIAR but the farmers are not aware of them or are not reaching them; or 3) whether these old varieties are indeed performing well and better than more recent INRA/CGIAR varieties and hence farmers prefer them.

Survey results showed that farmers are not up-to-date in terms of new varieties and when they are, seeds of new varieties are not often available. This confirms that a lack of information and unavailability of the seeds of most recent varieties in the market provide part or all of the explanation for the dominance of old wheat varieties in Morocco. Among many other factors, access to seed proves to be an important factor in determining farmers' adoption decisions. The combined effect of factors affecting access to seed (i.e., proximity to seed source, the ability to use certified seed and the ability to buy seed from seed companies in adequate quantity and in a timely fashion) is an increase in the propensity to adopt improved varieties by 15%. While this figure is high in and of itself, it is not high enough to take the whole blame for poor adoption levels. Instead, farmer characteristics were found to be the most important explanatory variable, accounting for 45% of the total variation, followed by farm characteristics, which explained 19% of the variation.

The adoption of improved wheat varieties leads to a 482kg/ha (49%) increase in yields, 1324 MAD/ha (48%) higher net income and 29.6 kg/capita/year (60%) increase in wheat consumption. Given the 41% adoption levels, these gains clearly show that the improved varieties are contributing to the improvement in livelihoods at household and national levels. The typical farmer in Morocco uses an average seeding rate for wheat of 176kg/ha (250 kg/ha for irrigated and 157kg.ha for rained), which translates to a national seed utilization rate of 5.12 million quintals per year. Out of the total seed utilized, 43% is used in the favorable zones and 33% in the intermediate while the remaining 24% is used in the unfavorable and mountainous zones. Out of the total wheat seed used nationally in the 2011/12 cropping season, 22% are confirmed to have come from the formal sector while the remaining 78% come from other sources including local seed dealers, seed dealers in neighboring villages and own saved seed. The average seed replacement rate is 2.1 years with some farmers replacing every year and some others not replacing for over 10 years. Farmers stated that unavailability of the desired seeds and high seed prices are the most important problems regarding seed.

6.2 Introduction

Background

While durum wheat was introduced in the country around the 7th century AD, the first bread wheat cultivars introduced into the country were of Algerian origin. By 1929, bread wheat acreage reached 0.25 million hectares (ha), out of which European cultivars constituted about 33%. In the late 1940's, bread wheat area increased to between 0.3-0.4 million ha while durum wheat area was about 1 million ha (Grillot, 1948). For the next four decades, bread and durum wheat areas stabilized at about 0.5 and 1.2 million ha respectively and increased further afterwards to reach an average of 2.04 million and 0.94 million ha respectively in the period 2008-2012. In the early 80's, wheat in general and bread wheat in particular respectively represented only 43% and 31% of total area under cereals, which increased to 59% and 40% towards 2010 showing the growing importance of wheat in general and bread wheat in particular in Moroccan agriculture (Figure 10).

While both bread and durum wheat areas have been increasing since the 1980s, the spectacular increase in bread wheat area is essentially the result of the intensification policies that have been pursued by the government since the early 1980s. The policy was launched by the Ministry of Agriculture in 1985 with the particular objective of increasing bread wheat production through wider adoption of improved varieties. The policy incentives that were used to encourage the production of bread wheat by farmers included guaranteed prices for the producer and fixed marketing margins. Currently, the value of bread wheat production represents 47% of total value of cereals while durum wheat and barley constitute 27% and 23% respectively.

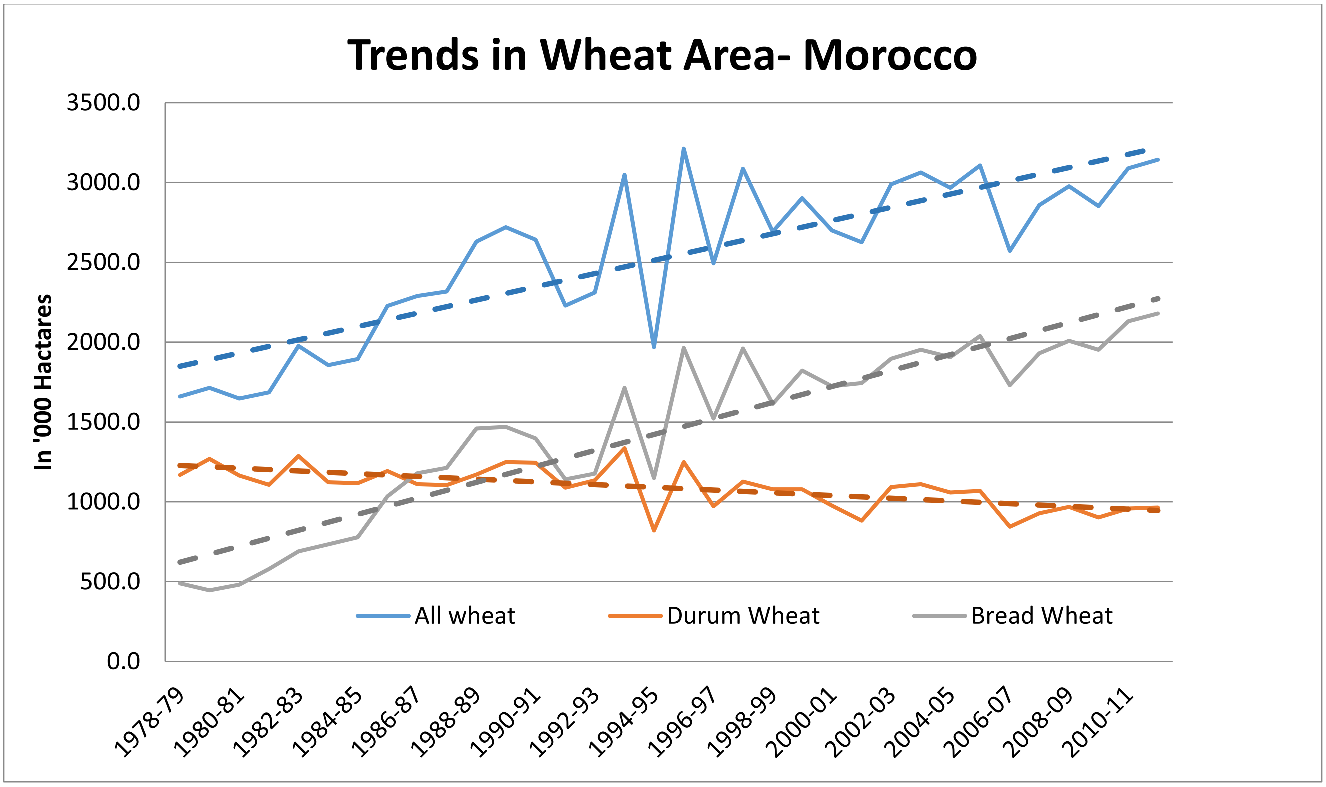

Figure 5: Trends in wheat area in Morocco

Source: Department of Strategies and Statistics (DSS) – Ministry of Agriculture

During the sixties and seventies, wheat yields at national level remained at low levels of about 0.9 tons per ha. The main reason for this was the low yield potential of the cultivars that existed in the country. With the arrival in 80's of a new and improved bread wheat variety called Nasma and durum wheat variety called Kyperounda, yield levels started to increase. After a decade in 1990, average yields reached about 1.21 tons per ha for durum wheat and 1.3 tons per ha for bread wheat. With the introduction of many newer and improved varieties (such as Marchouch and Achtar for bread wheat and Cocorit and Karim for durum wheat) in the subsequent years, significant increases in wheat yields were observed in Morocco which reached a 10-year average (for 2003-2012) of 1.53 tons/ha for durum wheat and 1.57 tons/ha for bread wheat – representing 26% and 20% increases in durum and bread wheat yields respectively since 1990 (Figure 2). A series of government interventions were responsible for this increase which include: the reorientation of the breeding program more towards disease and drought tolerance, establishment of a certified seed subsidy program and the launching of a large-scale demonstration of new cultivars through the national agricultural extension program.

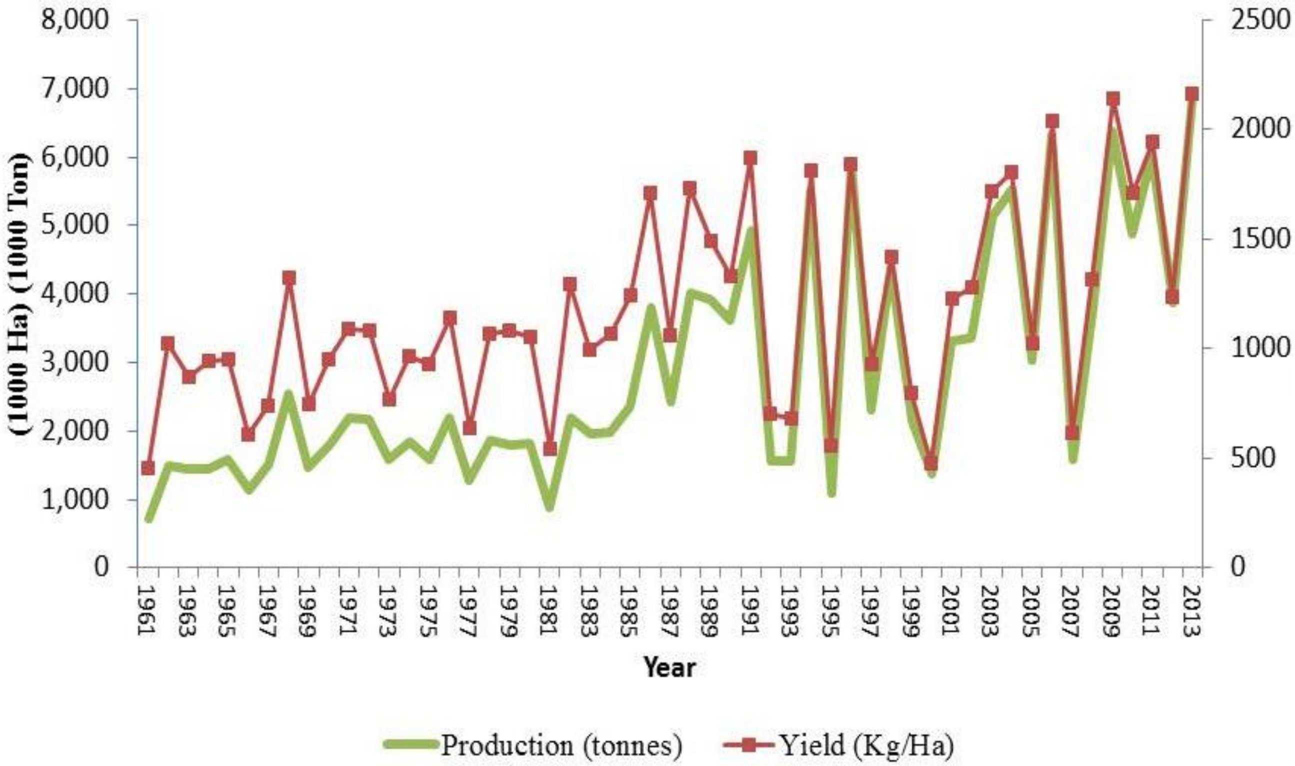

Figure 6: Trends in production and yield of wheat in Morocco, 1961- 2013
Source : FAOSTAT (http://faostat3.fao.org/)

While the trend in cultivated areas showed consistent but slight increases over the years, yield and production during the same period exhibited high variability. Rainfall variability is believed to be the major reason behind these fluctuations (Figure 3). With a 10-year average of about 2.96 million ha of total wheat area and total production of 4.65 million tons, domestic production in Morocco falls far short of meeting national consumption needs leaving the country dependent on imports for about 50% of its domestic demand. As a result, wheat imports have generally exhibited an increasing trend, especially since 1995 (Figure 4).

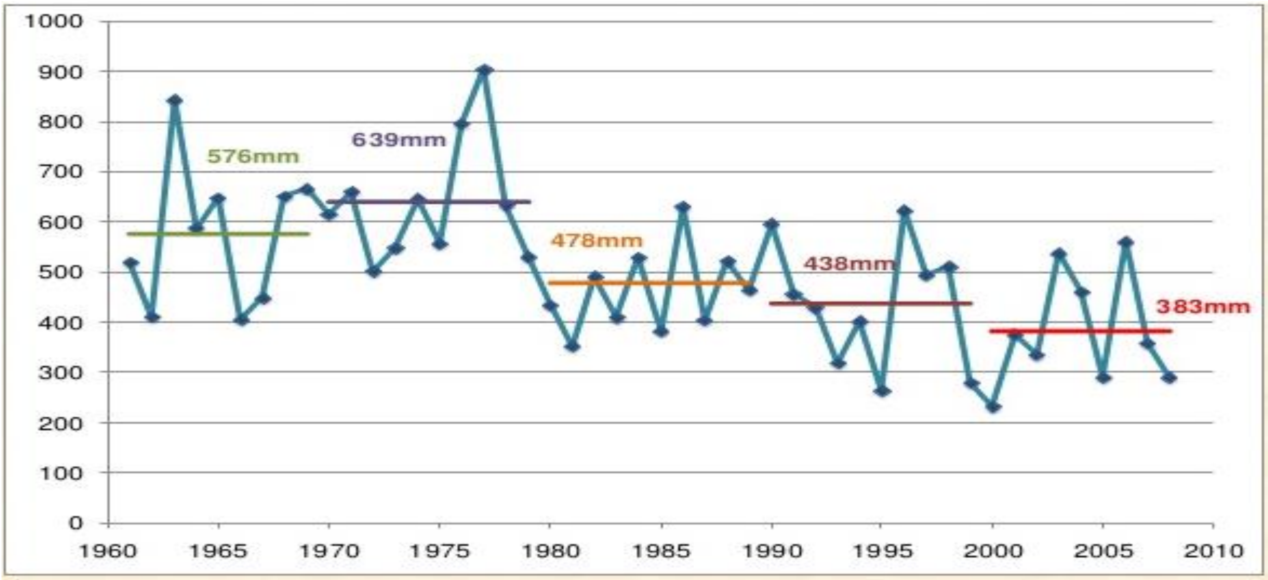

Figure 7: Historical rainfall pattern in Morocco
Source: Nasarellah (2012).

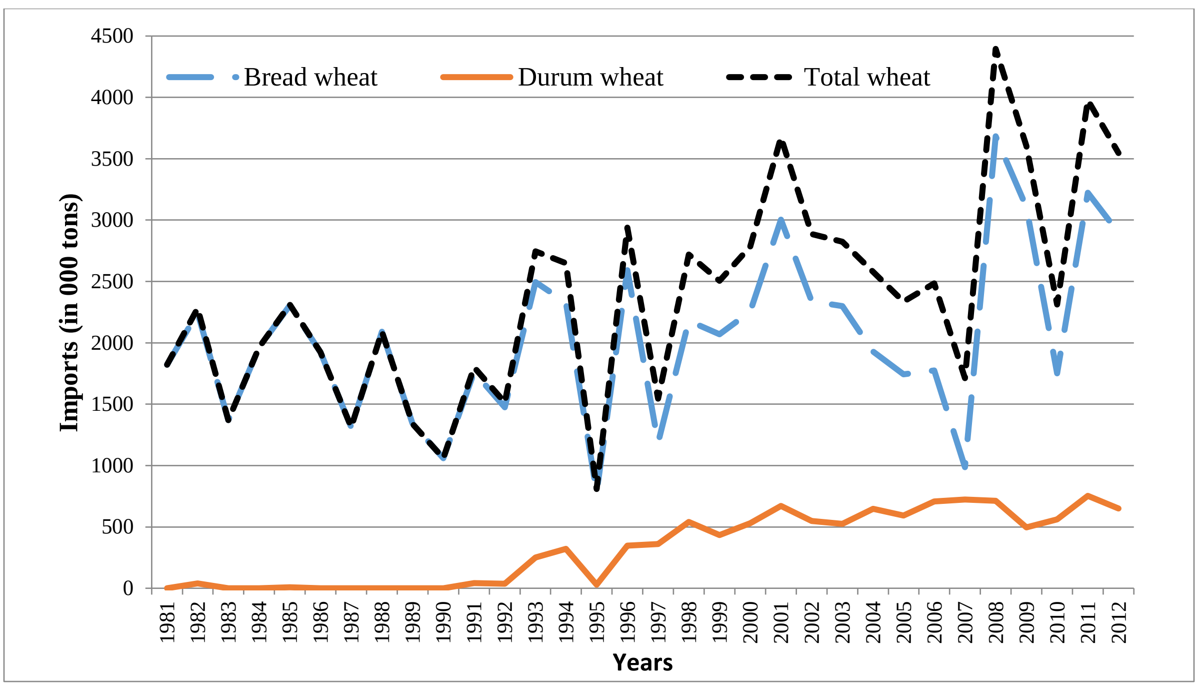

Figure 8: Trends in wheat imports of Morocco

Low yield levels in Morocco are the primary reason for the mismatch between production and consumption. Even though the country has observed substantial yield increases over the years, current yield levels of about 1.5ton/ha in Morocco still remain far behind both the global average of over 3 tons/ha and the African average of 2.3 tons/ha. The government of Morocco has demonstrated its commitment to the development of the wheat sector among other things by its sizeable investment in the wheat breeding program of the National Institute for Agricultural Research (INRA) of Morocco which averaged at about 0.3million US$ per year - making the wheat program at INRA one of the leading wheat breeding programs in the region.

Brief history of the wheat breeding program

Morocco was home to various local wheat land races that have been used by Moroccan farmers before the 1920's. However, these varieties had a number of limitations including poor yield potential, lack of adaptive capacity and instability of traits for which most of them are now out of production (Nsarellah, 2012). The land races were predominantly late maturing, tall and hence susceptible to lodging and had poor resistance to diseases. As a result, early wheat breeding programs in the country focused on the development of early maturing varieties and resistance to septoria and rust. After independence, the wheat breeding program gave priority to drought tolerance and resistance to Hessian fly which was the main constraint for wheat production in semi-arid zones. More recently, the wheat breeding program has also included grain quality into the breeding objectives.

INRA has also been actively working with international research organizations such as the International Wheat Improvement Center (CIMMYT) and the International Agricultural Research Center in the Dry Areas (ICARDA) which have made tremendous investments in further developing the capacity of INRA with training and also joint development and release of a number of improved wheat varieties. As a result, a number of durum wheat varieties that adapted to Moroccan conditions have been jointly developed with a wide spectrum of traits (such as high yields, semi-dwarf, lodging resistance, drought tolerance, and resistance to Hessian fly and various fungal diseases), out of which 25 bread wheat varieties and 34 durum wheat varieties were released by INRA. In the face of a strong national agriculture research system in the country and an active collaboration with international agricultural research institutions including CIMMYT and ICARDA, the current yield levels are rather depressing. This calls for a thorough study to understand the current adoption levels and underlying reasons which prevent the Moroccan wheat farmers from exploiting the yield potentials of available varieties.

6.3 Objectives

Over the years, about 60 improved varieties of wheat have been released by INRA. While national level data on wheat varietal adoption is scanty in Morocco, most of the new varieties appear not to have reached farmers. Access to seeds of improved varieties in general and certified seeds of those varieties in particular are often cited among the major determinants of successful adoption among farmers. Many studies conducted in both the developing and developed world cite farm, farmer, socio-economic, institutional, bio-physical and ecological factors as important determinants of adoption. This report therefore aims to make authoritative statements about the current levels of adoption of improved wheat varieties and their impacts, based on reliable estimates generated using statistically representative national data. Particularly, the report attempts to:

1) Provide an exhaustive list of varieties that are in farmers' hands;

2) Determine the current levels of use (in terms of both % area and % of farmers) of each of the local land races found in farmers' hands and identify the provinces in which they are grown;
3) Determine the adoption levels of improved wheat varieties (both in terms of % area and % of farmers) at national, regional and provincial levels;
4) Determine the current adoption levels by variety name and by agro-ecological classifications;
5) Identify the major determinants of the decision and speed of adoption of improved wheat varieties;
6) Identify farmer preferences and breeder objectives and make congruence/divergence analysis;
7) Determine the types of seed from the different sources used by farmers and the reasons for farmers' decisions to use these types and sources;
8) Determine the total seed demand by source;
9) Measure the impacts of the adoption of new improved wheat varieties on farm household income and wheat consumption;
10) Make comparisons between the net margins of wheat grain and wheat seed production.

6.4 Survey design

According to the Ministry of Agriculture (MoA), Morocco is subdivided into 6 agro-climatic zones. These are the favorable zone, the intermediate zone, the unfavorable south, the unfavorable oriental, the mountainous zone and the Saharan zone. Cereal production in Saharan zone is essentially limited to barley and represents only about 2% of Morocco's rainfed cereals. The unfavorable oriental zone also has similar characteristics. Therefore, as wheat production is either non-existent or very much limited, both agro-ecological zones were excluded from this study. Thus the four zones considered in this study were the favorable zone, intermediate, unfavorable south and the mountains zone.

