12 Varietal Output and Adoption in Barley, Chickpea, Faba Bean, Field Pea and Lentil in Ethiopia, Eritrea and Sudan

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Introduction[1]

The International Center for Agricultural Research in Dry Areas (ICARDA) was established in 1977 to undertake agricultural research relevant to the needs of people living in North Africa and West Asia. It has a global responsibility for the improvement of barley, lentil and faba bean in the CGIAR (Consultative Group on International Agricultural Research). Since its founding, it also has a regional responsibility for the improvement of chickpea. Even though ICARDA does not have a global or regional mandate for field peas, its former field pea programme has done some work in genetic improvement of this crop from which Ethiopia has benefited.

These five crops are also important in the Horn of Africa especially in Ethiopia where barley, chickpea, faba bean, field pea and lentil are prized both for their grain and their straw for animal feed. Ethiopia is the dominant producer in sub-Saharan Africa (SSA) where cultivated area in 2011 ranges from close to 1.0 million hectares for barley to only about 90,000 hectares for lentil. Total cultivated area for chickpea, faba bean and field pea approached 1.0 million hectares in SSA in 2011.

The five crops in this paper rank in the top half of the 20 commodities in the DIIVA Project in terms of production growth in SSA over the past 20 years. Most of this increase is due to area expansion that reflects strong market demand for the crop. From the perspective of small-producing households, the development and acceptance of improved varieties in these crops has excellent potential to alleviate poverty in the Horn of Africa where they are mostly cultivated in the longer 'meher' rainy season in the Highlands of Ethiopia and the uplands of Eritrea. They are hardy crops that tolerate cold temperatures and drought. Of the five, chickpea is perhaps characterized by the harshest production environment. As in India, it is planted in the post-rainy season and is cultivated on residual moisture in deeper black clay soils.

Survey Design and Data Collection

Initially, ICARDA's participation in the DIIVA Project centred on one cereal, barley, and three pulses, chickpea, faba bean and lentil, in one country, Ethiopia. Because ICARDA has supported genetic improvement in these crops in other countries in East Africa, Eritrea and Sudan were added to the study. Given the importance of field peas in Ethiopia, ICARDA

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also recommended that field pea be included during the project initiation workshop.

Five crops and three countries give 15 possible crop-by-country observations. Of these, six crop-by-country combinations are not relevant because of negligible area and production. The nine relevant observations pertain to the five crops in Ethiopia, barley and chickpea in Eritrea, and faba bean and chickpea in the Sudan.

Only one observation, barley in Ethiopia is available for a reliable before-and-after analysis. Ethiopia was the only country in SSA in the barley chapter in Evenson and Gollin (2003) (Aw-Hassan *et al.*, 2003a). Chickpea, faba pea and field pea were not covered in the 1998 Initiative. They are regarded as new crops for the DIIVA Project (Walker, Chapter 4, this volume). Even though lentil in Ethiopia and Sudan is included in both the 1998 and the current initiatives, estimates on certain aspects in the 1998 Initiative were incomplete (Aw-Hassan *et al.*, 2003b). Moreover, Sudan is traditionally not a lentil-growing country. In the 1980s in collaboration with ICARDA, a programme to promote lentil production started in the Sudan. Promotional policies to encourage lentil production in northern Sudan, especially in the Rubatab area, were launched. Consequently, cultivated area increased to about 9240 ha in 1992/1993; however, after removal of support, lentil crop area decreased sharply. Most farmers have abandoned lentil cultivation.

Assembly, elicitation and collection of project-related data on scientific staffing, varietal release and varietal adoption in Ethiopia involved a high degree of interaction between ICARDA and the Ethiopian Institute of Agricultural Research (EIAR). Multiple visits were made to Ethiopia, several workshops were held, and several surveys of scientists and farmers were carried out. Given that barley, faba beans and potato share the same agroecologies, a nationally representative adoption inquiry on improved varieties was conducted jointly with the International Potato Center (CIP) in the Ethiopian Highlands. In contrast, the degree of interaction with national scientists in Eritrea and the Sudan was low. Information in those countries was obtained from responses to questionnaires via e-mail.

Estimates of scientific staffing were collected by the national crop coordinators from their respective human resources departments. In Ethiopia, national estimates were compiled from two federal research centres and six EIAR regional research centres. The number of scientists involved in and the level of funding for research on the five crops at universities and by private companies are negligible (at most 5% of total national research investment for each crop). Therefore, only public-sector investments were included in the 2010 database on the scientific strength of crop improvement programmes.