After careful study of data on wheat production in the various provinces of Morocco and given the limitation in financial and human resources, all participants in the CRP3.1-funded wheat adoption and seed system analysis project inception workshop held on June 28-30, 2012 decided to limit the coverage of the survey to 90% of total national production and not more than 15 provinces. Accordingly, the top 15 wheat producing provinces, which account for about 79% of total wheat production were selected for inclusion in the survey (Table 33). During the preparation for the survey, the study team learned that new administrative reclassification has taken place in 2009 where the 15 provinces selected for the survey have actually become 21. This reclassification led to the distribution of wheat area as follows:

1. Wheat area of Berrechid represent 34% of wheat area of old Settat.
2. Wheat area of Guercif represent 20% of total wheat area of old Taza.
3. Wheat area of Sidi Bennour represent 47% of wheat area of old El Jadida.
4. Wheat area of Sidi Slimane represent 20% of wheat area of old Kénitra.
5. Wheat area of Rehamna represent 67% of wheat area of old El Kelâa.
6. Wheat area of Moulay Yaâcoub represent 87% of wheat area of old Fès

Table 33: Major wheat producing provinces of Morocco (according to the old classification)

Rank by production	Province	Production (1000 tons) (10-year average for 2002-2011)	% of total national production	Cumulative % of production	Agro-ecological zone (1=favorable, 2=intermediate, 3=unfavorable south, 4=mountains, 5= unfavorable East, 6=Saharan	Irrigation (1=irrigated, 2=partly irrigated, 3= rainfed)	Experts' opinion on the climate change (CC) impact and extent of adoption of improved wheat varieties (1=low and 5=high)		Expert estimates of adoption rate (% of area)
							Extent of CC impact	Level of Adoption of improved wheat varieties	
1	Sidi Kacem	395.99	8.60	8.60	1	3	1	3	45%
2	Beni Mellal	390.08	8.47	17.08	4	2	5	4	75%
3	Settat	374.57	8.14	25.21	2	3	3	4	75%
4	El Jadida	345.70	7.51	32.72	2	2	3	4	75%
5	Taounate	305.66	6.64	39.36	1	3	4	2	15%
6	El Kelaa	277.89	6.04	45.40	3	3	2	3	45%
7	Khemisset	256.64	5.58	50.98	1	3	3	4	75%
8	Kenitra	234.40	5.09	56.07	1	2	1	4	15%
9	Fes	175.45	3.81	59.88	1	3	3	5	100%
10	Safi	170.04	3.69	63.58	3	3	5	3	45%
11	Ben Slimane	159.85	3.47	67.05	1	3	4	5	100%
12	Khenifra	144.02	3.13	70.18	4	3	4	4	75%
13	Meknes	142.61	3.10	73.27	1	3	3	3	45%
14	Taza	141.59	3.08	76.35	1	3	3	2	15%
15	El Hajeb	106.62	2.32	78.67	1	3	2	5	100%
16	Tanger	87.91	1.91	80.58	1	3	5	1	8%
17	Oujda	80.17	1.74	82.32	5	3	2	2	15%
18	Nador	74.96	1.63	83.95	5	2	2	3	45%
19	Marrakech	72.88	1.58	85.53	3	3	5	2	15%
20	Chefchaouen	69.79	1.52	87.05	1	3	5	2	15%
21	Larache	62.32	1.35	88.40	1	2	5	1	8%
22	Khouribga	59.44	1.29	89.69	2	3			
23	Errachidia	54.19	1.18	90.87	6	1			
24	Ifrane	43.15	0.94	91.81	4	3			
25	Figuig	41.45	0.90	92.71	5	1			
26	Azilal	38.79	0.84	93.55	4	3			
27	Casablanca	37.92	0.82	94.37	1	3			
28	Taroudante	35.49	0.77	95.14	6	3			
29	Tetouan	34.11	0.74	95.89	1	3			
30	Ouarzazate	33.85	0.74	96.62	6	1			
31	Rabat	28.76	0.62	97.25	1	3			
32	Agadir	25.91	0.56	97.81	3	3			
33	Al Hoceima	25.65	0.56	98.37	5	3			
34	Essaouira	22.56	0.49	98.86	3	3			
35	Boulmane	22.43	0.49	99.34	5	3			
36	Tan-Tan	12.21	0.27	99.61	6	3			
37	Chichaoua	10.58	0.23	99.84	3	3			
38	Tiznit	5.19	0.11	99.95	6	3			
39	Tata	1.51	0.03	99.98	6	3			
40	Guelmim	0.75	0.02	100	6	3			
	Total	**4,603.1**							**53%**

As a result, the survey was carried out in 15 provinces (21 provinces according to the new classification). Most statistics that exist in the country are also based on the old classification. The last census for Morocco took place in 1996 and hence was too old to serve as our sampling frame, so looking for an alternative sampling frame was crucial. The Directorate of Strategy and Statistics (DSS) at the Ministry of Agriculture (MoA) has established a national sample of 20,000 farm households for its annual agricultural surveys on crop production. The sample was based on the "area frame" approach using the following steps:

1. In an effort to create more homogeneous groups of farms, five strata representing different farm sizes were established for the survey;
2. With high resolution maps drawn from satellite images acquired by the ministry of agriculture and other available maps, very accurate stratification of land was done. The stratification was done on topographic maps where sampling is based on a GIS application, which gives the GPS coordinates of the sample households;
3. Validation has been done using maps and actual interviews on the ground by enumerators from the DSS;
4. Data was consolidated and verified in the office;
5. Strata were identified and boundaries delineated digitally;
6. A GIS application was used to build area frames for the different strata from which samples were drawn randomly;
7. A total of 20,000 farm households were selected from the selected segments which became the master sample for the annual national agricultural surveys.

The area frame sampling technique is used for many purposes: crop areas, yields, the use of fertilizers, seeds etc. So, in the initial design, existing estimates of coefficients of variation for many variables were collected and the biggest one was used to cover all issues. The master sample that was generated now supports all studies and surveys conducted by the DSS. Consequently, the sample for cereal crops is deemed to be the best option as the sampling frame for this study.

The team of scientists from INRA and ICARDA involved in this study used power analysis to determine the minimum sample size that ensures 95% confidence and 3% precision levels for capturing improved wheat varieties adoption levels of up to 53% (the national estimate by experts). The minimum sample size required was 1061 households. Then, to account for possible absence or any unwillingness of farmers to participate in the survey, the sample was inflated upwards with an additional 15% of households increasing the final sample size to 1230. Therefore, a sample of 1230 farm households was drawn up for this study from the master sample described above, using a stratified sampling approach where provinces, districts and villages were used as strata. The total sample was distributed proportionally across 292 villages spread across 56 districts that were randomly drawn from the 21 provinces. Distribution of samples across the 21 provinces (according to the new administrative classification) selected for the survey is provided in Table 34 and 35.

In addition to the sample of 1230 wheat grower households an additional sample of 83 wheat seed growers was randomly drawn from the 1200 farm households that are members of the Moroccan Seed Growers Association (AMMS). The total area dedicated for wheat seed production in 2009 was 42 thousand ha which increased to about 65 thousand ha in 2013 (about 55% increase). The distribution of the sample of seed growers is presented in Table 36.

Table 34: Distribution of sample households for the wheat adoption study, Morocco

Region	Province	Wheat area (in 1000 ha), average for 2002-2011: Bread wheat	Wheat area: Durum wheat	Wheat area: Total	Total number of wheat growers in 2011 (in 1000)	Sample statistics: No. of districts	Sample statistics: No of villages	Number of Households: Male headed	Number of Households: Women headed	Number of Households: Total
Chaouia-Ouardigha	Benslimane	54.96	25.41	80.37	13.92	3	10	26	1	27
	Berrechid	131.96	133.9	90.39	20.70	2	13	40	3	43
	Settat			175.47	40.19	3	33	80	2	82
Doukkala-Abda	El Jadida	95.98	79.46	92.98	64.08	3	16	70	6	76
	Sidi Bennour			82.46	56.82	2	17	63	5	68
	Safi	74.74	73.59	148.33	63.25	3	19	128	2	130
Fes-Boulemane	Fes	69.79	29.72	12.94	3.64	1	1	8	0	8
	Moulay Yacoub			86.57	24.34	2	7	52	0	52
Gharb-Chrarda-Bni Hces	Kenitra	94.03	13.36	85.97	30.66	3	17	49	10	59
	Sidi Slimane			21.42	7.67	1	8	17	1	18
	Sidi Kacem	144.94	32.59	177.53	44.40	5	22	63	4	67
Marrakech-Tensift-Alhaouz	El Kelaa	155.36	67.91	73.68	20.33	2	12	36	2	38
	Rehamna			149.59	41.27	2	12	75	2	77
Meknès-Tafilalet	El Hajeb	48.95	9.88	58.83	9.02	3	7	22	0	22
	Khenifra	67.09	37.25	104.34	28.05	2	11	58	0	58
	Meknes	71.78	4.49	76.27	13.73	1	11	29	0	29
Rabat-Salé	Khemisset	127.62	29.58	157.2	32.67	4	25	61	6	67
Tadla-Azilal	Beni Mellal	153.68	37	190.68	46.06	3	7	89	1	90
Taza-Alhoceima-Taounate	Taounate	103.26	80	183.26	61.16	4	24	117	7	124
	Taza	32.83	70.34	82.54	39.24	5	14	75	0	75
	Guercif			20.63	9.81	2	6	20	0	20
Total Sample		**1,426.97**	**724.48**	**2,151.45**	**671.01**	**56**	**292**	**1178**	**52**	**1230**
Total National		**1930.07**	**979.90**	**2,909.97**	**Not available**					
Sample as % National Total				**73.9%**						

Table 35: Distribution of sample by province and farm size

Province	0 - < 1 Ha	1 - < 3 Ha	3 - < 5 Ha	5 - < 10 Ha	10 - < 20 Ha	20 - < 50 Ha	50 - < 100 Ha	> 100 Ha	TOTAL
El Jadida	8	19	16	19	9	3	1	1	76
Sidi Bennour	7	18	15	17	8	1	1	0	67
Kenitra	6	20	16	7	5	2	2	1	59
Beni Mellal	4	20	16	25	17	7	1		90
Taounate	12	44	20	22	21	3	2	0	124
Settat	3	24	17	15	12	7	3	2	82
Berrchid	3	12	9	8	6	3	2	1	43
El Kelaa	2	7	6	11	7	3	1	1	38

Province	0 - < 1 Ha	1 - < 3 Ha	3 - < 5 Ha	5 - < 10 Ha	10 - < 20 Ha	20 - < 50 Ha	50 - < 100 Ha	> 100 Ha	TOTAL
Rehamna	4	14	13	20	15	7	2	2	77
Khenifra	0	2	9	14	17	9	7	0	58
Fes	0	1	2	2	1	1	0	1	8
My Yacoub	3	9	12	16	4	4	2	2	52
Meknes	0	6	5	9	7	1	1		29
Khemisset	2	18	10	16	11	5	2	3	67
Taza	6	22	14	16	9	4	2	2	75
Guercif	2	5	3	4	2	1	2	1	20
El Hajeb	0	1	1	5	11	3	0	1	22
Safi	8	30	28	28	19	11	5	1	130
Sidi Kacem	7	11	19	15	7	4	2	2	67
Sidi Slimane	2	3	5	4	2	1	0	1	18
Ben Slimane	1	3	6	6	5	5	1	0	27
Total	79	289	241	279	195	85	39	22	1230

Table 36: Distribution of sample seed producers for the wheat adoption study, Morocco

Region	Province	No. of districts	No of villages	Number of Households		
				Male headed	Women headed	total
Chaouia-	Berrechid	2	6	30	0	30
Rabat-Salé	Khemisset	1	5	21	2	23
Tadla-Azilal	Beni Mellal	1	1	30	0	30
Total		**4**	**12**	**81**	**2**	**83**

6.5 Methodology

6.5.1 Modelling the adoption of new agricultural technologies

Previous empirical studies on the adoption and diffusion of agricultural innovations found that a wide variety of different factors affect farmers' adoption decisions (Feder et al., 1985; Foster and Rosenzweig 1996; Kohli and Singh 1998; Meinzen-Dick *et al*. 2004). Household head's gender (Overfield and Fleming 2001; Adugna 2002), literacy level and farming experience (Rahm and Huffman 1984) are important determinants of adoption. Many other variables also significantly influence farmers' adoption decisions: for example, household size (Tadesse and Kassa 2004; Smith 1997), physical and financial capital including access to credit (Putler and Zilberman 1988; Kansana, and Sharma 1996) and landholding size (Doss and Morris 2001; Daku 2002; Gabre-Madhin and Haggblade 2001). Farm income (Abebaw 1999 and Degu 2004), availability and accessibility to technologies such as seeds, and distance to input sources (Doss 2003; Nwosu 1995) also influence adoption decisions.

Schultz (1995), Doss (2003), and Wale and Yallew (2007) hypothesized that the probability of adoption of a new technology will depend on the ability of farmers to perceive the advantages and compatibility with existing socioeconomic conditions. There is general agreement that farmers' levels of knowledge on improved agricultural technologies influences their technology preference. For example, a study by Abebaw (1999) and Doss (2003) reported that adopters have better knowledge of fertilizer application than non-adopters did. Farmers' attitudes towards risk, access to information on the productivity of the technology, and yield and price stability are all-important factors (Kaguongo et al., 1997; Feder et al.1985; Kristjanson 1987). Those technologies that involve lower risk have a greater appeal to smallholders who tend to be more risk-averse (Meinzen-Dick *et al.* 2004).

Factors affecting the decision to adopt

The use of binomial and multinomial qualitative choice models in the analysis of adoption of technologies is well established in the adoption literature (Feder et al., 1985). One purpose of qualitative choice models is to determine the probability that an individual with a given set of attributes will make one choice over another (Green, 2000). The two most popular functional forms used for adoption models are the probit and the logit models. Dimara and Skuras (2003), however, acknowledging the contributions that previous adoption studies using dichotomous adoption decision models had made for the design of improved policies, contended that dichotomous adoption models have got inherent weakness. They indicated that despite the fact that most decision-making processes concerning innovation adoption involve a multistage procedure, static adoption models often consider the process as a single stage. Dimara and Skuras (2003) argued that the basic tenet of a single stage decision making process characterizing dichotomous adoption decision models is a direct consequence of the full information assumption embedded in the definition of adoption. However, the full information assumption is often violated and hence analysis of the adoption decision using logit, probit and Tobit models may suffer from model misspecification.

Over the years, a number of authors have tried to overcome these limitations in a number of ways. Byerlee and Hesse de Polanco (1986) and Leathers and Smale (1991) suggested a sequential adoption decision model. Abadi and Pannell (1999) assuming that previous adoption models did not adequately consider the dynamic learning process suggested the use of a dynamic adoption decision model, which includes farmers' personal perceptions, managerial abilities and risk preferences. Dimara and Skuras (2003), assuming that adoption of innovations involves a multistage process and drawing from literature that quite a good deal of the sample population in previous adoption studies did not have the necessary information and level of awareness concerning the new technology (violating the full information assumption), suggested a partial observability model.

In order to account for differential exposure among farmers, Diagne and Demont (2007) used the "treatment effect" framework to consistently estimate population adoption rates and their determinants for new rice varieties in Côte d'Ivoire. This study applied the two-stage regression method to correct for selectivity bias and endogeneity problem in the data, which represents an improvement compared to other impact assessment of crop technologies (e.g. Hossain et al., 2003). Accordingly, a first-stage probability of adoption estimate is derived which accounts for farmers' prior exposure to the new varieties by including a participation variable. Results are subsequently used to correct for the treatment effect in a second-stage income equation.

Given its potency in terms of correcting selectivity bias, the Heckman model (Heckman, 1979) is used here to study the determinants of adoption of improved wheat varieties in Morocco where the two-step Heckman procedure (Kumar, 1994) is used for parameter estimation. In the first step of the Heckman model, the so called selection equation is estimated where the dependent variable which is the adoption dummy (taking a value of 1 if adoption has taken place and 0 otherwise) is regressed on a number of exogenous variables such as farm size, wheat area, seed source, agro-ecological zones and the characteristics of the household head (gender, age, education, experience). Moreover, to handle the issue of non-exposure bias, proxy variables (participation on-farm trials and/or field days for the new wheat variety) that indicate whether or not the household has the minimum amount of information necessary for making adoption decisions are included in the selection equation. The selection equation takes the form:

$$Z^*_i = W_i\alpha + \varepsilon_i \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

$$Z_i = \begin{Bmatrix} 1, if\ Z_i^* > 0 \\ 0, if\ Z_i^* \leq 0 \end{Bmatrix}$$

Where:

Z_i = the observed behaviour of a household with respect to technology adoption; it takes the value of 1 if adoption is observed and 0 otherwise. In this step, the probability of (propensity to) adopt is estimated.

W_i = vector of covariates for observation *i* which include farmer and farmer characteristics such as age, sex, education and off farm employment of the household head; whether or not the farmer hosted demonstration trials and/or participated field days; farm size, wheat area, agro-ecological zone, and distance from seed sources;

α= vector of coefficients

ε_i = random disturbances

In the second step, the outcome equation is estimated where area cultivated with the improved wheat variety is regressed on the estimate of Zi from the first step estimation and some of the explanatory variables included in the selection equation. Two dummy variables included in the selection equation as explanatory variables are not included in the outcome equation because these variables may be important in deciding whether or not to adopt the variety but not so much on the decision regarding the area to be allocated for the variety. The exclusion of these variables will help the possible identification problem that might be introduced due to the non-linearity in the selection equation (Sartotri, 2003). The outcome equation takes the form:

$$Y_i = \begin{Bmatrix} X_i\beta + u_i, \text{if } \ Z_i^* > 0 \\ - \qquad\qquad , \text{if } \ Z_i^* \leq 0 \end{Bmatrix} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Where:

Y_i = the dependent variable of the outcome equation (total area under the improved wheat varieties)

X_i = vector of covariates including the Inverse Mills Ratio (IMR) derived from the first-stage equation which corrects for selectivity bias and endogeneity (Greene, 1998) and some of the covariates from the first step estimation;

β = vector of coefficients

u_i = random disturbances assumed identically and independently distributed normal with mean zero and a constant variance.

Factors affecting the speed of adoption

Duration analysis (N.M. Kiefer1988, M.A. Cleves2002) is used to analyze the time lag for the adoption of improved wheat varieties by farmers. This approach adds a dynamic element to the dichotomous choice methods by combining both individual adoption decisions and the cumulative aspect of innovation diffusion. Duration analysis (DA) is concerned with the timing of events where the event variable represents the transition from one state to another (Henry, 2012). The purpose of DA is to statistically identify those factors that have a significant effect (both positive and negative) on the length of a spell. A spell starts at the time of entry into a specific state and ends at a point when a new state is entered (Dadi, et al., 2004).

The early DA work applied in social sciences was focused on factors affecting employment periods (Lancaster, 1972). DA has been applied to choices in other fields like agriculture, considering the adoption of new production systems such as sustainable practices in one state of Brazil (De Souza, 1999), conservation tillage in Australia (D'Emden, 2006) or organic agriculture in UK (Burton, 2003).

DA studies the time (T) from when the innovation is available to the farmer until the moment he adopts the technology. Functional forms that have been tested for parametric duration models include the logistic, Weibull, exponential, lognormal, log logistic and Gompertz probability distributions. Our data follows a Weibull distribution (Karshenas and Stoneman, 1993; Abdulai, 2005). The Weibull model is suitable for modeling adoption where the hazard is duration dependent. So we model the optimal time of adoption of the improved wheat varieties using duration analysis assuming the Weibull distribution. The Weibull model estimates two ancillary parameters, ß0 and p, and assumes the form

$$\boldsymbol{h0(t) = ptp - 1exp(ß0)}$$

which collapses to the exponential model when $p = 1$. Individual covariates can be introduced in a number of ways, but the most common is to assume a proportional hazards model, where the impact of a covariate on the hazard is proportional to the baseline hazard. A proportional hazards model with a constant baseline hazard was specified in this study. So the relationship between the hazard rate $h(t)$ and explanatory variables Xt can be defined as

$$\boldsymbol{h(t) = h0exp(\beta' xt) = exp(ß0)exp(\beta' xt)}$$

The length of time farmers waited before adopting the wheat-improved variety is used as the dependent variable in the analysis. Duration is measured by the number of years that have elapsed since the improved wheat variety was first introduced in Morocco. Four major varieties have been used here, two bread and two durum. A number of variables that describe the farm and farmer characteristics are included as explanatory variables for the variation in the duration of adoption for the four varieties.

6.5.2 Measuring the impact of improved wheat varieties

Generally, impact studies face three interrelated challenges. The first and major challenge is one of establishing a viable counterfactual to predict outcome in the absence of the intervention. Second, it is often difficult to attribute the impact to an intervention; and the third challenge relates to coping with long and unpredictable lag times. Other issues that may cause confounding errors include endogeneity in program placement, selection bias, and other changes that take place simultaneously with the treatment.

Common methods used for impact evaluation include experimental approaches, longitudinal comparisons (before and after), cross-sectional comparisons (participants versus nonparticipants), and quasi-experimental methods including propensity score matching (PSM), the Endogenous Switching Regression (ESR) and the instrumental variables (IV) approaches. The only method that completely removes biases is the experimental approach, which constructs an estimate of the counterfactual situation by randomly assigning households to participants and nonparticipant groups. Random assignment ensures that both groups are statistically similar (i.e., drawn from the same distribution) in both observable and unobservable characteristics, thus avoiding program placement and self-selection biases. However, such an approach is often not feasible mainly for two reasons: 1) it requires planning where treatment and non-treatment groups need to be randomly adopted and hence baseline and post intervention data need to be collected – a case which is often impossible; 2) random assignment of treatments is difficult for demand-driven treatments such as agricultural technologies where farmers make their own decisions of whether or not to adopt (i.e., participation becomes a choice variable thereby introducing the endogeneity problem). As a result, very few studies use an experimental design, and some studies that have used control groups have run into design problems (Smale et al., 2008).

Given that the data for this study comes from a one shot cross sectional data, the experimental design approach is not feasible. Hence, the quasi-experimental approaches become the second best option. Among the quasi-experimental approaches, ESR and IV are potent in reducing biases introduced by both observable and unobservable factors. IV is often preferred to ESR but the challenge of finding a good instrument, especially when it is not planned for during program design makes it less popular. PSM does not require baseline data. Moreover, it is the second-best alternative to experimental design in minimizing selection biases from observable factors when the treatment assignment is not random (Baker, 2000). Therefore, the ESR along with PSM are used in this study. The rationale behind using the two methods is that by taking the difference between the impact estimates generated by both methods, we can see if unobservable factors are important in determining the final impact. If indeed non-observable factors are important, further studies will be needed to identify what these factors are and target them to enhance impact.

Propensity score matching

The main advantage (and drawback) of PSM relies on the degree to which observed characteristics drive program participation. If selection bias from unobserved characteristics is likely to be negligible, then PSM may provide a good comparison with randomized estimates (Khandker et al., 2010). Another advantage of PSM is that it does not necessarily require a baseline or panel survey, although in the resulting cross-section, the observed covariates entering the logit model for the propensity score would have to satisfy the conditional independence assumption (CIA). CIA states that if the observable differences in characteristics between the treated and untreated groups are controlled for, then the outcome that would result in the absence of the treatment is the same for both groups (Bryson et al, 2002). This assumption allows the counterfactual outcome for the treatment group to be inferred, and therefore for any differences between the treated and non-treated to be attributed to the effect of the program.

The propensity score matching method (Becker and Ichino, 2002) provides a more refined method of comparing the performance of participant and non-participant farmers by accounting for their inherent differences. The basic concept is to compare non-participant farmers who are similar to participant farmers in all relevant characteristics except for example the adoption of improved wheat varieties. The differences in the outcomes of participant farmers and the selected non-participant farmers can then be attributed to the adoption of the improved wheat varieties.
The use of PSM to minimize selectivity bias thus suggests that these differences are the result of adoption of the improved wheat varieties rather than the intrinsic characteristics of the sampled households. However, like the simple mean comparison, PSM may misinterpret the treatment effect, because it only controls for observed variables, and hidden self-selectivity bias may remain.

The propensity score is the probability of an individual adopting the technology given his observed covariates X. It is obtained from the fitted simple logistic regression model by substituting the values of the covariates (Rosenbaum and Rubin 1985). In this study, the logistic model is estimated to identify the factors influencing adoption of improved wheat varieties as follows:

$$Prob\ (Adoption\ = 1)\ =\ 1/(1 + e^{-z}) \qquad (1)$$

where $Z = \beta_0\ +\ \sum_{i=1}^{n} \beta_i\ X_i +\ \varepsilon_j$ (2)

Adoption is a dichotomous dependent variable taking a value of 1 if improved wheat variety adoption takes place and 0 otherwise; Xi is the vector of variables included in the model; βi are parameters to be estimated; ε_j is the error term of the model; and e is the base of natural logarithms.

The main purpose of the propensity score estimation is to balance the observed distribution of covariates across the groups of adopters and non-adopters (Lee, 2013). Since we do not condition on all covariates but on the propensity score, a balancing test is normally required after matching to ascertain whether the differences in the covariates in the two groups in the matched sample have been eliminated, in which case, the matched comparison group can be considered a plausible counterfactual (Abdulai, 2010). Although several versions of balancing tests exist in the literature, we use the mean absolute standardized bias (MASB) between adopters and non-adopters suggested by Rosenbaum and Rubin (1985). They recommend that a standardized difference of greater than 20% should be considered too large and an indicator that the matching process has failed

The main problem with using the MASB approach is that there is no clear criterion for testing the success of PSM. However, in empirical studies, it is often assumed that MASB below 3% or 5% after matching is acceptable (Caliendo and Kopeinig, 2008). Rosenbaum and Rubin (1985) argue that, after matching, total bias in excess of 20% should be considered as large. Following Sianesi (2004), we also make comparison of the pseudo R2 and p-values of the likelihood ratio test of the joint significance of all the regressors obtained from the logistic regression before and after matching the samples. After matching, there should be no systematic differences in the distribution of covariates between the two groups. As a result, the pseudo-R2 should be lower and the joint significance of covariates should be rejected (or the p-values of the likelihood ratio should be insignificant).

Endogenous switching regression

The difference in the outcomes of interest between adopters and non-adopters may not only be due to observable heterogeneity but also due to unobserved heterogeneity. Therefore, we use an endogenous switching regression (ESR) to account for both observable and unobservable endogeneity of the adoption decision by simultaneously estimating the adoption function (equation 1) and the outcome equation of interest for each group. Following Di Falco et al (2011) and Shiferaw et al. (2014) the ESR can be estimated as follows:

$$y_1 = X_1\omega_1 + \epsilon_1 \; if \; D = 1 \quad (2)$$

$$y_0 = X_0\omega_0 + \epsilon_0 \; if \; D = 0 \quad (3)$$

where y_i is a vector of dependent variables representing outcomes for adopters (y_1) and non-adopters (y_0), X_i is a matrix of explanatory variables, ω_i is a vector of parameters to be estimated, and ϵ_1, and ϵ_0 are error terms. The error terms from the three equations ε, ϵ_1, and ϵ_0 are assumed to have a trivariate normal distribution with mean vector zero and the following covariance matrix:

$$cov(\varepsilon, \epsilon_{1,}\epsilon_0) = \begin{bmatrix} \sigma_{\epsilon 0}^2 & \sigma_{\epsilon 1 \epsilon 0} & \sigma_{\epsilon 0 \varepsilon} \\ \sigma_{\epsilon 1 \epsilon 0} & \sigma_{\epsilon 1}^2 & \sigma_{\epsilon 1 \varepsilon} \\ \sigma_{\epsilon 0 \varepsilon} & \sigma_{\epsilon 1 \varepsilon} & \sigma_{\varepsilon}^2 \end{bmatrix} \quad (4)$$

where σ_{ε}^2 is the variance of the selection equation (equation 1), $\sigma_{\epsilon 0}^2$ and $\sigma_{\epsilon 1}^2$are the variances of the outcome equations for non-adopters and adopters while $\sigma_{\epsilon 0 \varepsilon}$ and $\sigma_{\epsilon 1 \varepsilon}$ represent the covariance between , ϵ_1, and ϵ_0. If ε is correlated with ϵ_1, and ϵ_0, the expected values of ϵ_1, and ϵ_0 conditional on the sample selection are non-zero:

$$E(\epsilon_1|D \; = 1) = \sigma_{\epsilon 1 \varepsilon}\frac{\phi(Z_i\omega_i)}{\Phi(Z_i\omega_i)} = \sigma_{\epsilon 1 \varepsilon}\lambda_1 \quad (5)$$

$$E(\epsilon_0|D\ = 0) = \sigma_{\epsilon 0 \varepsilon} \frac{-\phi(Z_i \omega_i)}{1-\Phi(Z_i \omega_i)} = \sigma_{\epsilon 0 \varepsilon} \lambda_0 \quad (6)$$

where ϕ and ϕ are the probability density and the cumulative distribution function of the standard normal distribution, respectively. If $\sigma_{\epsilon 1 \varepsilon}$ and $\sigma_{\epsilon 0 \varepsilon}$ are statistically significant, this would indicate that the decision to adopt and the outcome variable of interest are correlated, suggesting evidence of sample selection bias. Therefore, estimating the outcome equations using ordinary least square (OLS) would lead to biased and inconsistent results and Heckman procedures (Heckman, 1979) are normally used. In the face of heteroscedastic error terms, the full information maximum likelihood (FILM) estimator can be used to fit an endogenous switching regression that simultaneously estimates the selection and outcome equations to yield consistent estimates. The ESR can be used to compare the actual expected outcomes of adopters (7) and non-adopters (8), and to investigate the counterfactual hypothetical cases that the non-adopters did adopt (9) and the adopters did not adopt (10) as follows:

$$E(y_1|D\ = 1) = X_1 \omega_1 + \sigma_{\epsilon 1 \varepsilon} \lambda_1 \quad (7)$$

$$E(y_0|D\ = 0) = X_0 \omega_0 + \sigma_{\epsilon 0 \varepsilon} \lambda_0 \quad (8)$$

$$E(y_0|D\ = 1) = X_1 \omega_0 + \sigma_{\epsilon 0 \varepsilon} \lambda_1 \quad (9)$$

$$E(y_1|D\ = 0) = X_0 \omega_1 + \sigma_{\epsilon 1 \varepsilon} \lambda_0. \quad (10)$$

Finally, we calculate the average treatment effect on the treated (ATT) as the difference between (7) and (10) and the average treatment effect on the non-adopters (ATU) as the difference between (9) and (8). We also compute the effect of base heterogeneity for the group of adopters (BH_1) as the difference between (7) and (9), and for the group of non-adopters (BH_2) as the difference between (10) and (8).

A number of factors such as varieties used and the amounts of fertilizers, seed, labor and tillage are important in determining yield which in turn will affect income and consumption. Moreover, whether farmers participated only by hosting demonstration trials, only by attending field days or both can have effects on farmers' adoption decision for they are included in the estimation of both the PSM and ESR (Table 37). A check on the Variance Inflation Factor (VIF) showed that the data is free from multicollinearity with VIF values which are much less than the VIF threshold of 10 (Leahly, 2001). For creating a more homogenous dataset, logarithmic transformation of all the continuous variables (such as income, consumption, farmer age, years of education, distance to the nearest seed market, farm size, wheat area, value of assets, and all quantities of inputs) included in the ESR regression have been made. The Stata software (Stata, 2009) was used for all econometric estimation in this study.

Table 37: Characteristics of household heads

Variable	Minimum	Average	Maximum
Percentage of respondents which are household heads		98.1%	
Percentage of female household heads		4.2%	

Variable	Minimum	Average	Maximum
Percentage of married household heads		95.7%	
Percentage of household heads for which agriculture is the main source of employment		86.6%	
Household head is member of one or more cooperatives		9.6%	
Percentage of household heads who are community leaders		1%	
Age of household head (years)	22	59.4	100
Number of years the respondent has been living in this village	5	55.2	100
Education of household head (years)	0	2.6	14
Percentage of household heads which are illiterate		52%	
Percentage of household heads that have primary school or Koranic education		33.3%	
Percentage of household heads that have secondary school education		11.4%	
Percentage of household heads with university education		3.3%	

6.6 Results

6.6.1 Characterization of the sample wheat grain and wheat seed producing households

The majority of the respondents were the heads of households. They were relatively old, married men with low levels (on average 2.6 years) of education. More than half (52%) of the household heads were illiterate with another 33% having no more than either primary or Koranic education.

The average family size in the surveyed farm households was 7.04 out of which 54% were male and 46% female. The typical Moroccan farm household is composed of family members in a wide range of age distribution where the majority (about 61%) are in the productive age range of 15-65 years of age. Under 15 years old children account for about 31% showing that the population is growing older relative to the past where the young population constituted over 50% (Table 38).

Table 38: Household demographics

Age group	Minimum	Mean	Maximum
Total	**0**	**7.1**	**32**
<7 years old	0	0.8	16

Age group	Minimum	Mean	Maximum
8-15 years old	0	1.3	13
15 – 65 years old	0	4.3	19
> 65 years old	0	0.6	9
Total Male	**0**	**3.81**	**22**
male <7 years old	0	0.46	11
male 8-15 years old	0	0.71	9
male 15 – 65 years old	0	2.31	11
male > 65 years old	0	0.32	5
Total female	**0**	**3.25**	**16**
Female <7 years old	0	0.41	13
Female 8-15 years old	0	0.59	6
Female 15 – 65 years old	0	2.00	10
Female > 65 years old	0	0.25	6

Agriculture is the main source of employment. The majority (83%) of the farm households in the surveyed area derive their income mainly from agriculture. For the typical sample farm household, agriculture constitutes 74.4% of total family income. For some households in the survey, the contribution of agriculture to family income goes up to as high as 100% while for few others, it goes as low as only 5% (Table 39).

Table 39: Share of agriculture in family income

	Minimum	Mean	Maximum
Percentage of households for which agriculture is main source of income		82.7	
Share of agriculture in total family income	5	74.42	100
Number of rooms in the house	1	4.71	18

In terms of family labor contribution to agriculture, only 68% of the family members who are in the productive age range of 15-65 years are involved in own farm activities, spending on average 78% of their time on their own farm activities. The majority (69%) of family farm labor contribution comes from male members (Table 40).

Table 40: Family labor in agriculture

	Minimum	Mean	Maximum
Total number of family members working on family farm	0	2.96	16
Number of male family members working on family farm	0	2.04	10
Number of female family members working on family farm	0	0.92	8
Percentage of time spent on agriculture by family members working on own farm	5	77.96	100

The average farm size among the sample households is 12.49 ha out of which 85% is cropped under rainfed conditions. This figure did not change much over the last 10 years. The typical farm household owns about 10.77ha (86.2% the total land it operates) while the rest is either leased or sharecropped (Table 41). The total land holding by male-headed and female-headed households respectively are 12.35ha and 14.98 ha and the corresponding figures for wheat area are 5.86 and 5.93.

Table 41: Land holding and land tenure

	20011-12			10 years a go		
	Minimum	**Mean**	**Maximum**	**Minimum**	**Mean**	**Maximum**
Total cropped area	0.2	12.49	600	0.2	12.6	600
Irrigated area	0	1.9	400	0	1.7	400
Owned area	0.1	10.77	595	0.1	10.5	400
Rented in area	0	0.5	595	0	0.27	320
given for rent	0	0.6	100	0	0.59	100
Sharecropped out	0	0.1	70	0	0.12	70
Sharecropped in	0	0.3	22	0	0.23	25

The majority of sample farmers (92%) reported that for their household, cereals rank 1st in terms of their area coverage, while 2% farm households ranked legumes at the 1st level of importance – showing the absence or low level of practice of crop rotation. Particularly, bread wheat is ranked top in importance by 54% of the sample households followed by durum wheat and barley (24% and 13% respectively). Disregarding the species, wheat is ranked as the single most important crop by 78% of the farmers (Table 42).

Table 42: Importance of crops in farmers crop portfolio

	Rank of importance (in terms of area coverage)					Total
Crop type	**1**	**2**	**3**	**4**	**5 or more**	
Bread wheat	54%	28%	7%	2%	9%	100%
Durum wheat	24%	31%	14%	4%	28%	100%
Barley	13%	15%	32%	10%	31%	100%
Faba bean	0%	7%	15%	19%	41%	100%
lentils	0%	1%	1%	5%	93%	100%
maize	1%	4%	6%	5%	84%	100%
Pea	2%	0%	2%	5%	91%	100%
Chickpea	0%	2%	2%	2%	94%	100%

Our results show that there is very low machinery ownership with only 21% of sample farm households owning tractors and only 5% owning combine harvesters. However, the ratio of machinery to operated land seems to be high with one tractor for every 50 ha of land and 1 combine harvester for every 208 ha of land (Table 39). Other sources reported a national average of 158 ha per tractor and 1120 ha for every combine harvester (FAO, 2011). Livestock production is also an important activity in the survey areas with the typical farm household owning about 5 cattle, 26 small ruminants and 1.5 equines (Table 43).

Table 43: Asset ownership

Asset/Indicator	Minimu m	Mean	Maximum
Number of rooms in the house	1	4.71	18
Estimated value of the house (MAD)	2,000	144,544	3,000,000
Number of tractors owned	0	0.25	6
Number of combine harvesters owned	0	0.06	2
Number of water pumps owned	0	0.25	5
Number of cars/picks-ups owned	0	0.18	3
Number of trucks owned	0	0.03	2
Number of cattle (oxen and cows) owned	0	5.28	300
Number of small ruminants (sheep, goats) owned	0	26.08	665
Number of equines (mules, donkeys, horses) owned	0	1.48	20

6.6.2 Adoption of improved wheat varieties

Using our survey of 1230 farm households distributed across 21 provinces, we found that there are 40 wheat varieties in farmers' hands (Annex I). 19 of the varieties have been identified to be bread wheat and another 15 to be durum wheat while the remaining 6 were not identified. Out of the 34 identified varieties, 10 are more than 20 years of age, 15 are between 11 and 20 years and 9 are 10 or less years old. Out of the 40 varieties, the names of the institutions that released 33 of them have been identified while that of the remaining 7 were not. Information on the pedigree, selection history and institutional origin of the varieties are scanty. We have documented in Annex I as much information as we were able to collect from different sources including the national database, the Wheat Atlas database and INRA and ICARDA scientists. Out of 27 varieties from which the breeding programs were identified, 18 come from an INRA breeding program. Out of the 18 varieties that were released through the INRA breeding program, 1 contains INRA material, 11 contain CIMMYT material, 1 contains ICARDA material, and 5 contain material from the joint ICARDA/CIMMYT program, showing that 94% of the varieties released by INRA are the fruit of the strong collaboration between INRA and the CGIAR.

Adoption rates (percentage of farmers cultivating improved varieties)

Adoption rate by variety

Out of the 40 wheat varieties that were found in farmers' hands, the top 10 varieties are being cultivated by more than 91% of wheat growers. Among the top 10 varieties, four are at least 24 years old. The top four varieties cover 56% of the total wheat area. This shows that old varieties still dominate the Moroccan wheat fields. It is worth noting here that the top two varieties in terms of number of growers are Karim and Achtar which are being cultivated by 38.1% of the Moroccan farmers (Table 44).

Table 44: Adoption rate (% of growers) by variety

Adoption Rank	Variety Name	Number of communities in which variety was found	Adoption Rate (% of farmers)	Cumulative adoption rate (%)
1	Karim	60	19.21	19.21
2	Achtar	58	18.9	38.11
3	Merchouch	52	14.07	52.18
4	Marzak	55	11.37	63.55
5	Amal	43	9.84	73.39
6	Radia	43	6.32	79.71
7	Arrehane	31	3.61	83.32
8	Saidi	27	3.14	86.46
9	Wissam	16	2.48	88.94
10	Crioca	30	2.4	91.34
11	Salama	21	1.74	93.08
12	Bread wheat (local)	10	1.44	94.52
13	Rajae	7	0.7	95.22
14	Baida	3	0.61	95.83
15	Viton	7	0.57	96.40
16	Nassim	7	0.52	96.92
17	Beldi	8	0.48	97.40
18	Aguilal	5	0.39	97.79
19	Tigre	6	0.35	98.14
19	Cocorit	5	0.35	98.49
21	Durum wheat (local)	3	0.17	98.66
22	El Wafia	2	0.13	98.79
22	Manal	1	0.13	98.92
22	Anouar	2	0.13	99.05
25	Oum Rabia	1	0.09	99.14
25	Kanz	2	0.09	99.23
25	Mehdia	1	0.09	99.32
25	Massira	2	0.09	99.41
25	Irride	2	0.09	99.50
25	Mazrouba	2	0.09	99.59
31	Prosse Pero	1	0.04	99.63
31	Amjad	1	0.04	99.67
31	Faiza	1	0.04	99.71
31	El Manar	1	0.04	99.75
31	Tomouh	1	0.04	99.79
31	Vitrico	1	0.04	99.83
31	Ouissane	1	0.04	99.87
31	Ourgh	1	0.04	99.91
31	Krifla Kahla	1	0.04	99.95
31	Jouda	1	0.04	99.99
	TOTAL	**522**	**99.99**	

The 17 varieties that are identified to have come out of the collaborative work between the INRA and CGIAR breeding programs over the last four decades are being cultivated by 81.8% of the wheat growers in the country – showing that the joint INRA/CGIAR varieties are still the favorite varieties among Moroccan farmers. When this is disaggregated by year of release of the varieties none of the INRA/CGIAR varieties released in the last 10 years is found in farmers' hands. And varieties which are between 10 and 20 years old are being cultivated by only 15% of the farmers. This shows that the INRA/CGIAR varieties released more than 20 years ago are still dominant in the Moroccan farmers' portfolios.

Adoption rate by province

Adoption rate for newly released varieties is the highest in Berrechid with 72.1% of farmers cultivating varieties of 10 years and less, followed by Safi, Khemisset and Settat which have adoption rates of 40.3%, 37.8% and 31.7% respectively. In contrast Khenifra province is dominated by very old varieties. 98.3% of growers there are cultivating varieties which are more than 20 years old. Other provinces where old varieties dominate include Beni Mellal, Rehamna and El Kelaa where 95.6%, 76.6% and 76.3% of the farmers respectively are growing 20 years or older varieties (Table 45). The adoption rates disaggregated by gender show that 64% of women-headed households and 31% of men-headed households are adopters of improved wheat varieties less than 20 years old.

Adoption rate by agro-ecological zones

Among the four major wheat growing agro-ecological zones in Morocco, the unfavorable south is surprisingly leading the rest of the agro ecologies in terms of percentage of farmers cultivating more recent varieties. For example, 33.1% of the wheat growers in the unfavorable south are cultivating varieties which are 10 years old or less while the corresponding figure for the intermediate, favorable and mountainous zones are 20.4%, 8.6% and 1% respectively. The whole picture changes when the cut off point for the varietal age is increased to 20 years. Almost 50% of the farmers in the favorable zone grow varieties which are less than 20 years old. The corresponding figures for the unfavorable south, the intermediate and mountainous regions are 46.5%, 45.9% and 3.4% respectively (Table 46).

Adoption rate – National level

The national adoption rates for more recent varieties generally stand at very low levels. Less than 1% of Moroccan wheat growers cultivate varieties released five or less years ago. The corresponding figure for varieties released up to 10 years ago stands at 16% which is still very low. Very old varieties still dominate the Moroccan farmers' portfolios, where more than 58% of the growers are still cultivating varieties released more than 20 years ago (Table 47).

Table 45: Percentage of farmers planting wheat varieties of different release dates – by province

Year	Beni Mellal	Benslimane	Berrechid	El Hajeb	El Jadida	El Kelaa	Fes	Guercif	Kenitra	Khemisset	Khenifra	Meknes	My Yacoub	Rehamna	Safi	Settat	Sidi Bennour	Sidi Kacem	Sidi Slimane	Taounate	Taza
1921	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1982	90.0	100.0	100.0	100.0	98.7	100.0	100.0	100.0	100.0	100.0	89.7	100.0	100.0	100.0	97.3	100.0	98.5	100.0	100.0	100.0	100.0
1984	87.8	100.0	100.0	100.0	98.7	100.0	100.0	100.0	100.0	100.0	87.9	100.0	100.0	100.0	97.3	100.0	98.5	100.0	100.0	100.0	100.0
1985	75.6	90.9	93.0	77.3	90.7	84.2	62.5	72.2	85.2	94.6	58.6	96.6	92.3	84.4	71.8	63.4	80.6	93.8	100.0	83.2	70.0
1988	40.0	86.4	90.7	68.2	85.3	73.7	37.5	44.4	82.0	89.2	58.6	89.7	69.2	67.5	62.4	53.7	73.1	90.8	100.0	60.4	48.6
1991	4.4	40.9	86.0	40.9	36.0	23.7	37.5	27.8	36.1	73.0	15.5	79.3	65.4	23.4	51.7	47.6	41.8	64.6	72.2	42.3	45.7
1993	4.4	40.9	**86.0**	40.9	36.0	23.7	37.5	27.8	36.1	**73.0**	1.7	**79.3**	65.4	23.4	51.7	47.6	41.8	64.6	**72.2**	42.3	45.7
1994	1.1	40.9	79.1	27.3	32.0	23.7	25.0	22.2	4.9	73.0	1.7	27.6	21.2	19.5	45.0	43.9	25.4	13.8	16.7	22.8	44.3
1995	1.1	40.9	79.1	27.3	32.0	7.9	25.0	0.0	4.9	73.0	1.7	27.6	19.2	10.4	44.3	43.9	25.4	13.8	16.7	22.8	2.9
1996	1.1	40.9	79.1	22.7	32.0	7.9	0.0	0.0	4.9	73.0	1.7	24.1	7.7	10.4	44.3	43.9	25.4	13.8	16.7	11.4	2.9
1997	1.1	4.5	72.1	9.1	10.7	7.9	0.0	0.0	1.6	37.8	0.0	13.8	7.7	7.8	40.3	31.7	22.4	12.3	11.1	8.1	0.0
2003	1.1	4.5	**72.1**	9.1	10.7	7.9	0.0	0.0	1.6	**37.8**	0.0	10.3	7.7	7.8	**40.3**	**31.7**	22.4	12.3	11.1	8.1	0.0
2004	1.1	4.5	72.1	9.1	10.7	7.9	0.0	0.0	1.6	37.8	0.0	10.3	7.7	7.8	40.3	31.7	22.4	12.3	11.1	7.4	0.0
2005	0.0	4.5	67.4	9.1	4.0	5.3	0.0	0.0	1.6	32.4	0.0	6.9	7.7	6.5	34.2	25.6	17.9	12.3	11.1	6.0	0.0
2006	0.0	0.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.7	0.0
2007	0.0	0.0	**7.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**1.2**	0.0	0.0	0.0	0.0	0.0
2010	0.0	0.0	4.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0
2011	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2012	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 46: Percentage of farmers in each agro-ecological zone that have adopted varieties released in different years

	Favorable	**Intermediate**	**Unfavorable south**	**Mountain**
1921	100.0	100.0	100.0	100.0
1982	100.0	99.4	98.5	89.9
1984	100.0	99.4	98.5	87.8
1985	84.6	87.6	71.0	68.9
1988	71.1	76.4	61.3	47.3
1991	49.7	45.9	46.5	8.8
1993	49.7	45.9	46.5	3.4
1994	27.3	32.2	41.6	1.4
1995	20.6	29.6	39.0	1.4
1996	16.4	27.7	39.0	1.4
1997	8.8	20.4	33.1	0.7
2003	8.6	20.4	33.1	0.7
2004	8.4	20.4	33.1	0.7
2005	7.4	16.9	27.5	0.0
2006	0.2	1.0	0.4	0.0
2007	0.00	0.96	0.37	0.00
2010	0.00	0.64	0.37	0.00
2011	0.00	0.00	0.00	0.00
2012	0.00	0.00	0.00	0.00
% share in Total number of growers in the 4 agro ecological zones	40.27	26.37	21.65	11.71

Table 47: Percentage of farmers planting wheat varieties of different release dates – national figures

(adoption rates are generated by using number of growers in each province as weights)

Year	Beni Mellal	Benslimane	Berrechid	El Hajeb	El Jadida	El Kelaa	Fes	Guercif	Kenitra	Khemisset	Khenifra	Meknes	My Yacoub	Rehamna	Safi	Settat	Sidi Bennour	Sidi Kacem	Sidi Slimane	Taounate	Taza	Total	Cumulative
1921	0.73	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.31	0.00	0.09	0.00	0.00	0.00	0.00	1.7	100
1982	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.2	98
1984	0.89	0.16	0.23	0.32	0.54	0.51	0.22	0.41	0.92	0.15	1.30	0.07	0.30	1.02	2.92	2.31	1.08	0.33	0.00	1.95	1.72	17.4	98
1985	2.59	0.08	0.08	0.13	0.36	0.34	0.15	0.41	0.21	0.15	0.00	0.15	0.89	1.10	1.08	0.62	0.45	0.17	0.00	2.65	1.23	12.8	81
1988	2.59	0.82	0.15	0.39	3.34	1.61	0.00	0.25	2.88	0.46	1.91	0.22	0.15	2.88	1.23	0.39	1.90	1.40	0.41	2.11	0.16	25.3	68
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.6	43
1993	0.24	0.00	0.23	0.19	0.27	0.00	0.07	0.08	1.95	0.00	0.00	1.12	1.70	0.25	0.77	0.23	0.99	2.73	0.83	2.26	0.08	14.0	42
1994	0.00	0.00	0.00	0.00	0.00	0.51	0.00	0.33	0.00	0.00	0.00	0.00	0.07	0.59	0.08	0.00	0.00	0.00	0.00	0.00	2.37	3.9	28
1995	0.00	0.00	0.00	0.06	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.07	0.44	0.00	0.00	0.00	0.00	0.00	0.00	1.33	0.00	2.1	24
1996	0.00	0.65	0.23	0.19	1.44	0.00	0.00	0.00	0.21	1.00	0.08	0.22	0.00	0.17	0.46	0.77	0.18	0.08	0.08	0.39	0.16	6.3	22
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	16
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.1	16
2004	0.08	0.00	0.15	0.00	0.45	0.08	0.00	0.00	0.00	0.15	0.00	0.07	0.00	0.08	0.69	0.39	0.27	0.00	0.00	0.16	0.00	2.6	16
2005	0.00	0.08	2.00	0.13	0.27	0.17	0.00	0.00	0.10	0.93	0.00	0.15	0.30	0.42	3.93	1.54	1.08	0.66	0.17	0.62	0.00	12.6	13
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.1	0.39
2007	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.31
2010	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.2	0.23
2011	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00
2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00
% share in Total number of growers in the 21 provinces	7.29	1.79	3.31	1.43	6.77	3.22	0.59	1.47	6.27	2.85	4.44	2.17	3.84	6.53	11.47	6.32	6.05	5.37	1.49	11.63	5.72	100.0	

Adoption rate – By wheat species

Provincial adoption levels for bread wheat varieties generally follow similar patterns with the provincial adoption levels for total wheat (regardless of species) reported in Section 5.2.1.2 above. Berrchid leads all provinces in terms of the percentage of farmers adopting recent bread wheat varieties (Table 48). 72.4% of the farmers in this province cultivate varieties 10 years old or less, followed by Settat (47.7%), Khemisset (41.2%) and Safi (36.8%). When it comes to old varieties, 97.4% of farmers in Khenifra province are still cultivating varieties over 20 years old, followed by Beni Mellal (94.5%) and El Kelaa (92.3%). At national level, the number of farmers cultivating improved bread wheat varieties of five years old or less account for under 1% of the total national number of bread wheat growers. While the figure improves slightly when the cutoff point is raised to 10 years and 20 years, more than 53% of the total national number of bread wheat growers are still cultivating varieties which are older than 20 years (Table 49).

Once again, Berrechid leads all provinces in terms of the percentage of farmers adopting recent durum wheat varieties (Table 50). 71.4% of the farmers in this province cultivate varieties up to 10 years old, followed by Safi (51.4%), Ben Slimane (33.3%) and Sidi Bennour (22%). With varieties up to 20 years old Berrechid still leads nationally with 71.4% of farmers cultivating these old durum varieties, followed by El Kelaa (58.3%), Safi (54.3%) and Meknes (33.3%).

The national figures for durum wheat show that even though they are still very low, adoption rates of improved durum wheat varieties released five years or less ago are slightly higher compared to those for bread wheat. However, when the cutoff points are raised to 10 and 20 years, durum wheat loses to bread wheat where only 11% of durum wheat farmers cultivate varieties which are up to 10 years old, while the vast majority (72%) are still cultivating varieties more than 20 years old (Table 51). These figures contrast sharply with the 90% adoption rate from the WANADDIN project survey cited by Belaid et al. (2005). One possible source of discrepancy is in the definition of improved varieties. Belaid et al. (2005) do not make any distinction among varieties based on their release date while this paper pays special attention to the year of release. In this report, a 90% adoption corresponds to all varieties which are released during the last 27 years (between 1986 and 2013). Any variety released before 1993, though improved is considered very old. Therefore, a separate category, namely “obsolete improved” varieties is established for such varieties.

Table 48: Percentage of farmers planting bread wheat varieties of different release dates – by province

Year	Beni Mellal	Benslimane	Berrechid	El Hajeb	El Jadida	El Kelaa	Fes	Guercif	Kenitra	Khemisset	Khenifra	Meknes	My Yacoub	Rehamna	Safi	Settat	Sidi Bennour	Sidi Kacem	Sidi Slimane	Taounate	Taza
1921	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1982	83.6	100.0	100.0	100.0	98.6	100.0	100.0	100.0	100.0	100.0	84.6	100.0	100.0	100.0	96.5	100.0	98.2	100.0	100.0	100.0	100.0
1984	83.6	100.0	100.0	100.0	98.6	100.0	100.0	100.0	100.0	100.0	82.1	100.0	100.0	100.0	96.5	100.0	98.2	100.0	100.0	100.0	100.0
1985	63.6	94.7	100.0	78.9	90.1	80.8	50.0	66.7	84.7	97.1	82.1	96.2	94.4	84.0	64.9	88.6	82.5	93.7	100.0	81.9	50.0
1988	63.6	94.7	100.0	78.9	90.1	80.8	50.0	66.7	84.7	97.1	82.1	96.2	94.4	84.0	64.9	88.6	82.5	93.7	100.0	81.9	50.0
1991	5.5	42.1	93.1	47.4	38.0	7.7	50.0	16.7	37.3	79.4	23.1	84.6	88.9	16.0	50.9	77.3	45.6	66.7	72.2	56.2	30.0
1993	5.5	42.1	93.1	47.4	38.0	7.7	50.0	16.7	37.3	79.4	2.6	84.6	88.9	16.0	50.9	77.3	45.6	66.7	72.2	56.2	30.0
1994	1.8	42.1	82.8	31.6	33.8	7.7	33.3	0.0	5.1	79.4	2.6	26.9	27.8	12.0	42.1	70.5	26.3	14.3	16.7	31.4	20.0
1995	1.8	42.1	82.8	31.6	33.8	7.7	33.3	0.0	5.1	79.4	2.6	26.9	27.8	12.0	42.1	70.5	26.3	14.3	16.7	31.4	20.0
1996	1.8	42.1	82.8	26.3	33.8	7.7	0.0	0.0	5.1	79.4	2.6	23.1	11.1	12.0	42.1	70.5	26.3	14.3	16.7	15.2	20.0
1997	1.8	0.0	72.4	10.5	11.3	7.7	0.0	0.0	1.7	41.2	0.0	11.5	11.1	8.0	36.8	47.7	22.8	12.7	11.1	10.5	0.0
2003	1.8	0.0	72.4	10.5	11.3	7.7	0.0	0.0	1.7	41.2	0.0	11.5	11.1	8.0	36.8	47.7	22.8	12.7	11.1	10.5	0.0
2004	1.8	0.0	72.4	10.5	11.3	7.7	0.0	0.0	1.7	41.2	0.0	11.5	11.1	8.0	36.8	47.7	22.8	12.7	11.1	9.5	0.0
2005	0.0	0.0	65.5	10.5	4.2	3.8	0.0	0.0	1.7	35.3	0.0	7.7	11.1	6.0	28.9	36.4	17.5	12.7	11.1	7.6	0.0
2006	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0	0.0	0.0	0.0
2007	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0	0.0	0.0	0.0
2010	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0	0.0	0.0	0.0
2011	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2012	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 49: Percentage of farmers planting bread wheat varieties of different release dates – national figures
(adoption rates are generated by using number of growers in each province as weights)

Year	Beni Mellal	Benslimane	Berrechid	El Hajeb	El Jadida	El Kelaa	Fes	Guercif	Kenitra	Khemisset	Khenifra	Meknes	My Yacoub	Rehamna	Safi	Settat	Sidi Bennour	Sidi Kacem	Sidi Slimane	Taounate	Taza	Total	Cumulative
1921	1.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.63	0.00	0.00	0.00	0.42	0.00	0.12	0.00	0.00	0.00	0.00	2.3	100
1982	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	98
1984	1.23	0.11	0.00	0.36	0.75	0.58	0.31	0.23	1.28	0.11	0.00	0.10	0.20	0.93	3.82	0.53	1.12	0.46	0.00	2.04	0.56	14.7	98
1985	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	83
1988	3.57	1.12	0.21	0.54	4.60	2.22	0.00	0.34	3.97	0.64	2.43	0.31	0.20	3.97	1.70	0.53	2.61	1.94	0.57	2.90	0.23	34.6	83
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.8	48
1993	0.22	0.00	0.32	0.27	0.37	0.00	0.10	0.11	2.69	0.00	0.00	1.55	2.24	0.23	1.06	0.32	1.37	3.76	1.14	2.80	0.11	18.7	47
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	29
1995	0.00	0.00	0.00	0.09	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.10	0.61	0.00	0.00	0.00	0.00	0.00	0.00	1.83	0.00	2.8	29
1996	0.00	0.90	0.32	0.27	1.99	0.00	0.00	0.00	0.28	1.38	0.11	0.31	0.00	0.23	0.64	1.06	0.25	0.11	0.11	0.54	0.23	8.7	26
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	17
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.1	17
2004	0.11	0.00	0.21	0.00	0.62	0.12	0.00	0.00	0.00	0.21	0.00	0.10	0.00	0.12	0.95	0.53	0.37	0.00	0.00	0.22	0.00	3.6	17
2005	0.00	0.00	2.02	0.18	0.37	0.12	0.00	0.00	0.14	1.28	0.00	0.21	0.41	0.35	3.50	1.59	1.24	0.91	0.23	0.86	0.00	13.4	14
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.11
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.11
2010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.1	0.11
2011	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00
2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00
% share in Total number of growers in the 21 provinces	6.14	2.14	3.08	1.70	8.83	3.04	0.61	0.68	8.36	3.62	4.11	2.68	3.66	5.84	12.10	4.67	7.09	7.18	2.05	11.30	1.13	100.0	

Table 50: Cumulative percentage farmers who are cultivating wheat varieties released in specific years or later – by province

Year	Beni Mellal	Benslimane	Berrechid	El Hajeb	El Jadida	El Kelaa	Fes	Guercif	Kenitra	Khemisset	Khenifra	Meknes	My Yacoub	Rehamna	Safi	Settat	Sidi Bennour	Sidi Kacem	Sidi Slimane	Taounate	Taza
1921	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0	100.0	100.0
1982	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0	100.0	100.0
1984	94.3	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0	100.0	100.0
1985	94.3	66.7	78.6	66.7	100.0	91.7	100.0	75.0	100.0	66.7	10.5	100.0	87.5	85.2	94.3	34.2	70.0	100.0	0.0	86.4	73.3
1988	2.9	33.3	71.4	0.0	0.0	58.3	0.0	33.3	0.0	0.0	10.5	33.3	12.5	37.0	54.3	13.2	20.0	0.0	0.0	9.1	48.3
1991	2.9	33.3	71.4	0.0	0.0	58.3	0.0	33.3	0.0	0.0	0.0	33.3	12.5	37.0	54.3	13.2	20.0	0.0	0.0	9.1	48.3
1993	2.9	33.3	71.4	0.0	0.0	58.3	0.0	33.3	0.0	0.0	0.0	33.3	12.5	37.0	54.3	13.2	20.0	0.0	0.0	9.1	48.3
1994	0.0	33.3	71.4	0.0	0.0	58.3	0.0	33.3	0.0	0.0	0.0	33.3	6.3	33.3	54.3	13.2	20.0	0.0	0.0	2.3	48.3
1995	0.0	33.3	71.4	0.0	0.0	8.3	0.0	0.0	0.0	0.0	0.0	33.3	0.0	7.4	51.4	13.2	20.0	0.0	0.0	2.3	0.0
1996	0.0	33.3	71.4	0.0	0.0	8.3	0.0	0.0	0.0	0.0	0.0	33.3	0.0	7.4	51.4	13.2	20.0	0.0	0.0	2.3	0.0
1997	0.0	33.3	71.4	0.0	0.0	8.3	0.0	0.0	0.0	0.0	0.0	33.3	0.0	7.4	51.4	13.2	20.0	0.0	0.0	2.3	0.0
2003	0.0	33.3	71.4	0.0	0.0	8.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.4	51.4	13.2	20.0	0.0	0.0	2.3	0.0
2004	0.0	33.3	71.4	0.0	0.0	8.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.4	51.4	13.2	20.0	0.0	0.0	2.3	0.0
2005	0.0	33.3	71.4	0.0	0.0	8.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.4	51.4	13.2	20.0	0.0	0.0	2.3	0.0
2006	0.0	0.0	21.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0
2007	0.0	0.0	21.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2010	0.0	0.0	14.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2011	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2012	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 51: Percentage of farmers planting durum wheat varieties of different release dates – national figures
(adoption rates are generated by using number of growers in each province as weights)

Year	Beni Mellal	Benslimane	Berrechid	El Hajeb	El Jadida	El Kelaa	Fes	Guercif	Kenitra	Khemisset	Khenifra	Meknes	My Yacoub	Rehamna	Safi	Settat	Sidi Bennour	Sidi Kacem	Sidi Slimane	Taounate	Taza	Total	Cumulative
1921	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	100
1982	0.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.6	100
1984	0.00	0.30	0.84	0.24	0.00	0.31	0.00	0.89	0.00	0.28	4.74	0.00	0.54	1.23	0.56	7.01	0.99	0.00	0.00	1.70	4.76	24.4	99
1985	9.43	0.30	0.28	0.47	1.31	1.23	0.54	1.49	0.75	0.56	0.00	0.55	3.22	4.01	3.92	2.24	1.64	0.60	0.00	9.66	4.46	46.7	75
1988	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.6	28
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	28
1993	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.31	0.00	0.00	0.00	0.00	0.00	0.85	0.00	1.7	28
1994	0.00	0.00	0.00	0.00	0.00	1.85	0.00	1.19	0.00	0.00	0.00	0.00	0.27	2.16	0.28	0.00	0.00	0.00	0.00	0.00	8.63	14.4	26
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	12
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	12
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.3	12
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	11
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	11
2005	0.00	0.30	1.96	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62	5.04	1.40	0.66	0.00	0.00	0.00	0.00	10.3	11
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.00	0.3	1
2007	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.3	1
2010	0.00	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.6	1
2011	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00
2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00
% share in Total number of growers in 21 provinces	10.32	0.89	3.93	0.71	1.31	3.70	0.54	3.57	0.75	0.84	5.29	0.82	4.30	8.33	9.81	10.66	3.29	0.60	0.00	12.50	17.85	100.0	

Adoption degree (percentage of wheat area under improved varieties)

Adoption degree by variety

The top 10 varieties out of the 40 wheat varieties found in the Moroccan farmers' hands cover more than 92% of total area. This is consistent with the adoption rate of 91% for the top 10 varieties presented in Section 5.1.1.1. Among the top 10 varieties, four are at least 24 years old and cover 56% of the total wheat area, showing that old varieties still dominate the Moroccan wheat fields. The top two varieties in terms of area are Achtar and Merchouch. The two varieties constitute over 35.2% of total national wheat area. The 17 varieties that are identified to have come out of the joint INRA/CGIAR breeding programs are being cultivated on 79.41% of the total wheat area in the country – showing that the INRA/CGIAR varieties still dominate the landscape (Table 52). Further disaggregation of the adoption degrees by year of release of the varieties shows that none of the INRA/CGIAR varieties released in the last 10 years are found on the Moroccan wheat fields. Even the varieties between 10 and 20 years old are being cultivated only on 21% of the total wheat area in the country. This shows that the INRA/CGIAR varieties released over 20 years ago still dominate, covering about 59% of the total wheat area in the country.

Adoption degree by province

With an adoption degree of 62.6% (of area) for improved wheat varieties released in the last10 years, Berrechid is leading all the provinces followed by Safi, Settat, El Hajeb and Sidi Kacem where 41.27%, 39.96%, 32.15% and 27.29% of their wheat areas are covered by varieties 10 or less years old. In contrast, Khenifra province is most dominated by very old varieties - 98.6% of its wheat fields are cultivated with varieties which are more than 20 years old. Other provinces where old varieties dominate include Beni Mellal, El Kelaa and Rehamna (Table 53).

Table 52: Adoption degree (% of area) by variety

Adoption degree rank	Variety name	Number of communities in which variety was found	Adoption degree (% of area %)	Cumulative degree of adoption (%)
1	Achtar	58	22.20	22.20
2	Merchouch	52	13.01	35.21
3	Amal	43	12.45	47.66
4	Karim	60	12.31	59.97
5	Radia	43	10.24	70.21
6	Marzak	55	8.25	78.46
7	Arrehane	31	7.09	85.55
8	Crioca	30	2.54	88.09
9	Saidi	27	2.45	90.54
10	Wissam	16	2.17	92.71
11	Salama	21	1.45	94.16
12	Bread wheat (local)	10	0.99	95.15
13	Rajae	7	0.90	96.05
14	Tigre	6	0.80	96.85
15	Nassim	7	0.64	97.49
16	Baida	3	0.44	97.93
17	Viton	7	0.37	98.30

Adoption degree rank	Variety name	Number of communities in which variety was found	Adoption degree (% of area %)	Cumulative degree of adoption (%)
18	Cocorit	5	0.26	98.56
19	El Wafia	2	0.25	98.81
20	Aguilal	5	0.14	98.95
21	Oum Rabia	1	0.13	99.08
22	Prosse Pero	1	0.11	99.19
23	Beldi	8	0.10	99.29
23	Kanz	2	0.10	99.39
25	Mehdia	1	0.08	99.47
25	Massira	2	0.08	99.55
25	Irride	2	0.08	99.63
28	Durum wheat (local)	3	0.06	99.69
28	Amjad	1	0.06	99.75
30	Manal	1	0.05	99.80
31	Mazrouba	2	0.03	99.83
31	Faiza	1	0.03	99.86
31	El Manar	1	0.03	99.89
34	Tomouh	1	0.02	99.91
34	Vitrico	1	0.02	99.93
34	Anouar	2	0.02	99.95
34	Ouissane	1	0.02	99.97
38	Ourgh	1	0.01	99.98
38	Krifla Kahla	1	0.01	99.99
40	Jouda	1	0.00	99.99
	Total	522	99.99	

Table 53: Cumulative percentage of wheat area under wheat varieties released in specific years or later – by province

Year	Beni Mellal	Benslimane	Berrechid	El Hajeb	El Jadida	El Kelaa	Fes	Guercif	Kenitra	Khemisset	Khenifra	Meknes	My Yacoub	Rehamna	Safi	Settat	Sidi Bennour	Sidi Kacem	Sidi Slimane	Taounate	Taza
1921	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1982	95.40	100.00	99.06	100.00	99.39	100.00	100.00	100.00	100.00	100.00	82.75	100.00	100.00	99.84	99.31	100.00	99.41	100.00	100.00	99.13	100.00
1984	94.19	100.00	89.66	99.36	99.39	100.00	100.00	100.00	100.00	100.00	78.81	100.00	100.00	99.67	99.25	98.35	99.41	100.00	100.00	99.13	94.83
1985	56.64	88.50	73.73	90.23	91.22	68.73	59.52	52.62	96.42	98.13	46.83	94.87	92.63	55.67	91.04	64.01	67.97	98.97	61.80	81.68	48.52
1988	22.04	79.38	67.62	86.94	76.04	51.28	45.63	31.81	95.73	89.92	43.78	86.00	73.91	42.32	81.45	50.82	50.53	93.18	49.06	62.38	27.19
1991	1.82	54.47	66.99	61.00	25.47	10.20	45.63	20.27	24.70	85.07	10.68	73.37	58.83	10.48	75.86	48.97	26.18	81.00	35.08	52.63	26.00
1993	1.82	54.47	66.99	61.00	25.47	10.20	45.63	20.27	24.70	85.07	1.41	73.37	58.83	10.48	75.86	48.97	26.18	81.00	35.08	52.63	26.00
1994	0.06	50.13	63.86	37.26	23.70	9.93	29.76	14.25	8.99	85.07	1.41	37.48	24.00	8.53	48.91	44.85	17.91	35.23	5.41	23.72	24.82
1995	0.06	50.13	63.86	37.26	23.70	7.24	25.79	0.00	8.99	85.07	1.41	37.48	23.56	3.28	43.08	44.85	17.91	35.23	5.41	23.72	1.69
1996	0.06	50.13	63.86	35.43	23.70	7.24	0.00	0.00	8.99	84.56	1.41	35.90	3.46	3.28	42.96	44.85	17.91	35.23	5.41	6.79	1.69
1997	0.06	10.85	62.60	32.15	8.80	7.24	0.00	0.00	0.21	12.79	0.00	14.99	3.46	2.93	41.27	39.96	15.66	27.29	4.14	6.01	0.00
2003	0.06	10.85	62.60	32.15	8.80	7.24	0.00	0.00	0.21	12.79	0.00	13.41	3.46	2.93	41.27	39.96	15.66	27.29	4.14	6.01	0.00
2004	0.06	10.85	62.60	32.15	8.80	7.24	0.00	0.00	0.21	12.79	0.00	13.41	3.46	2.93	41.27	39.96	15.66	27.29	4.14	5.22	0.00
2005	0.00	10.85	54.76	32.15	3.79	7.03	0.00	0.00	0.21	10.83	0.00	9.47	3.46	2.52	36.88	34.50	10.34	27.29	4.14	5.22	0.00
2006	0.00	0.00	5.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.30	0.00
2007	0.00	0.00	5.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.00	0.00
2010	0.00	0.00	2.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.00	0.00
2011	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Adoption degree (% of area) by agro-ecological zones

As is the case for the number of growers presented in Section 5.2.1.3, the unfavorable south surprisingly leads the rest of the agro ecologies in terms of percentage of wheat area covered by more recent varieties. While 28.67% of all wheat areas in the unfavorable south are planted with varieties that are 10 years old or younger, only 12.49%, 12.07% and less than 1% of wheat areas in the intermediate, favorable and mountainous zones respectively are covered with varieties aged 10 years or less. With regard to varieties with 20 years of age or less, the favorable zone becomes the leader in terms of total area covered by such varieties, followed by the unfavorable south, intermediate and mountainous zones respectively (Table 54).

Table 54: Percentage of wheat area in each agro-ecological zone that is under varieties released in different years

	Favorable	**Intermediate**	**Unfavorable south**	**Mountain**
1921	100.00	100.00	100.00	100.00
1982	99.88	99.70	99.73	89.13
1984	99.41	98.34	99.30	86.58
1985	87.46	68.98	76.45	51.78
1988	78.26	55.14	63.16	32.80
1991	56.06	29.66	45.66	6.21
1993	56.06	29.66	45.66	1.62
1994	34.64	20.88	33.86	0.73
1995	32.31	18.06	30.57	0.73
1996	29.50	14.25	30.52	0.73
1997	12.13	12.49	28.67	0.03
2003	12.07	12.49	28.67	0.03
2004	11.96	12.49	28.67	0.03
2005	11.51	10.42	25.53	0.00
2006	0.04	0.72	0.15	0.00
2007	0.00	0.72	0.15	0.00
2010	0.00	0.30	0.15	0.00
2011	0.00	0.00	0.00	0.00
2012	0.00	0.00	0.00	0.00
% share in total wheat area in the 4 agro-ecological zones	44.20	23.94	18.99	12.87

5.2.2.4 Adoption degree (% of area) – National level

Wheat production in Morocco is characterized by the dominance of old varieties. Less than 1% of the total national wheat area is covered with varieties that were released five or less years ago. While the figure improves to about 15% when the cutoff point for varietal age is increased to 10, generally varieties 20 or more years old dominate the landscape with an area-weighted average varietal replacement rate of 21.9. About 41.1% of the total national wheat area is under improved wheat varieties of 20 years old or less (Table 55).

At national level, women-headed households have adopted improved wheat varieties 20 years old or less on an average of 3.29 ha (i.e., on 55% of their wheat area), while men-headed households have adopted the improved varieties on 1.52ha (26% of their wheat area). This shows that female-headed households have adopted the improved varieties both in terms of the number of farm households and in terms of intensity of adoption. A comparison of adoption rate and adoption degree shows that the percentage of area covered by the more recent wheat varieties is higher than the percentage of farmers which are cultivating more recent varieties. These results are an indication of the fact that farmers with relatively larger wheat areas are adopting more recent varieties than those with relatively small wheat areas which is consistent with the theoretical expectation.

Table 55: Percentage of wheat area under varieties of different release dates – national figures
(adoption Degrees are generated by using wheat areas in each of the provinces as weights)

Year	Beni Mellal	Benslimane	Berrechid	El Hajeb	El Jadida	El Kelaa	Fes	Guercif	Kenitra	Khemisset	Khenifra	Meknes	My Yacoub	Rehamna	Safi	Settat	Sidi Bennour	Sidi Kacem	Sidi Slimane	Taounate	Taza	Total	Cumulative
1921	0.40	0.00	0.04	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.72	0.00	0.00	0.01	0.05	0.00	0.02	0.00	0.00	0.07	0.00	1.25	100.0
1982	0.11	0.00	0.41	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.01	0.00	0.14	0.00	0.00	0.00	0.00	0.19	0.90	98.75
1984	3.26	0.37	0.69	0.25	0.37	1.01	0.28	0.46	0.16	0.14	1.34	0.18	0.33	2.87	0.61	2.85	1.28	0.08	0.53	1.42	1.68	21.26	97.86
1985	3.01	0.29	0.27	0.09	0.69	0.56	0.10	0.20	0.03	0.61	0.13	0.32	0.84	0.87	0.72	1.10	0.71	0.46	0.18	1.57	0.77	12.31	76.60
1988	1.76	0.80	0.03	0.70	2.30	1.32	0.00	0.11	3.22	0.36	1.38	0.45	0.67	2.07	0.42	0.15	0.99	0.98	0.19	0.79	0.04	22.44	64.29
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44	41.86
1993	0.15	0.14	0.14	0.64	0.08	0.01	0.11	0.06	0.71	0.00	0.00	1.28	1.55	0.13	2.01	0.34	0.34	3.67	0.41	2.35	0.04	13.90	41.41
1994	0.00	0.00	0.00	0.00	0.00	0.09	0.03	0.14	0.00	0.00	0.00	0.00	0.02	0.34	0.43	0.00	0.00	0.00	0.00	0.00	0.84	2.45	27.52
1995	0.00	0.00	0.00	0.05	0.00	0.00	0.18	0.00	0.00	0.04	0.00	0.06	0.90	0.00	0.01	0.00	0.00	0.00	0.00	1.38	0.00	2.18	25.07
1996	0.00	1.26	0.05	0.09	0.68	0.00	0.00	0.00	0.40	5.29	0.06	0.75	0.00	0.02	0.13	0.41	0.09	0.64	0.02	0.06	0.06	8.09	22.89
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	14.79
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.05	14.77
2004	0.01	0.00	0.34	0.00	0.23	0.01	0.00	0.00	0.00	0.14	0.00	0.14	0.00	0.03	0.33	0.45	0.22	0.00	0.00	0.00	0.00	1.45	14.72
2005	0.00	0.35	2.15	0.87	0.17	0.23	0.00	0.00	0.01	0.80	0.00	0.34	0.15	0.16	2.75	2.82	0.42	2.19	0.06	0.40	0.00	13.03	13.28
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.02	0.24
2007	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.23
2010	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.11	0.11
2011	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% share in total wheat area in the 21 sample provinces	**8.69**	**3.20**	**4.36**	**2.72**	**4.54**	**3.22**	**0.69**	**0.97**	**4.53**	**7.37**	**4.18**	**3.57**	**4.46**	**6.52**	**7.46**	**8.31**	**4.06**	**8.02**	**1.38**	**8.13**	**3.63**	**100.00**	

Adoption degree (% of area) – By wheat species

With an adoption degree of 71.38%, the province of Berrechid leads all other provinces in terms of the percentage of bread wheat fields which are covered by more recent varieties 10 or less years old (Table 56). Settat, Safi and El Hajeb follow with bread wheat areas covered with varieties 10 years old or less of 58%, 43% and 34% respectively. Kinifra, Beni Mellal and Rehamna are at the bottom of the list as the bread wheat fields in these provinces are dominated by very old varieties (Table 57). Berrechid also leads all provinces in terms of the percentage of durum wheat areas cultivated with more recent varieties (Table 58). 52% of the durum wheat areas in this province are cultivated with varieties 10 years old or less followed by Ben Slimane (41%) and Settat (23%). A number of provinces (El Hajeb, El Jadida, Kenitra, Kenifra, Khemisset, Sidi Kacem and Sidi Slimane) exhibit no trace of durum varieties less than 20 years old. For a country like Morocco where a lot of investment is being made in research and where a number of potent varieties have been released, these results are rather disappointing. Understanding the root cause and hence devising mitigative measures should be a high priority if the country is to benefit from its own and the CG's investment in research, and if it is to minimize and possibly eliminate its dependence on imports.

At national level also, the adoption degree for durum wheat varieties of 20 years old or less stands at a very low level of 21%. Comparison between national degrees of adoption of durum wheat (Table 58) and bread wheat varieties (Table 57) show that a relatively higher percentage of total bread wheat areas are covered with more recent varieties than those of durum wheat (Table 59).

Table 56: Cumulative percentage of wheat area under bread wheat varieties released in specific years or later – by province

Year	Beni Mellal	Benslimane	Berrechid	El Hajeb	El Jadida	El Kelaa	Fes	Guercif	Kenitra	Khemisset	Khenifra	Meknes	My Yacoub	Rehamna	Safi	Settat	Sidi Bennour	Sidi Kacem	Sidi Slimane	Taounate	Taza
1921	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1982	91.45	100.00	98.28	100.00	99.25	100.00	100.00	100.00	100.00	100.00	72.08	100.00	100.00	99.78	99.01	100.00	99.05	100.00	100.00	98.87	100.00
1984	91.45	100.00	81.11	99.33	99.25	100.00	100.00	100.00	100.00	100.00	66.48	100.00	100.00	99.56	99.01	96.59	99.05	100.00	100.00	98.87	100.00
1985	39.36	93.49	80.54	90.93	93.56	70.63	50.72	35.53	96.54	98.14	66.48	94.27	94.04	49.68	92.04	79.64	79.47	99.05	56.22	79.47	18.29
1988	39.36	93.49	80.54	90.93	93.56	70.63	50.72	35.53	96.54	98.14	66.48	94.27	94.04	49.68	92.04	79.64	79.47	99.05	56.22	79.47	18.29
1991	1.82	59.50	79.39	63.80	31.34	10.75	50.72	12.18	24.90	92.85	17.28	80.18	73.32	6.34	84.04	75.80	40.49	86.10	40.20	66.76	12.96
1993	1.82	59.50	79.39	63.80	31.34	10.75	50.72	12.18	24.90	92.85	2.28	80.18	73.32	6.34	84.04	75.80	40.49	86.10	40.20	66.76	12.96
1994	0.11	53.58	73.67	38.97	29.16	10.35	31.40	0.00	9.07	92.85	2.28	40.09	32.37	3.80	45.50	68.12	27.25	37.45	6.20	30.55	7.62
1995	0.11	53.58	73.67	38.97	29.16	10.35	31.40	0.00	9.07	92.85	2.28	40.09	32.37	3.80	45.50	68.12	27.25	37.45	6.20	30.55	7.62
1996	0.11	53.58	73.67	37.06	29.16	10.35	0.00	0.00	9.07	92.29	2.28	38.33	4.75	3.80	45.50	68.12	27.25	37.45	6.20	8.47	7.62
1997	0.11	0.00	71.38	33.62	10.83	10.35	0.00	0.00	0.21	13.96	0.00	14.98	4.75	3.32	43.08	58.00	23.65	29.01	4.74	7.45	0.00
2003	0.11	0.00	71.38	33.62	10.83	10.35	0.00	0.00	0.21	13.96	0.00	14.98	4.75	3.32	43.08	58.00	23.65	29.01	4.74	7.45	0.00
2004	0.11	0.00	71.38	33.62	10.83	10.35	0.00	0.00	0.21	13.96	0.00	14.98	4.75	3.32	43.08	58.00	23.65	29.01	4.74	6.42	0.00
2005	0.00	0.00	57.07	33.62	4.67	10.05	0.00	0.00	0.21	11.82	0.00	10.57	4.75	2.77	36.81	46.70	15.14	29.01	4.74	6.42	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.28	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.28	0.00	0.00	0.00	0.00	0.00
2010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.28	0.00	0.00	0.00	0.00	0.00
2011	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 57: Percentage of wheat area under bread wheat varieties of different release dates – national figures
(adoption degrees are generated by using bread wheat areas in each province as weights)

Year	Beni Mellal	Benslimane	Berrechid	El Hajeb	El Jadida	El Kelaa	Fes	Guercif	Kenitra	Khemisset	Khenifra	Meknes	My Yacoub	Rehamna	Safi	Settat	Sidi Bennour	Sidi Kacem	Sidi Slimane	Taounate	Taza	Total	Cumulative
1921	0.54	0.00	0.06	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.98	0.00	0.00	0.01	0.07	0.00	0.03	0.00	0.00	0.10	0.00	1.70	100.
1982	0.00	0.00	0.56	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.01	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.87	98.3
1984	3.32	0.21	0.02	0.30	0.29	0.88	0.38	0.41	0.21	0.17	0.00	0.25	0.26	3.25	0.50	0.93	0.68	0.10	0.70	1.65	0.90	17.72	97.4
1985	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	79.7
1988	2.39	1.09	0.04	0.96	3.13	1.80	0.00	0.15	4.41	0.49	1.73	0.61	0.92	2.82	0.57	0.21	1.35	1.33	0.26	1.08	0.06	30.38	79.7
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61	49.3
1993	0.11	0.19	0.19	0.88	0.11	0.01	0.15	0.08	0.98	0.00	0.00	1.75	1.81	0.17	2.74	0.42	0.46	5.00	0.54	3.07	0.06	18.39	48.7
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	30.3
1995	0.00	0.00	0.00	0.07	0.00	0.00	0.24	0.00	0.00	0.05	0.00	0.08	1.22	0.00	0.00	0.00	0.00	0.00	0.00	1.87	0.00	2.95	30.3
1996	0.00	1.71	0.07	0.12	0.92	0.00	0.00	0.00	0.55	7.21	0.08	1.02	0.00	0.03	0.17	0.55	0.12	0.87	0.02	0.09	0.08	11.02	27.3
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.3
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.06	16.3
2004	0.01	0.00	0.47	0.00	0.31	0.01	0.00	0.00	0.00	0.20	0.00	0.19	0.00	0.04	0.45	0.62	0.29	0.00	0.00	0.00	0.00	1.97	16.3
2005	0.00	0.00	1.86	1.19	0.23	0.30	0.00	0.00	0.01	1.09	0.00	0.46	0.21	0.18	2.62	2.48	0.52	2.98	0.08	0.55	0.00	14.29	14.3
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
2010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.05	0.05
2011	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% share in total bread wheat area in the 21 sample provinces	6.37	3.19	3.25	3.54	5.03	3.00	0.77	0.63	6.16	9.20	3.52	4.36	4.42	6.52	7.11	5.47	3.45	10.27	1.60	8.49	1.10	100.00	

Table 58: Percentage of durum wheat area under durum wheat varieties of different release dates – by province

Year	Beni Mellal	Benslimane	Berrechid	El Hajeb	El Jadida	El Kelaa	Fes	Guercif	Kenitra	Khemisset	Khenifra	Meknes	My Yacoub	Rehamna	Safi	Settat	Sidi Bennour	Sidi Kacem	Sidi Slimane	Taounate	Taza
1921	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0	100.0	100.0
1982	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0	100.0	100.0
1984	94.3	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0	100.0	100.0
1985	94.3	66.7	78.6	66.7	100.0	91.7	100.0	75.0	100.0	66.7	10.5	100.0	87.5	85.2	94.3	34.2	70.0	100.0	0.0	86.4	73.3
1988	2.9	33.3	71.4	0.0	0.0	58.3	0.0	33.3	0.0	0.0	10.5	33.3	12.5	37.0	54.3	13.2	20.0	0.0	0.0	9.1	48.3
1991	2.9	33.3	71.4	0.0	0.0	58.3	0.0	33.3	0.0	0.0	0.0	33.3	12.5	37.0	54.3	13.2	20.0	0.0	0.0	9.1	48.3
1993	2.9	33.3	71.4	0.0	0.0	58.3	0.0	33.3	0.0	0.0	0.0	33.3	12.5	37.0	54.3	13.2	20.0	0.0	0.0	9.1	48.3
1994	0.0	33.3	71.4	0.0	0.0	58.3	0.0	33.3	0.0	0.0	0.0	33.3	6.3	33.3	54.3	13.2	20.0	0.0	0.0	2.3	48.3
1995	0.0	33.3	71.4	0.0	0.0	8.3	0.0	0.0	0.0	0.0	0.0	33.3	0.0	7.4	51.4	13.2	20.0	0.0	0.0	2.3	0.0
1996	0.0	33.3	71.4	0.0	0.0	8.3	0.0	0.0	0.0	0.0	0.0	33.3	0.0	7.4	51.4	13.2	20.0	0.0	0.0	2.3	0.0
1997	0.0	33.3	71.4	0.0	0.0	8.3	0.0	0.0	0.0	0.0	0.0	33.3	0.0	7.4	51.4	13.2	20.0	0.0	0.0	2.3	0.0
2003	0.0	33.3	71.4	0.0	0.0	8.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.4	51.4	13.2	20.0	0.0	0.0	2.3	0.0
2004	0.0	33.3	71.4	0.0	0.0	8.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.4	51.4	13.2	20.0	0.0	0.0	2.3	0.0
2005	0.0	33.3	71.4	0.0	0.0	8.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.4	51.4	13.2	20.0	0.0	0.0	2.3	0.0
2006	0.0	0.0	21.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0
2007	0.0	0.0	21.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2010	0.0	0.0	14.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2011	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2012	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 59: Percentage of durum wheat area under durum wheat varieties of different release dates – national figures
(adoption degrees are generated by using durum wheat areas in each of the provinces as weights)

Year	Beni Mellal	Benslimane	Berrechid	El Hajeb	El Jadida	El Kelaa	Fes	Guercif	Kenitra	Khemisset	Khenifra	Meknes	My Yacoub	Rehamna	Safi	Settat	Sidi Bennour	Sidi Kacem	Sidi Slimane	Taounate	Taza	Total	Cumulative
1921	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	100
1982	0.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.6	100
1984	0.00	0.30	0.84	0.24	0.00	0.31	0.00	0.89	0.00	0.28	4.74	0.00	0.54	1.23	0.56	7.01	0.99	0.00	0.00	1.70	4.76	24.4	99
1985	9.43	0.30	0.28	0.47	1.31	1.23	0.54	1.49	0.75	0.56	0.00	0.55	3.22	4.01	3.92	2.24	1.64	0.60	0.00	9.66	4.46	46.7	75
1988	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.6	28
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	28
1993	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.31	0.00	0.00	0.00	0.00	0.00	0.85	0.00	1.7	28
1994	0.00	0.00	0.00	0.00	0.00	1.85	0.00	1.19	0.00	0.00	0.00	0.00	0.27	2.16	0.28	0.00	0.00	0.00	0.00	0.00	8.63	14.4	26
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	12
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	12
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.3	12
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	11
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	11
2005	0.00	0.30	1.96	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62	5.04	1.40	0.66	0.00	0.00	0.00	0.00	10.3	11
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.00	0.3	1
2007	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.3	1
2010	0.00	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.6	1
2011	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00
2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00
% share in total durum wheat area in the 21 sample provinces	15.09	3.21	7.42	0.45	3.20	3.80	0.46	1.79	0.14	2.33	6.01	1.41	4.57	6.51	8.44	16.17	5.73	1.79	0.65	7.13	10.71	100	

5.2.3 Factors affecting farmers' decisions, intensity and speed of adoption

Factors affecting farmers' decision and intensity of adoption

Looking at the adoption levels reported in section 5.2 above, the number of farmers who have adopted varieties 10 years old or less is only 16% of total national growers. However, the adoption level for varieties 20 years old or younger is 42%, which shows that there is a sizeable number of farmers who have cultivated them. So using this cut off point would provide good representation of both adopters and non-adopters in our sample. For the purpose of this study, improved varieties are defined as varieties released in or after 1993, and farmers who cultivate varieties released before 1993 are therefore categorized as non-adopters. One can argue that, as long as certified seeds of these varieites are being produced, it is difficult to call them non-adopters. However, one should keep in mind the difference between new improved varieties and old improved varieites as well as production of certified seeds.

Parameter estimates for the Heckman selection model are provided in Table 60. Given the significant coefficient estimate on the inverse mills ration (IMR) on the "area under improved varieties" equation, the Heckman selection model is an appropriate choice for correcting the selection bias that is introduced either by farmers themselves or by other factors over which they don't have control. Model results show that neither the size of area dedicated to wheat nor total crop land owned and/or cultivated have a role in significantly affecting farmers' decisions whether or not to adopt improved varieties of wheat. Theoretically one would expect larger wheat farms (often commercial) to find it worthwhile to invest in improved varieties, as they focus more on yield regardless of specific quality traits that are important for own home consumption. However, given the small share of own consumption in total wheat production, these results are not unreasonable.

Table 60: Parameter estimates from the Heckman Selection Model

Variables	Outcome Equations		Selection equation		Marginal effects
	Area under the new varieties		Adoption dummy		
	Coef.	Std.Er.	Coef.	Std.Er.	
Age (Years)	0.064	(0.030) **	0.010	(0.004) **	0.001
Sex {1=Male, 0=Female}	0.104	(0.033) ***	0.579	(0.271) **	0.046
Number of years of education	0.162	(0.019) ***	1.957	(0.138) ***	0.154
Number of family members working on own farm (Person days/ha)	0.097	(0.016) ***	0.140	(0.026)***	0.011
Get a credit from a bank {1=yes, 0=No}	0.115	(0.016) ***	0.636	(0.117) ***	0.050
Off-farm employment {1=yes, 0=No}	0.028	0.019	-0.351	(0.165) **	-0.028
Irrigated {1=yes, 0=No}	0.027	0.018	0.060	0.156	0.005
Wheat area (Ha)	0.384	(0.013) ***	0.001	0.006	0.0001
Total cropped area (Ha)	-0.001	0.003	-0.002	0.002	0.0001
Walking distance from seed sources (km)	-0.345	(0.008) ***	-0.078	(0.006) ***	-0.006
Hosted wheat demonstration/ PVS trials {1=yes, 0=No}			1.692	(0.491) ***	0.133
Visited demonstration fields or attended field days {1=yes, 0=No}			0.442	0.459	0.035
Was the seed you used certified? {1=yes, 0=No}	0.052	(0.015) ***	0.939	(0.116) ***	0.074
Seed from seed company {1=yes, 0=No}	0.037	(0.020) *	0.573	(0.153) ***	0.045
Seed from Agro-dealers/Agro-vets {1=yes, 0=No}	0.007	0.014	-0.225	0.118	-0.018
Price of seed	0.005	0.020	0.071	0.069	0.006
Farm in favorable zone{1=yes, 0=No}	0.176	(0.019) ***	1.671	(0.157) ***	0.132
Farm in intermediate zone {1=yes, 0=No}	-0.007	0.018	0.618	(0.166) ***	0.049
Inverse mills ratio (λ)	0.407	(0.024***)	NA		
Constant	-0.021	0.133	-6.494	(0.525)***	

Rho	0.591	-	-	
Sigma	0.053	-	-	

Description of dependent variables:

- Selection equation: Adoption dummy = a dummy variable for the adoption of the improved wheat variety which takes a value of 1 if the farmer is an adopter and 0 otherwise
- Outcome equation: Area under the new varieties (ha),

*, ** and *** respectively represent significance at 0.1, 0.05 and 0.01 levels.

Household heads' age, gender, and the number of years of education, as well as the number of family members working on the farm, and access to credit all have positive and significant effects on the decision whether or not to adopt improved wheat varieties. These factors also have an impact on the share of wheat land to be dedicated to the improved wheat varieties. These results are valid as older farmers (who are implicitly also often more experienced) and educated farmers are likely to better understand the benefits and also have the knowledge and skills to better manage new technology packages such as wheat and other associated management practices including fertilization.

Generally, due to poorer access to information, productive resources including land, labor and financial capital, women-headed households are expected to be less likely to adopt new technologies than men-headed households. Moreover, if women-headed households adopt new agricultural technologies at all, you would expect that they do it at a lower scale. Farmers with better access to credit are also likely to be more inclined to adopt new varieties as they will have the needed financial liquidity to purchase certified seeds and other complementary inputs such as fertilizers, herbicides, pesticides and the extra labor that might be needed. Having more family members working on the farm would also mean a greater need to make the farm enterprise profitable, to make their time on the farm worthwhile. Adopting new varieties can be a strategic way of achieving higher profitability. Moreover, more family labor would mean less stress in terms of meeting the higher management requirements of adopting technology packages.

Farmers who hosted demonstration trials on their own farms are also found to have a higher propensity to adopt improved wheat varieties. However, participating in field days alone does not significantly affect farmers' adoption decisions. These results are also consistent with theoretical expectations, as demonstration trials would give the farmer hands-on training and first-hand information about the pros and cons of the technology while participation in field days would not fully answer the questions and clear the doubts farmers may have about the technologies. Farmers who are located in the favorable and intermediate zones of Morocco have a higher propensity to adopt improved wheat varieties than those in the unfavorable south or mountainous zones. Naturally, investment in new technologies is likely to have a bigger impact in favorable areas than unfavorable ones and hence these results don't come as a surprise.

What is rather surprising is that whether or not the farm has access to irrigation does not have a significant effect on a farmer's decision to adopt improved varieties. This may be justified on grounds that farmers who are in rainfed areas are desperate to get varieties which are early maturing and drought tolerant in order to minimize risk to their crops, and hence are more eager to adopt new varieties than modern irrigated farms. Farmers who have other forms of employment alongside their work on their farms are found to have less inclination to adopt improved wheat varieties. This result makes intuitive sense as having other alternative sources of income would make farmers less interested in investing in agriculture, as agriculture is often regarded as an inferior occupation. Moreover, having off-farm employment means that the person will not have enough time to devote to agriculture, so they will not be able meet the demands of adopting new varieties and associated technology packages.

Holding all other factors constant, access to seed proves to be an important factor in determining farmers' adoption decisions. For instance, farmers who have to walk or drive long distances to seed sources have lesser propensity to adopt improved varieties of wheat than those who live close by. This could be justified on two grounds. Living closer would lead to better flow of information about the varieties and also the seed. Moreover, the travel cost (both in terms of time and money) and the hustle of going to other places would discourage farmers - who are used to using their own saved seed or seed exchanged with neighbors - from exploring improved varieties. Farmers who purchase certified seed are found to have a higher tendency to adopt more recent improved varieties than those who use uncertified seeds. This shows that certified seeds constitute more of improved varieties, which are not too old than seeds which are uncertified. This finding does not come by surprise as certified seed production often focusses on more recent varieties. However, depending on the definition of improved vareitieties, the results may change. For example, if adoption was to be defined as the use of varieties which are 10 years or less, then the results would have been opposite as the vast majority of farmers cultivate varieties which are more than 10 years old.

Also, farmers who get their seed from seed companies are more likely to adopt new varieties than those who get their seed from other sources, including local traders and seed dealers. This clearly shows the importance of having more seed distribution networks which are close to the farmers. Moreover, though farmers' risk attitudes and preferences towards varietal attributes are vital to their adoption decisions, model results clearly show that the age of varieties that are cultivated is highly dependent on the type and age of varieties for which certified seed is being produced and sold by seed companies. The combined effect of proximity to seed source, the ability to use certified seed and the ability to buy seed from seed companies in adequate quantity and in timely fashion can be quantified. These factors together result in an increase in the propensity to adopt improved varieties of 13%.

In summary, model results show that 79% of the total variation in adoption decisions was explained by all the variables included into the regression while the remaining 21% is explained by variables (such as farmers' risk attitude) which were not included in the model. Among the variables included, farmer characteristics (such as age, gender, education, credit access, off-farm employment and whether the farmer hosted demonstration trials) in general were found to be the most important explanatory variables accounting for 45% of the total variation followed by farm characteristics (such as the size of wheat area, access to irrigation, agro-ecological zone in which the farm is located, and distance of the farm from farmers' residences) which explained 19% of the variation. Variables that hamper access to seeds (such as distance of seed source, availability of adequate quantity and quality of seed at the desired time and the choice to buy certified seed, having seed companies as the source of seed, and seed price) explained the remaining 15% of the total variation. While this figure is high it is not high enough to be the sole reason for poor adoption levels, as is often heard among breeders, development practitioners, policy makers and donors alike.

The insignificant coefficient on the seed price variable would at first glance appear counterintuitive. However, the definition of improved varieties is “varieties which are 20 years old or younger”. The major differences in seed prices are between seed that is or isn’t certified, rather than on whether the seeds are for new or old varieties. Given that the certified seed that is being produced and sold in the country includes both old and new varieties, the insignificant coefficient on seed prices should not come as a surprise. Moreover, given the high price subsidy for certified seeds, the price gap between certified and uncertified seeds is insignificant and hence seed prices are not expected to explain adoption decisions. In the outcome equation, almost all variables which affected the decision to adopt also affected the intensity of adoption in the same direction. The only exceptions to this are off-farm employment, the location of farm in the intermediate zone and size of the wheat area. While farmers who have off-farm employment have a lower propensity to adopt, once they do adopt they tend to adopt on a large scale. A possible explanation for this is that these farmers have better financial liquidity and hence once they are convinced, they can afford to adopt the new varieties in bigger quantities, as capital for the purchase of complementary inputs may not be as limiting as is the case for farmers who don’t have off farm employment opportunities. Likewise, once the decision to adopt is made, farmers with relatively larger wheat farms are more likely to plant the improved varieties on a larger scale than those farmers with smaller farms.

Factors affecting farmers’ speed of adoption

Analysis of the speed of adoption requires a definition of the release year as a reference point. Therefore, we have deliberately chosen to build duration models for the adoption of four of the most adopted improved wheat varieties, two of which are bread wheat varieties (Achtar, Merchouch) which cover 35% of the total area under bread wheat and 33% of the householders, and two are durum wheat varieties **(**Karim, Amal**)** which cover 77% of the total area under durum wheat and 82% of the householders. The only two variables which have consistent effects on the speed of adoption across all varieties are whether seed is certified or not and whether or not seed was purchased from seed companies through their distribution networks (Table 61). Farmers who purchased certified seed and did so from seed companies are more likely to adopt improved wheat varieties faster than farmers who did not use certified seed and who purchased their seed from sources other than seed companies. The other variables either had no significant effect on the speed of adoption or have mixed effects across varieties, which makes it difficult to explain.

For instance, farmers who are located in the favorable zone of Morocco are less likely to adopt the variety Amal quickly while farmers who are located in the intermediate zone adopt Achtar and Karim relatively faster. With negative and significant coefficients, hosting demonstration trials appears to be an important factor that speeds up the adoption of three of the varieties, namely, Merchouch, Karim, and Amal, while it does not have a significant effect on the speed of adoption of Achtar.

Table 61: Maximum likelihood estimates of parameters for Hazard Function for Morocco farmer's adoption of improved wheat variety

	Achtar			Merchouch			Karim			Amal		
Variable	**Coef.**	**St. Errs**	**% Δ**	**Coef.**	**St. Errs**	**% Δ**	**Coef.**	**St. Errs**	**% Δ**	**Coef.**	**St. Errs**	**% Δ**
Age (Years)	0.0002	0.0011	-0.02	0.0004	0.0011	-0.04	-0.0006	0.0008	0.06	-0.0019	0.0018	0.19
Sex (1=Male, 0=Female)	0.0263	0.0780	-2.66	0.0015	0.0660	-0.15	0.0332	0.0755	-3.38	-0.0192	0.0720	1.91
Number of years of education	-0.0701	(0.0269)***	6.77	-0.0334	0.0267	3.29	0.0132	0.0198	-1.33	-0.0138	0.0257	1.37
Number of family members working on own farm (Person days/ha)	-0.0032	0.0082	0.32	0.0040	0.0067	-0.40	0.0033	0.0058	-0.33	0.0124	0.0123	-1.25
Get a credit from a bank (1:yes, 0=No)	0.0575	(0.0286) ***	-5.92	0.0250	0.0286	-2.53	-0.0014	0.0233	0.14	0.0540	0.0543	-5.55
Off-farm employment {1=yes, 0=No}	0.0514	0.0351	-5.27	-0.0152	0.0340	1.51	-0.0114	0.0316	1.13	0.0769	0.0579	-7.99
Irrigated {1=yes, 0=No}	-0.0158	0.0297	1.57	-0.0484	0.0387	4.73	0.0177	0.0293	-1.79	0.0283	0.0544	-2.87
Wheat area (Ha)	-0.0004	0.0008	0.04	0.0008	0.0013	-0.08	-0.0019	0.0033	0.19	-0.0006	0.0012	0.06
Total cropped area (Ha)	-0.0001	0.0004	0.01	0.0003	0.0004	-0.03	-0.0001	0.0003	0.01	0.0006	0.0006	-0.06
Walking distance from seed sources (km)	-0.0002	0.0012	0.02	0.0000	0.0011	0.00	-0.0005	0.0010	0.05	-0.0003	0.0023	0.03
Hosted wheat demonstration/ PVS trials {1=yes, 0=No}	-0.1583	0.2948	14.64	-0.3208	(0.0960) ***	27.45	-0.5258	(0.0782) ***	40.89	-0.3580	(0.0893) ***	30.09
Visited demonstration fields or attended field days {1=yes, 0=No}	-0.0029	0.1062	0.29	-0.1476	0.0936	13.73	0.1378	(0.1394) **	-14.77	0.2211	0.1043	-24.74
Was the seed you used certified? {1=yes, 0=No}	-0.0995	(0.0324) ***	9.47	-0.7380	(0.0664) ***	52.19	-0.1570	(0.0235) ***	14.53	-0.3249	(0.0464) ***	27.74
Seed from seed company {1=yes, 0=No}	-0.2140	(0.0482) ***	19.27	-0.1986	(0.0383) ***	18.01	-0.0638	(0.0373) ***	6.19	-0.3068	(0.0543) *	26.42
Seed from Agro-dealers/Agro-vets {1=yes, 0=No}	-0.0079	0.0287	0.79	0.0614	(0.0278) **	-6.33	0.0094	0.0212	-0.94	-0.0356	0.0483	3.50
Price of seed	-0.0222	0.0171	2.20	-0.0148	0.0171	1.47	-0.0386	(0.0131) **	3.78	-0.0685	(0.0282) ***	6.62
Farm in favorable zone{1=yes, 0=No}	-0.0261	0.0390	2.57	0.0271	0.0323	-2.74	0.0652	0.0278	-6.73	0.1856	(0.1051) **	-20.39
Farm in intermediate zone {1=yes, 0=No}	-0.0571	(0.0309) *	5.55	0.0152	0.0327	-1.53	-0.0064	(0.0242) **	0.64	0.2465	0.1144	-27.95
Constant	3.1421	(0.1166) ***		3.1123	(0.1052) ***		3.2181	(0.0824) ***		2.8326	(0.1962) ***	
Weibull parameter (α)	3.6868	(0.1539) ***		4.5782	(0.2204) ***		4.8276	(0.1929) ***		3.2366	(0.1856) ***	

6.6.3 Impact of improved wheat varieties

A summary of the propensity scores for the estimates for the selection equation of the Heckman model are provided in Table 62 below. Based on the selection criteria of a number of covariates which have no significant difference between adopters and non-adopters after matching, Pseudo R2 and a number of observations on support, the Radius caliper (0.01) matching algorithm is selected as it performed better than the nearest neighbor and Kernel bandwidth matching algorithms. The common support region is therefore between 3.949E-32 and 0.88. Hence, 1100 observations (48%) with propensity scores less than 3.649E-32 and over 0.88 are dropped from the analysis, which is a huge loss of observations.

Table 62: Mean of estimated propensity scores

Group	Mean	Min	Max
Total households	0.33	3.949E-32	1.00
Non-adopters	0.1	3.949E-32	0.88
Adopters	0.87	1.09E-04	1

Source: model results

Impact per unit area

Impacts on Yield

Estimates of treatment effects from PSM are provided in Table 63 below. The results show that adoption of varieties with less than 20 years of age (the majority of which are 15-20 years) provide on average 425.4 kg/ha (35%) yield gain for adopters. If non-adopters were to adopt the improved varieties, they would have obtained 289.6kg/h higher yields showing that the benefit to those who already adopted is higher, which may explain why they adopted while the others have not.

Table 63: Treatment effects on yield (kg/ha) from propensity score matching

Group	**Treatment group**	**Control group**	**Difference**	**S.E.**	**T-stat**
Unmatched	1818.6	1243.5	575	55	10.5[a]
ATT	1641	1215.5	425.4	149	2.9[b]
ATU	1257.3	1546.9	289.6		
ATE			313.2		

[a] and [b] show significance at 0.01 and 0.05 levels

Estimates of the Endogenous Switching Regression (ESR) are provided in Table 64 below. As the main objective of this section is one of measuring the impact of adoption of improved varieties, we will provide only a brief discussion of the regression estimates. Quantities of inputs (nitrogen and DAP fertilizers and seeds) are found to have positive and significant effects on yield, as expected. Irrigated plots also give higher yields than non-irrigated plots. The same is true for larger farms and farms with a larger wheat area. The use of certified seeds also leads to higher yields than uncertified seeds, showing a clear advantage to using certified seeds. Estimates of treatment effects from ESR are provided in Table 65. The results show that adopters of 20 years or younger varieties on average obtain about 482.4kg/ha (49%) more yield than the counterfactual (i.e., what they would have obtained if they had not adopted). Taking an average grain price of 3.15 MAD/kg and ignoring the cost implications of adoption of improved wheat varieties, this yield gain would translate into a gain in gross revenue of 1,518 MAD/ha (US$176/ha)[11]. At the current average adoption level of 1.6ha/family, each farm household obtains about 771kg per year more yield and 2,429 MAD (US$282) per year.

[11] The exchange rate in 2012 was: 1US$= 8.62 Moroccan Dirhams (MAD)

Table 64: Full information maximum likelihood estimates of the endogenous switching regression model for yields (kg/ha)

Independent Variables	Yield Equation for Adopter		Yield Equation for Non-Adopter		Adoption of ZT (No=0,Yes=1)	
	Coef.	Std.Er	Coef.	Std.Er	Coef.	Std.Er
Age (Years)	-0.040	(0.022)[c]	0.027	0.019	0.499	0.283
Sex (0=Male, 1=Female)	0.029	(0.018)[c]	0.034	0.028	0.318	0.311
Number of years of education	0.010	0.021	-0.015	0.016	4.084	(0.406)[a]
Number of family members working on own farm (Person days/ha)	0.012	0.014	-0.008	0.010	0.404	(0.139)[a]
Get a credit from a bank (1:yes, 0=No)	0.026	(0.016)[c]	-0.021	(0.009)[b]	0.402	(0.133)[a]
Off-farm employment {1=yes, 0=No}	0.010	0.015	-0.012	0.012	-0.201	0.186
Irrigated {1=yes, 0=No}	1.393	(0.020)[a]	1.333	(0.016)[a]	0.047	0.249
Wheat area (Ha)	0.030	(0.010)[a]	0.075	(0.009)[a]	-0.850	(0.149)[a]
Total cropped area (Ha)	0.006	(0.002)[a]	-0.003	0.002	-0.024	0.029
Walking distance from seed sources (km)	-0.004	0.008	0.012	0.010	-1.406	(0.111)[a]
Hosted wheat demonstration/ PVS trials {1=yes, 0=No}	-		-		0.996	(0.139)[a]
Visited demonstration fields or attended field days {1=yes, 0=No}	-				0.528	(0.183)[a]
Was the seed you used certified? {1=yes, 0=No}	0.218	(0.013)[a]	0.165	(0.010)[a]	-0.228	0.136
Seed from seed company {1=yes, 0=No}	0.017	0.012	0.046	(0.015)[a]	0.213	0.190

Independent Variables	Yield Equation for Adopter		Yield Equation for Non-Adopter		Adoption of ZT (No=0,Yes=1)	
	Coef.	Std.Er	Coef.	Std.Er	Coef.	Std.Er
Seed from Agro-dealers/Agro-vets {1=yes, 0=No}	0.026	(0.011) [a]	-0.012	0.009	0.629	(0.196) [a]
Price of seed	-0.014	0.015	-0.020	0.013	0.023	0.080
Farm in favorable zone{1=yes, 0=No}	0.020	0.021	-0.031	(0.013)[b]	-0.093	0.083
Farm in intermediate zone {1=yes, 0=No}	0.033	0.022	0.024	(0.011)[b]	0.079	0.210
Quantity of nitrogen fertilizer used (kg/ha)	0.016	(0.006) [a]	0.013	(0.005) [a]	1.614	(0.183) [a]
Quantity of DAP fertilizer used (kg/ha)	0.041	(0.006) [a]	0.055	(0.005) [a]	1.329	(0.527) [a]
Amount of seed used(kg/ha)	0.064	(0.016) [a]	0.099	(0.014) [a]	0.643	0.493
Constant	6.408	(0.128) [a]	5.678	(0.111) [a]	-3.340	(1.639)[b]
Log likelihood						720.7
Rho	0.01	(0.150)	-0.412	(0.200) a		
sigma	-1.984	(0.026) [a]	-1.761	(0.019) a		

Table 65: Average expected treatment and heterogeneity effects on yield (kg/ha) from endogenous switching regression

	Decision Stage		
Subsamples Effects	To Adopt	Not to Adopt	Treatment
Farm households that adopted	(a) 1454.9	(c) 972.5	482.4***
Farm households that did not adopt	(d) 1285.9	(b) 978.5	307.4***
Heterogeneity effects	169.1	-6	175.1

Given that ESR is good at correcting for biases both from observable and unobservable factors, the 13% higher yield effects from ESR relative to PSM shows that unobservable factors such as skills of the farmers who have adopted the technology are important in explaining the differences in yield effects. In this particular case, the unobservable factors are leading to underestimation of the yield impact, which ESR was able to correct while PSM couldn't.

Impact on Net Margins

Estimates of the treatment effects on net margins from PSM are provided in Table 66 below. The results show that adoption of improved wheat varieties under 20 years old (the majority of which are 15-20 years old) provides on average 1232 MAD/ha (33%) higher net wheat income for adopters. If non-adopters would adopt the improved varieties, they would have earned 1230 MAD/ha more net income, showing that the non-adopters would have almost the same benefits as the adopters if they were to adopt the new varieties. Given the average area under improved varieties per family of 1.6 ha, a typical adopter family currently earns 1,971 MAD of additional net wheat income each year.

Table 66: Treatment effects on net margins (MAD/ha) from propensity score matching

Group	**Treatment group**	**Control group**	**Difference**	**S.E.**	**T-stat**
Unmatched	5421.3	3716.5	1704.8	195.0	8.74[a]
ATT	4880.1	3647.9	1232.2	528.7	2.33[b]
ATU	3759.6	4989.9	1230.3		
ATE			1230.6		

[a] and [b] show significance at 0.01 and 0.05 levels

The Estimates of the Endogenous Switching Regression (ESR) are provided in Table 67. As the main objective of this section is to measure the impact of adoption of improved varieties, we will provide only a brief discussion of the regression estimates. From among the inputs, quantities of DAP fertilizers used are found to have positive and significant effects on yields for both adopters and not adopters, while the quantity of nitrogen fertilizer does not. Given that both have a positive effect on yields, this shows that adopters are using less DAP and hence are saving costs which leads to a gain in net income. Irrigated plots also give higher net income than non-irrigated plots because yield gains exceed any additional costs of irrigation. The use of certified seeds also leads to higher yields than uncertified seeds, showing there is a clear advantage to certified seeds.

Table 68 presents the estimates of treatment effects from ESR. The results show that adoption of improved wheat varieties under 20 years old (the majority of which are 15-20 years) provide on average 1324 MAD/ha (48%) higher net wheat income for adopters. If non-adopters were to adopt the improved varieties, they would have earned 1059 MAD/ha more net income showing that the benefit to those who already adopted is higher, which may explain why they adopted while the others have not.

Table 67: Full information maximum likelihood estimates of the endogenous switching regression model for net income

Independent Variables	Yield Equation for Adopter		Yield Equation for Non-Adopter		Adoption of ZT (No=0,Yes=1)	
	Coef.	Std.Er	Coef.	Std.Er	Coef.	Std.Er
Age (Years)	-0.094	(0.044)[b]	0.038	0.046	0.542	(0.286)[c]
Sex (0=Male, 1=Female)	0.066	(0.035)[c]	0.108	0.068	0.415	0.314
Number of years of education	-0.031	0.041	0.020	0.035	4.214	(0.394) [a]
Number of family members working on own farm (Person days/ha)	-0.020	0.027	-0.039	0.024	0.393	(0.141 [a])
Get a credit from a bank (1:yes, 0=No)	0.039	0.031	-0.015	0.023	0.415	(0.136) [a]
Off-farm employment {1=yes, 0=No}	0.005	0.030	-0.018	0.029	-0.234	0.188
Irrigated {1=yes, 0=No}	1.504	(0.039)[a]	1.746	(0.039) [a]	-0.006	0.250
Wheat area (Ha)	0.027	0.020	0.098	(0.021) [a]	-0.859	(0.150) [a]
Total cropped area (Ha)	0.008	(0.004)[c]	-0.004	0.005	-0.023	0.030
Walking distance from seed sources (km)	-0.017	0.015	-0.006	0.023	-1.416	(0.111) [a]
Hosted wheat demonstration/ PVS trials {1=yes, 0=No}	-				0.941	(0.139) [a]
Visited demonstration fields or attended field days {1=yes, 0=No}	-				0.600	(0.181) [a]
Was the seed you used certified? {1=yes, 0=No}	0.144	(0.026)[a]	0.147	(0.023) [a]	-0.251	0.138
Seed from seed company {1=yes, 0=No}	0.044	(0.024)[c]	0.033	0.036	0.185	0.192

Independent Variables	**Yield Equation for Adopter**		**Yield Equation for Non-Adopter**		**Adoption of ZT (No=0,Yes=1)**	
	Coef.	Std.Er	Coef.	Std.Er	Coef.	Std.Er
Seed from Agro-dealers/Agro-vets {1=yes, 0=No}	0.005	0.021	0.000	0.023	0.627	(0.201) [a]
Price of seed	-0.076	(0.029)[a]	-0.180	(0.031) [a]	0.022	0.085
Farm in favorable zone{1=yes, 0=No}	0.063	0.041	0.058	(0.030)[b]	-0.066	0.083
Farm in intermediate zone {1=yes, 0=No}	0.010	0.044	0.019	0.025	0.110	0.208
Quantity of nitrogen fertilizer used (kg/ha)	0.010	0.012	-0.005	0.012	1.614	(0.187) [a]
Quantity of DAP fertilizer used (kg/ha)	0.046	(0.012) [a]	0.057	(0.012) [a]	1.515	(0.541) [a]
Amount of seed used(kg/ha)	0.123	(0.031) [a]	0.044	0.032	0.637	0.532
Constant	7.499	(0.252) [a]	6.993	(0.266) [a]	-3.743	(1.629) [b]
Log likelihood					-1144.88	
Rho	0.130	0.121	-0.113	0.142		
sigma	-1.303	(0.026) [a]	-0.891	(0.018 [a])		

Table 68: Average expected treatment and heterogeneity effects on net income (MAD/ha) from endogenous switching regression

	Decision Stage		
Subsamples Effects	To Adopt	Not to Adopt	Treatment
Farm households that adopted	(a) 4049.6	(c) 2725.6	1324.1***
Farm households that did not adopt	(d) 3566	(b) 2507	1059***
Heterogeneity effects	483.7	218.6	265.1

Given that ESR is potent in correcting for biases both from observable and unobservable factors, the 7% higher effects on net income from ESR relative to PSM shows that unobservable factors such as skills of the farmers who have adopted the technology are important in explaining the differences in net income effects. In this particular case, the unobservable factors lead to underestimation of the net income impact, which ESR was able to correct while PSM couldn't.

The adoption of improved varieties has a positive and significant effect on net wheat income. After controlling for all the above confounding factors, our results show that by adopting improved varieties of wheat, the typical Moroccan wheat farmer who adopted improved wheat varieties earned about 1324 Moroccan Dinars (MD) (US$154) more per ha than they would have if they did not adopt. This figure is much less than the increase in gross revenue of 1,518 presented in section 5.3.1.1 above, showing that adoption of improved varieties and hence obtaining additional yields can only be achieved at an additional cost. However, the value of the gain in yields more than offsets the additional cost needed for the adoption of improved varieties, leading to about 49% higher net margins. Given the average area under improved varieties per family of 1.6 ha, a typical adopter family may earn 2,118 MAD (US$245) of additional net wheat income each year.

Impact on consumption

PSM estimates of treatment effects are presented in Table 69 below. The results show that adoption of varieties under 20 years old (the majority of which are 15-20 years) provide a 25.4 kg/capita/year (54%) gain in wheat consumption for adopters. If non-adopters were to adopt the improved varieties, they would have consumed 8.5 kg/capita/year (14%) more wheat showing that the benefit to those who already adopted is higher, which may provide part of the explanation for why a large number of farmers did not adopt the improved wheat varieties.

Table 69: Treatment effects on wheat consumption (kg/capita/year): Propensity score matching

Group	**Treatment group**	**Control group**	**Difference**	**S.E.**	**T-stat**
Unmatched	86.7	51.1	35.6	1.2	28.7[a]
ATT	72.6	47.2	25.4	3.4	7.5[a]
ATU	50.7	59.3	8.5		

ATE			11.5		

[a] and [b] show significance at 0.01 and 0.05 levels

The Estimates of the Endogenous Switching Regression (ESR) are provided in Table 70. As the main objective of this section is to measure the impact of adoption of improved wheat varieties, only a brief discussion of the regression estimates is provided here. Total wheat area and whether or not the plot is irrigated seem to have positive and significant effects on wheat consumption among both adopters and non-adopters. while all other variables including quantities of input (nitrogen, DAP fertilizers and seeds) are found to have differential effects on wheat consumption between adopters and non-adopters.

Estimates of treatment effects from ESR are provided in Table 71. The results show that adopters of varieties 20 years or younger on average consume about 29.6 kg/capita/year (60%) more wheat than the counterfactual (i.e., what they would have consumed if they had not adopted). If non-adopters were to adopt the improved varieties, they would have consumed 6.5 kg/capita/year (15%) more wheat showing that the benefit to those who already adopted is much higher – a possible explanation for why a large number of farmers did not adopt the improved wheat varieties yet.

Table 70: Full information maximum likelihood estimates of the endogenous switching regression model for wheat consumption (kg/capita/year)

Independent Variables	Yield Equation for Adopter		Yield Equation for Non-Adopter		Adoption of ZT (No=0,Yes=1)	
	Coef.	Std.Er	Coef.	Std.Er	Coef.	Std.Er
Age (Years)	-0.006	0.042	-0.018	0.022	0.623	(0.280)[b]
Sex (0=Male, 1=Female)	-0.022	0.033	0.024	0.032	0.502	(0.305)[c]
Number of years of education	0.014	0.038	0.037	(0.018)[b]	3.965	(0.394)[a]
Number of family members working on own farm (Person days/ha)	-0.164	(0.025)[a]	-0.160	0.011	0.358	(0.137)[a]
Get a credit from a bank (1:yes, 0=No)	0.108	(0.029)[a]	-0.005	0.011	0.381	(0.133)[a]
Off-farm employment {1=yes, 0=No}	0.026	0.028	0.015	0.014	-0.216	0.183
Irrigated {1=yes, 0=No}	0.473	(0.037)[a]	0.587	(0.019)[a]	-0.081	0.246
Wheat area (Ha)	0.297	(0.019)[a]	0.577	(0.010)[a]	-0.870	(0.141)[a]
Total cropped area (Ha)	0.002	0.004	-0.002	0.002	-0.028	0.029
Walking distance from seed sources (km)	-0.158	(0.014)[a]	0.017	0.011	-1.491	(0.113)[a]
Hosted wheat demonstration/ PVS trials {1=yes, 0=No}	-				0.949	(0.136)[a]
Visited demonstration fields or attended field days {1=yes, 0=No}	-				0.509	(0.181)[a]
Was the seed you used certified? {1=yes, 0=No}	0.169	(0.025)[a]	0.091	(0.011)[a]	-0.275	(0.134)[b]

Independent Variables	Yield Equation for Adopter		Yield Equation for Non-Adopter		Adoption of ZT (No=0,Yes=1)	
	Coef.	Std.Er	Coef.	Std.Er	Coef.	Std.Er
Seed from seed company {1=yes, 0=No}	-0.027	0.023	-0.005	0.017	0.175	0.185
Seed from Agro-dealers/Agro-vets {1=yes, 0=No}	-0.030	0.020	-0.022	(0.011)[b]	0.653	(0.197)[a]
Price of seed	0.004	0.027	-0.002	0.015	-0.013	0.085
Farm in favorable zone{1=yes, 0=No}	0.047	0.038	-0.014	0.015	-0.058	0.082
Farm in intermediate zone {1=yes, 0=No}	0.030	0.041	0.018	0.012	0.067	0.202
Quantity of nitrogen fertilizer used (kg/ha)	-0.012	0.011	-0.033	(0.005)[a]	1.564	(0.186)[a]
Quantity of DAP fertilizer used (kg/ha)	-0.027	(0.011)[a]	0.009	(0.005)[c]	1.652	(0.561)[a]
Amount of seed used(kg/ha)	0.082	(0.029)[a]	-0.001	0.015	0.606	0.510
Constant	3.679	(0.236)[a]	3.191	(0.126)[a]	-3.263	(1.589)[b]
Log likelihood					69.838	
Rho	0.346	(0.130)[a]	0.422	(0.199)[b]		
sigma	-1.363	(0.019)[a]	-1.636	(0.019)[a]		

Table 71: Average expected treatment and heterogeneity effects on wheat consumption (kg/capita/year) from endogenous switching regression

	Decision Stage		
Subsamples Effects	To Adopt	Not to Adopt	Treatment
Farm households that adopted	(a) 78.9	(c) 49.3	29.6***
Farm households that did not adopt	(d) 49.1	(b) 42.6	6.5***
Heterogeneity effects	29.8	6.7	23.1

Given that ESR is good at correcting for biases both from observable and unobservable factors, the 6% higher consumption effects from ESR relative to PSM shows that unobservable factors are important in explaining the differences in consumption effects. In the case of consumption, the unobservable factors lead to an underestimation of the yield impacts. PSM failed to correct this, while ESR did correct it. During the survey, farmers were asked about the impact of improved wheat varieties (Table 72). The results are consistent with the empirical evidence in that the improved varieties have led, among other things, to higher farm income and consumption.

Table 72: Stated impacts of improved wheat varieties

Change in:	Decreased	No change	Increased
Availability of wheat for food at home	3.1	29.8	67.2
Availability of other food items	3.5	43.3	53.2
Cash income from selling wheat	3.6	30.8	65.5
Investment in children's education	2.5	63.8	33.7
Investment in health for the family	2	65.1	32.9
Investment in livestock husbandry	7.9	37.8	54.3
Investment in clothing and footwear for family	1.9	69.1	28.9
Investment in household utensils	1.9	75	23.1
Investment in residential house (size and quality)	2.7	74.1	23.2
Investment in communication (phone, TV, etc.)	3.5	74.8	21.7
Investment in transport (bicycle, horse, mule, etc.)	3.5	80.2	16.3
Investment in fertilizer use for crop production	5.7	54.9	39.4
Investment in social activities	3.2	82.6	14.2
More time for leisure	3.5	78.5	18

5.3.1 National impacts at current adoption levels

The total wheat area in the 21 provinces covered by the survey is 2.151 million hectares, of which 42% (903,609ha) is under improved varieties of wheat 20 years old or younger. Given the average yield gain of 482kg/ha, the introduction of the improved wheat varieties has so far led to an additional 0.43 million tons of wheat in the 21 provinces which represents about 17% higher annual production. Assuming that on average the adoption levels and yield impacts in the other wheat growing areas that are not covered by the survey are also the same, Morocco has been producing a total of 0.58 million tons more wheat due to the adoption of improved varieties. This level of increase in total national food production is high. Even at the current 42% level of adoption it is making a sizeable contribution to national food security and Morocco's aim to become self-sufficient in food.

Likewise, the total net income gains due to a 42% adoption of improved varieties in the 21 provinces surveyed is about 6.8 billion MD (US$0.78 billion), which represents an additional gain of 20% in total net income from wheat production in the 21 sample provinces. Assuming that the adoption levels and yield impacts in the other wheat growing areas that are not covered by the survey are on average the same as the average of the 21 provinces, Morocco is earning a net wheat income gain of about 9.1 billion MD or US$1.1 billion per year. The total population of Morocco in 2012 was about 33 million. Assuming average per-capita consumption from our survey of 57.63, the additional 0.58 million tons of wheat produced due to the adoption of improved wheat varieties translates to about 17kg/capita/year of extra wheat availability for consumption. This calculation however assumes out differences in terms of access and entitlement to the produced wheat, which is a very unrealistic assumption.

Potential national impact

While current adoption levels are low, the gain in total production and hence contribution to national food security and food self-sufficiency documented above is sizeable, not to mention that newly released improved varieties might lead to even higher yields. Assuming the current yield gains per unit area, then if adoption of improved varieties were to increase to higher levels, Morocco would benefit all the more (Table 73).

Table 73: Potential impact of improved wheat varieties with different levels of assumed adoption levels

Assumed adoption level	**Realized/Potential gain**		
	Production (million tons)	**Net Income (billion MAD)**	**Net Income (billion US$)**
Current level (42%)	0.58	9.15	1.06
50%	0.70	10.90	1.26
60%	0.84	13.08	1.52
70%	0.98	15.26	1.77
80%	1.12	17.44	2.02
90%	1.26	19.62	2.28
100%	1.40	21.80	2.53

This shows that any effort that enhances the adoption of improved varieties that are currently in the Moroccan wheat production system is worthwhile. What is more, varieties which have been released more recently might have higher yield potential and hence the country in general and individual farmers in particular could expect even higher benefits than that are being realized at the moment or those hypothesized in Table 73. Tables 74 and 75 provide data from the survey which show how grain yields vary based on the age of varieties, agro-ecologies and variety names and how net margins decrease with age of variety.

Table 74: Yields and gross margins by year of release and agro-ecology

Release date	Irrigated		Rainfed	
	Yield (kg/ha)	Gross margins (MAD/ha)	Yield (kg/ha)	Gross margins (MAD/ha)
1921	2775	8299	647	1376
1982	3375	11702	797	1954
1984	3705	12627	820	2007
1985	3559	13196	838	2356
1988	4024	13154	984	2535
1991			848	2424
1993	4024	12853	971	2526
1994	3800	14172	781	2504
1995	3625	14093	844	2296
1996	3987	13253	997	2673
1997	4525	14720		

Table 75: Yields and gross margins by variety and agro-ecology

	Irrigated		Rainfed	
	Yield (kg/ha)	gross margin (MAD/ha)	Yield (kg/ha)	Gross margin (MAD /ha)
ACHTAR	4024.1	13153.5	987.2	2542.1
SALAMA	4717.9	14005.0	1079.6	2735.9
ARREHANE	4015	12829.4	988.2	2572.1
AGUILAL	4075	15377.5	1016.3	3547.2
RADIA	5058.3	15060.7	1113.0	3263.9
RAJA			914.1	2294.4
AMAL	4025.6	12819.3	988.4	2553.8
TIGRE	3875	13251.4	1053.3	2656.6
MERCHOUCH	3725	11736.0	892.5	2070.9
KARIM	3559.2	13196.1	838.1	2356.2
CRIOCA	5091.7	17819.9	940.3	3354.8
OUM RABIA			720	2379.275
MARZAK	3683.9	13611.4	728.0	1924.3
VITON	3925	13611.4	859.2	2527.3
VITRICO			965	3539.9
SAIDI	3800	14172.4	780.9	2504.4
COCORIT			752.5	2063.8
BELDI	2775	8299.2	679	1619.6
MAZROUBA			675	1809.14
MEHDIA			975	3249.575
ANOUAR			781.7	2038.7
OUISSANE			600	1749.4
KRIFLA KAHLA			575	1061

	Irrigated		Rainfed	
	Yield (kg/ha)	**gross margin (MAD/ha)**	**Yield (kg/ha)**	**Gross margin (MAD /ha)**
WISSAM			844.3	2295.5
JOUDA			725	2267.825
NESSMA	3375	11701.5	829.9	1874.1
MASSIRA			915	1992.8
MANAL			1126.3	3294.8
BLE TENDRE LOCAL			651.4	1303.3
FAIZA			1225	3121.3
BLE DUR LOCAL			570	1172.3
AMJAD			1225	3675.3
IRRIDE			1225	4095.7
PROSSE PERO			1005	3835.5
EL WAFIA			1128.3	2580.5
EL MANAR			575	1221.6
BAIDA			847.9	2423.6
KENZ			780	1599.0
TOMOUH	4525	14720.45		
OURGH	3625	14092.8		
Total	3994.16	13302.64	896.64	2390.63

6.6.4 Seed demand analysis

Farmer perceptions and opinions about wheat seed issues

Survey results show that 49% of farmers believe they are still growing local wheat varieties. While in reality, with a few exceptions, no local wheat varieties exist in the regions covered by the survey. When asked about the certainty of the origin and purity of the seeds of the varieties which they call local, only 24% of the farmers responded that they are very sure while the remaining 76% are either unsure or have doubts. One possible explanation for this high figure for local varieties is that some farmers may consider all uncertified seed which they buy from local markets as local varieties.

For a question about the use of improved varieties, 88.5% of the farm households responded that they are using improved varieties. Along with the figure shown in the previous paragraph for local varieties, this figure shows that sizeable number of farmers believe that they are cultivating both the local and improved varieties, more probably on multiple plots. As is often the case, the farmers don't make any distinction between more recent and old varieties Looking at the adoption rates presented in Section 5.2.1.4, this corresponds to varieties 28 years old or less – showing that even very old varieties are still considered by many farmers as improved varieties. The adoption level of all improved varieties regardless of their release date is above 98%. This shows that about 10% farmers who cultivate improved varieties think that they are cultivating local varieties.

Sample farmers were also asked if they always get all the amount of seed they need and 76% responded yes. This is a high percentage but as it does not specify the type of seed (improved/local or certified/uncertified) and the type of the previous year (good /bad rainfall) this figure may not necessarily be too high. For those who answered "No", only an average of 58% of their annual seed demand was met regardless of the sources where the main reasons for this are unavailability of seeds in the market (76.5%) and very high prices (18.3%).

Estimation of quantity of seed used

Amount of seed used by geographic and agro-ecological zones

The typical sample farmer is using about 176kg of wheat seed per hectare (250 kg/ha for irrigated and 157kg.ha for rained). Applying the area weights to the individual provinces, the total amount of seed that is being utilized in the 21 provinces is estimated at 3.852 million quintals per year. Therefore, assuming the same seeding rate for the provinces that are not covered by our sample, and based on the 5-year average total national wheat area of 2.91 million ha, the total national amount of wheat seed use is estimated at 5.12 million quintals. Out of the total 5.12 million quintals of national seed per annum [AUTHOR PLEASE CHECK THIS FIGURE], about 43% was used in the favorable zones and 33% in the intermediate ones. (Table 76).

Table 76: Seed use by agro-ecological zones

Seed by AEZ	**Total for 21 sample provinces (million quintals)**	**Estimated Total national (million quintals)**	**% of total national**
Favorable	1.670	2.218	43%
Intermediate	1.273	1.693	33%
Unfavorable south	0.444	0.592	12%
Mountain	0.465	0.618	12%
Total	**3.852**	**5.120**	**100%**

The provincial distribution seems to follow the geographic size of the provinces. Sidi Kacem, Settat, Safi and Beni Mellal used 0.35, 0.33, 0.32 and 0.32 million quintals of wheat seed in 2011/12 cropping season (Table 77).

Table 77: Seed use by province (21 sample provinces)

Province	**Total (million quintals)**
Sidi Kacem	0.350
Settat	0.333
Safi	0.323
Beni Mellal	0.322
Taounate	0.287
Rehamna	0.259
Khemisset	0.258
Sidi Bennour	0.204

Kenitra	0.199
El Jadida	0.179
My Yacoub	0.150
Berrechid	0.148
Khenifra	0.143
Meknes	0.139
Taza	0.123
El Kelaa	0.121
Benslimane	0.107
El Hajeb	0.092
Sidi Slimane	0.059
Guercif	0.033
Fes	0.024
Total	3.852

Amount of seed used by variety and by source

Achtar, Amal, Karim, Radia and Merchouch are the top 5 varieties with the highest seed use in Morocco. Secondary data sources also show that the total amount of certified seed produced and distributed in the country follows similar patterns (Table 78). These results are consistent with the adoption degree by variety reported in Section 5.2.1.1 above, but in a slightly different order. These same varieties occupy the largest area relative to other varieties. Estimates of the total amount of seed used by variety and by province are presented in Annex II.

Table 78: Total seed use and certified seed production by variety (21 sample provinces)

Total national seed use (million quintals)			**Total amount of certified seed produced in 2012 (million quintals)**		
Rank	Variety	Amount used in 2012	Rank	Variety	Amount Produced in 2012
1	Achtar	0.732	1	Achtar	0.099
2	Amal	0.517	2	Amal	0.178
3	Karim	0.480	3	Radia	0.214
4	Radia	0.445	4	Salama	0.098
5	Merchouch	0.430	5	Arrehane	0.080
6	Marzak	0.358	6	Rajae	0.058
7	Arrehane	0.318	7	Tigre	0.022
8	Crioca	0.121	8	Wissam	0.058
9	Wissam	0.083	9	Marchouch	0.012
10	Salama	0.074	10	Manal	0.017
11	Saidi	0.073	11	Mehdia	0.010
12	Tigre	0.036	12	Wafia	0.046
13	Ble tendre local	0.032	13	Massira	0.015
14	Raja	0.027	14	Nassim	0.010
15	Nessma	0.022	15	Kanz	0.001
16	Viton	0.015	16	Faiza	0.013
17	Baida	0.015	17	Najia	0.012

Total national seed use (million quintals)			Total amount of certified seed produced in 2012 (million quintals)		
Rank	Variety	Amount used in 2012	Rank	Variety	Amount Produced in 2012
18	El wafia	0.013	18	Samia	0.009
19	Cocorit	0.011	19	Fadela	0.008
20	Aguilal	0.009	20	Resulton	0.003
21	Beldi	0.005	21	Zanzibar	0.003
22	Prosse pero	0.004	22	Gades	0.002
23	Oum rabia	0.003	23	Siena	0.002
24	Ble dur local	0.003	24	Aguilal	0.000
25	Kenz	0.003	25	Bandera	0.001
26	Tomouh	0.003	26	Saragola	0.000
27	Irride	0.003			
28	Massira	0.002			
29	Mehdia	0.002			
30	Manal	0.002			
31	Amjad	0.002			
32	Faiza	0.002			
33	El manar	0.002			
34	Anouar	0.001			
35	Ouissane	0.001			
36	Krifla kahla	0.001			
37	Mazrouba	0.001			
38	Vitrico	0.001			
39	Ourgh	0.001			
40	Jouda	0.000			
Total		**3.852**	**Total**		**0.970**

Analysis of the actual amount and source of seeds used for the 2011/12 cropping season show that 22% of the seed used were of SONACOS origin (17.81% acquired from the local government extension service units and 4.21% from SONACOS' own seed distribution points). Another 13.3% of seed used in 2011/12 were purchased from local informal seed traders in the villages which sell uncertified seed, and still another 13.39% come from seed traders from outside the village (Table 79). The biggest share of about 51.19% is reported to have come from non-official sources (NOS) that include own saved seed. NOS refers to all sources other than the known government and private seed distribution points and shops and businesses including farmer-to-farmer exchange. This shows that the sources for a large quantity of seed are own-saved seed, local grain producers, local grain markets and from seed exchanges between farmers.

Table 79: Seed amount by source

Total Seed Used/Source	Total amount of seed (in million quintals)	% Share out of total seed used
State	0.686	17.81%
Seed company	0.162	4.21%
Non Official Sources (NOS) including own saved seed	1.972	51.19%
Local seed trader	0.512	13.30%

Trader outside the village	0.516	13.39%
Cooperatives	0.004	0.10%
Total	**3.852**	**100.00%**

Among the farmers who said they save their own seed, only 27% said they treat their seed. The remaining 73% said they don't. In terms of storage however, the majority (55%) said they store their own saved seed separately (Table 80). Most of the farmers (86%) store their seed in jute bags kept inside the house and another 11% in polypropylene bags kept in the house (Table 81). Weevils and Bruchids (for legumes) are the main storage problems for 71% and 15% of farmers respectively.

Table 80: Management of own saved seed

	If farm saved, did you treat your seed?	Did you store seed separate from other grains?
Yes	26.7	54.7
No	73.3	45.3
Total	**100**	**100**

Table 81: Mode of storage for own saved seed

Where do you store the seed?	% of farmers
In jute bags kept in house	86.4
In polypropylene bags kept in house	11.1
In jute bags kept in storage area outside house	0.1
Traditional stores	2.3
Total	**100**

From among the sample farmers only 1.3% said that they have plots exclusively for seed production.

Amount of seed used by type and analysis of farmers' seed choices

Out of the total seed they used in the 2011/12 cropping season, farmers reported that 18.5% was certified while the remaining 81.5% was uncertified. The average seed replacement rate is 2.1 years with some farmers replacing every year and some others not replacing for over 10 years. The 10-year average wheat seed and wheat grain sales prices per quintal reported by farmers were 359 MAD (US42.2) and 268MAD (US$31.5) respectively. When asked about the names of their most preferred variety which they know or have heard about, Achtar, Merchouch, Amal, Radia and Arrehane were the top 5 bread wheat varieties mentioned by 32.7%, 26.1%, 13.1%, and 6.3% respectively. Similarly, Karim, Marzak, Carioca and Vitron were the top 4 favorite durum wheat varieties (57.9%, 30.1%, 6.9% and 1.3% of farmers respectively). With the exception of Radia and Carioca, which were both released less than 10 years ago and both of which are non-INRA varieties, all the other 7 farmer preferred varieties are from the INRA/CGIAR collaborative work but are more than 20 years old. This raises a number of important questions on whether: 1) there are new improved INRA/CGIAR varieties which are superior to these old varieties; 2) there are indeed new and better varieties from INRA/CGIAR but the farmers are not aware of them or are not reaching them; or 3) these old varieties are indeed performing well and better than more recent INRA/CGIAR varieties and hence farmers prefer them.

To shed light on some of these questions, farmers were asked if they cultivate their favorite varieties. The results show that 77.4% and 57% of farmers responded "Yes", referring to bread wheat and durum wheat respectively. For those who responded "No", the main reason given (75.7% of the cases) was non-availability of insufficient quantities in the market due to many reasons including lack of adequate rain or irrigation water in the previous cropping season followed by high prices (21.6%). When asked whether they have heard about the new Hesian fly resistant durum wheat variety from INRA called Faraj which was released in 2007 and is hailed by breeders as one of the best available varieties, almost 96% of the farmers responded "No" while the remaining 4% responded "Yes". Among those who responded "Yes", 75.5% said they liked the variety and hence wanted to plant it. But 95.5% said they couldn't get the seed in the market, confirming that lack of information and unavailability of the seeds of most recent varieties in the market provide part or all of the explanation for the dominance of old wheat varieties in Morocco.

Farmers were also asked what they think would be the best way to solve the current seed related problems. The main solutions proposed by farmers are that 1) Seed companies should know better what farmers want and produce enough quantities of those varieties (29.5%); 2) Government should intervene and solve these problems (28%); 3) Purchasing the varieties from the local market (24.5%) - which we understand as farmers saying that the informal sector needs to be strengthened to fill the gap; 4) Creating better access to credit facilities for seed purchase and seed production under irrigation (15.5%). The minimum, average and maximum prices per quintal (100kg) farmers are willing to pay for seed of their favorite variety were 200MAD (US$23.5), 284MAD (US$33.4) and 600MAD (US$70.6) respectively. Their average willingness to pay for seed is more or less equivalent to the actual average harvest-time wheat grain price of about 270MAD (US$31.7). These results are consistent with the traditional way of thinking among most farmers who think the seed prices and grain prices should be the same.

In response to the question about the main problems or issues related to the use of certified seeds, high price of certified seeds was among the main issues for 60% of the farmers. While seed is highly subsidized in the country, the fact that such a vast majority of farmers feel that the price is still high could provide a good explanation to the low level of use of certified seeds. while unavailability of certified seeds and the certified seeds of preferred varieties were important issues for 14.1% and 4.7% of the farmers respectively. About 8% and 6% of the farmers said that long distance to the certified seed distribution centers and lack of access to credit facilities were important factors in their decision for the use of certified seeds.

Regarding the quality of certified seeds, from their own personal experience or from what they hear from other farmers or from what they think, about 80% and 77% of the farmers said they are happy about the genetic purity and physical purity respectively of the certified seeds sold in the market. The seed health and germination ability of the certified seeds were also both good to about 79% of the respondent farmers. Few farmers (11%) said they once in a while engage in exchange of seeds with other farmers while a sizeable number (44%) said that they do save seed from their own wheat grain production of the previous cropping season.

Comparison of net margins between wheat grain and wheat seed production

Production of seed requires more attention, skill, intensive management and extra activities and efforts than producing grains. Moreover, seed production carries higher risk because failing to meet the minimum quality requirements might lead to financial loss, as what was produced as seed might need to be sold as grain. In the face of a substantial gap between the total national seed demand and national supply of certified seeds, one could wonder if there is a role for village-based seed enterprises to play. While this may have a number of political, legal and operational implications and can create a conflict of interest among a number of actors in the seed sector, a first step for studying its feasibility is to make profitability analysis to determine if there are enough economic incentives for the ordinary grain producing farmer or group of farmers to be attracted to the production of seeds. To this effect, we develop crop budget for the typical wheat grain producer, the typical commercial wheat seed producer and a typical local (informal) wheat seed producer who sells the seed to farmers in his/her neighborhood, and we make profitability comparisons. As profits will depend on the ecology of production (irrigated vs. rainfed), by species (durum vs. bread) and by variety (as yields and perhaps input costs might differ across varieties), we selected a total of 6 varieties - 3 bread wheat varieties (Table 82) and 3 durum wheat varieties (Table 83) for comparison.

Survey results show that with the exception of Achtar produced by local seed growers under rainfed conditions and Crioca produced by commercial seed growers also under rainfed conditions, all the rest of cases for which data was available show that seed production indeed leads to higher net margins. However, there is no clear pattern in terms of which mode of seed production (commercial or local) leads to the highest net margins as this seems to vary by variety and agro-ecology. We don't have good explanation for this. Therefore, a more focused and more rigorous study is needed to identify factors which affect the profitability of seed production and also to explain sources of differences in profitability across ecological zones, wheat species, varieties and mode of production. From the results we have, there is a clear indication that with proper training and institutional support, local seed growers can be made profitable. Given the high risk involved, the introduction of crop insurance might also make local seed production more attractive to both large and smallholder grain producers alike.

Table 82: Comparison of crop budget for grain producers, commercial seed producers and local seed producers – bread wheat

Variety	Ecology	Type of producer	Cost (MAD/Ha)									Revenue components (MAD)					% gain relative to grain producers
			Seed	N	DAP	Tillage	Pesticide	Herbicide	Harvest	Transport	Total Cost	Yield (kg/ha)	Grain or seed Price MAD	Value of Residue (MAD/ha)	Total Revenue	Net Margin	
Achtar	Irrigated	Grain producers	490	2983	1106	400	147	79	571	362	6139	4024	2.83	7872	19279	13141	
		Commercial seed producers	751	2801	1238	600	210	113	849	402	6964	4467	3.30	7983	22723	15759	19.9%
		Local seed producers	None in the sample														
Achtar	Rainfed	Grain producers	526	477	282	400	154	83	138	89	2147	987	2.79	1939	4695	2548	
		Commercial seed producers	452	828	401	400	81	44	193	91	2491	1016	3.30	2078	5431	2940	15.4%
		Local seed producers	458	1350	375	400	105	57	191	90	3026	1005	3.30	2103	5419	2393	-6.1%
Radia	Irrigated	Grain producers	607	3670	1436	400	118	63	719	455	7469	5058	2.84	8142	22529	15061	
		Commercial seed producers	725	2574	1706	600	228	123	1148	544	7647	6042	3.29	8598	28475	20828	38.3%
		Local seed producers	628	2484	1500	600	158	85	1131	536	7121	5950	3.29	9235	28810	21689	44.0%
Radia	Rainfed	Grain producers	502	583	313	400	82	44	155	100	2180	1113	2.77	2339	5444	3264	
		Commercial seed producers	452	936	498	400	91	49	229	108	2764	1203	3.29	2182	6141	3377	3.5%
		Local seed producers	481	912	544	400	105	57	229	109	2836	1208	3.29	2216	6189	3353	2.7%
Amal	Irrigated	Grain producers	487	3161	1127	400	130	70	566	362	6302	4026	2.81	7807	19122	12819	
		Commercial seed producers	670	2693	1323	600	210	113	851	403	6864	4479	3.27	8277	22923	16059	25.3%
		Local seed producers	638	2889	1245	600	200	108	868	411	6958	4570	3.27	8342	23286	16328	27.4%
Amal	Rainfed	Grain producers	472	479	314	400	126	68	135	89	2084	988	2.75	1929	4638	2554	
		Commercial seed producers	437	1125	225	400	105	57	214	101	2664	1125	3.27	2196	5875	3211	25.7%
		Local seed producers	483	630	461	400	131	71	200	95	2470	1050	3.27	2207	5640	3170	24.1%

Table 83: Comparison of crop budget for grain producers, commercial seed producers and local seed producers – durum wheat

Variety	Ecology	Type of producer	Cost (MAD/Ha)									Revenue components (MAD)					% gain relative to grain producers
			Seed	N	DAP	Tillage	Pesticide	Herbicide	Harvest	Trans-port	Total Cost	Yield (kg/ha)	Grain or seed Price MAD	Value of Residue (MAD/ha)	Total Revenue	Net Margin	
Karim	Irrigated	Grain producers	486	3115	1192	400	119	64	599	320	6295	3559	3.37	7506	19499	13204	
		Commercial seed producers	727	2624	1287	600	212	114	802	380	6747	4222	3.82	5796	21925	15178	15.0%
		Local seed producers	596	2822	1400	600	210	113	717	340	6799	3773	3.82	5925	20339	13540	2.5%
Karim	Rainfed	Grain producers	492	394	284	400	126	68	139	75	1977	838	3.31	1557	4330	2353	
		Commercial seed producers	488	931	596	400	73	39	191	90	2808	1003	3.82	1549	5381	2573	9.3%
		Local seed producers	462	831	356	400	118	64	194	92	2517	1019	3.82	1580	5471	2955	25.5%
Marzak	Irrigated	Grain producers	516	2912	1085	400	75	40	605	332	5963	3684	3.28	7484	19575	13611	
		Commercial seed producers	None in the sample														
		Local seed producers	619	2504	1125	600	210	113	732	347	6249	3850	3.74	6031	20430	14181	4.2%
Marzak	Rainfed	Grain producers	501	435	260	400	121	65	118	66	1966	728	3.24	1533	3890	1924	
		Commercial seed producers	546	1028	475	400	123	66	192	91	2920	1008	3.74	1661	5432	2511	30.5%
		Local seed producers	None in the sample														
CRIOCA	Irrigated	Grain producers	691	3627	1593	400	96	52	873	458	7790	5092	3.43	8150	25610	17820	
		Commercial seed producers	751	2592	1500	600	210	113	1093	518	7376	5750	3.74	5945	27450	20074	12.6%
		Local seed producers	None in the sample														
CRIOCA	Rainfed	Grain producers	511	491	224	400	56	30	149	85	1946	940	3.19	2312	5300	3355	
		Commercial seed producers	440	930	721	400	90	49	235	111	2976	1236	3.74	1631	6253	3277	-2.3%
		Local seed producers	None in the sample														

6.7 Summary and concluding remarks

After the introduction of durum wheat by the Arabs from the Arabian Peninsula around the 7th century AD and bread wheat by the French colonizers at the turn of the 20th century, both crops have been expanding rapidly in Morocco, reaching an average of 2.04 million and 0.94 million ha in the period 2008-2012. Around 2010 wheat in general and bread wheat in particular represented about 59% and 40% of the total cereals area respectively, showing the growing importance of wheat in the Moroccan agriculture. During the sixties and seventies, wheat yields at national level remained at low levels of about 0.9 tons per ha. This started to increase after the arrival of new and improved bread wheat varieties in the 1980s. After a decade, average yields reached about 1.21 tons per ha for durum wheat and 1.3 tons per ha for bread wheat. With the introduction of many newly improved varieties in the subsequent years, significant increases in wheat yields were observed in Morocco.

However, even though the yield increases over the years are commendable, current yield levels of about 1.5ton/ha in Morocco still remain far behind both the global average of over 3 tons/ha and the African average of 2.3 tons/ha. In the face of the availability of new varieties with yields reaching 4-5 tons/ha, the current yield levels are rather depressing and hence understanding the major reasons behind these low yields and developing mitigation strategies is critical. Low adoption levels of improved varieties are often cited as one of the major constraints which itself is a function of many other variables including an ineffective seed delivery system. Using a nationally representative sample of 1,230 farm households from 21 provinces distributed across 56 districts and 292 villages, this study attempted to provide accurate estimates of current national and provincial adoption levels of improved varieties with special attention to their release date. Analysis of factors influencing adoption of improved wheat varieties and estimation of farm, provincial and national level seed demand have been conducted. The study also attempted to measure impacts of the adoption of improved varieties on the livelihoods of households.

During the survey, 40 wheat varieties were found in farmers' hands (19 bread wheat, 15 durum wheat and 6 unidentified). Out of the 34 identified varieties 10 of them are old (over 20 years of age). The breeding programs of 27 varieties were identified and 18 of them come from the INRA breeding program. With the exception of only 1 variety, the other 17 varieties released by INRA came from the joint INRA/ICARDA/CIMMYT program, showing strong collaboration between INRA and the CGIAR. All these varieties are over 10 years old and are being cultivated by 81.8% of the wheat growers in the country – an indication that they are still the favorite varieties among Moroccan farmers. None of the INRA/CGIAR varieties released in the last 10 years have found their way into farmers' hands. Generally, the top 10 varieties are being cultivated by more than 91% of wheat growers on 92% of total wheat area. Among the top 10 varieties, four are at least 24 years old and cover 56% of the total wheat area, showing that old varieties still dominate the Moroccan wheat fields. Karim and Achtar (both of which come from the INRA/CGIAR program) are the top two varieties being cultivated by 38.1% of the Moroccan farmers.

The national adoption rates for more recent varieties generally stand at very low levels. Only 16% of Moroccan wheat growers cultivate varieties that were released 10 or less years ago while 48% of the farmers cultivate varieties which are 20 or less years old on 41% of total wheat area. With an area-weighted national average varietal replacement rate of 22 years, very old varieties still dominate the Moroccan farmers' portfolio where more than 58% of the growers are still cultivating varieties that were released more than 20 years ago. This raises a number of important questions: 1) whether there are new improved INRA/CGIAR varieties which are superior to these old varieties; 2) whether there are indeed new and better varieties from INRA/CGIAR but the farmers are not aware of them or are not reaching them; or 3) whether these old varieties are indeed performing well and better than more recent INRA/CGIAR varieties and hence farmers prefer them.

Survey results showed that farmers are not up-to-date in terms of new varieties and when they are, seeds of new varieties are not often available. This confirms that lack of information and unavailability of the seeds of most recent varieties in the market provide part or all of the explanation for the dominance of old wheat varieties in Morocco. Availability of seed has a significant effect on adoption. However, the effect is not high enough for seed to take the whole blame for poor adoption levels as is often heard among breeders, development practitioners, policy makers and donors alike. Instead, farmer characteristics (such as age, gender, education, credit access, off-farm employment and whether the farmer hosted demonstration trials) were found to be the most important explanatory variables accounting for 45% of the total variation followed by farm characteristics, which explained 19% of the variation.

The adoption of improved wheat varieties leads to improvements in livelihoods indicators including: 482kg/ha (49%) increase in yields, 1324 MAD/ha (48%) higher net income and 29.6 kg/capita/year (60%) increase in wheat consumption. Given an average area per farm household under the improved wheat varieties of 1.6 ha, the typical adopter farm households are obtaining 771 kg extra wheat production and 2118 MAD (US$246) additional net income - all clearly showing that the improved varieties are contributing to livelihoods improvements. Nationally, the adoption of the improved varieties has led to 17% higher annual production, net wheat income gains of about 9.1 billion MD or US$1.1 billion per year and about 17kg/capita/year of extra wheat availability for consumption from domestic production.

The average seeding rate for wheat in Morocco is 176kg/ha (250 kg/ha for irrigated and 157kg.ha for rained) which translates to a national seed utilization rate of 5.12 million quintals per year. Out of the total seed utilized, 43% is used in the favorable zones and 33% in the intermediate while the remaining 24% is used in the unfavorable and mountainous zones. Achtar, Amal, Karim, Radia and Merchouch are the top five varieties with the highest seed use in Morocco. With the exception of Karim, certified seed is not produced. These results are consistent with the total amount of certified seed produced and distributed in the country.

Out of the total wheat seed used nationally in the 2011/12 cropping season, 22% were of SONACOS origin (17.81% acquired from the local government extension service units and 4.21% from SONACOS' own seed distribution points) while the remaining 78% are from other sources including local seed dealers, seed dealers in neighboring villages and own saved seed. The average seed replacement rate is 2.1 years with some farmers replacing every year and some others not replacing for over 10 years. Farmers stated that unavailability of the desired seeds and high seed prices are the most important problems regarding seed.

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