Data on scientific strength in pulse improvement obtained from the Sudan and Eritrea were not disaggregated by crop type. Likewise, in the case of Ethiopia, data were available for two groups: lentil and chickpea were in one regional research subprogramme, and faba bean and field pea were in another. These grouped estimates were disaggregated using shares allocated to each crop estimated by national counterparts.

For Ethiopia, elicitation of adoption estimates was carried out in a systematic manner during a workshop held in Addis Ababa in mid-2011. Breeders, research managers and economists from EIAR headquarters met with economists from ICARDA. Major agroecological zones were identified for improved varieties as a group for the four ICARDA mandate crops into one of three (high, medium and low) levels of uptake (see Appendix Table 12.A1). Generating estimates of the area under local and improved varieties of each crop by agroecological zone was the third step in the process. These figures were further disaggregated by variety. After variety-specific estimates were obtained, EIAR's crop-research coordinators were asked to disaggregate the adoption estimates into administrative zones, which are easier to understand and more immediate.

At every stage of the estimation and disaggregation process, the adoption estimates were refined and seemed to better reflect reality. During the initial stages, there were sharper disagreements among the different experts on the estimates, whereas, at the later stages, when the estimates started to become smaller (especially when the zonal level adoption estimates were generated), most experts arrived at a consensus, suggesting that estimates are more realistic when conducted for smaller geographic areas.

Scientific Strength of the Barley, Chickpea, Faba Bean, Field Pea and Lentil Improvement Programmes

Crop improvement is defined broadly and includes not only plant breeding but also all other disciplines that contribute to the programme, such as pathology, physiology, entomology, social science and postharvest technology (Table 12.1). A quick look at the total number of full-time equivalent (FTE) scientists suggests that the crop improvement programmes in Ethiopia and the Sudan are adequately staffed. Each programme has at least 6.85 FTE scientists and, relative to its economic importance, the chickpea improvement programme in the Sudan is one of the largest in the DIIVA Project. Better-staffed programmes in Ethiopia and Sudan were expected in large agricultural countries in SSA with strong national programmes at EIAR and ARC (Agriculture Research Corporation, Sudan).

The same cannot be said for the level of investment in agricultural research in Eritrea, which reinforces the stereotype of a very small NARS setting that is at best able to maintain some germplasm and engage in borrowing from neighbouring countries. Staff is only deployed in breeding. The pulse programme does not conduct any research on chickpea or faba bean.

Ethiopian crop improvement programmes are characterized by a heavy concentration on plant breeding that approaches or exceeds half of FTE positions. The emphasis on breeding is especially marked in the improvement of field pea and faba bean in Table 12.1. A decentralized regional research setting may explain the apparent concentration on breeding relative to other disciplines. In contrast, Sudan has invested heavily in pathology and agronomy in a more diversified disciplinary setting where the number of pathologists and agronomists equals the number of plant breeders. In Sudan, the main production region of chickpea is in the River Nile State where farmers realized that traditionally grown local varieties are highly susceptible to wilt disease, which reduces yield considerably. Hence, searching for resistance to *Fusarium* wilt and *Ascochyta* blight is an important component of the chickpea improvement programme, which, in turn, partially explains the strong demand for pathologists.

Scientific staff in both Ethiopia and the Sudan are well educated relative to their peers in other crop improvement programmes in SSA. In the pulse programmes, PhD and MSc staff outnumber BSc staff in both countries. In contrast, the three members of staff in Eritrea listed in Table 12.1 are at the BSc level.

Likewise, estimated research intensities compare favourably with estimates for other crops discussed in earlier chapters of this volume. For example, in Ethiopia, the number of FTE scientists per million tonnes of production ranges from a low of about 11 in field pea and faba bean to a high of 43 in lentil.

Between 1998 and 2010, scientific staffing in the barley programme in Ethiopia has expanded from 4.8 to more than 20 FTE scientists (Aw-Hassan *et al.*, 2003a). This significant expansion did not, however, usher in a change in the disciplinary composition of scientific staff. In 1998, barley improvement was concentrated in breeding as it is today.

Table 12.1. Full-time equivalent (FTE) staff by major specialization in 2010.

Crop	Country	Breeding	Pathology	Entomology	Agronomy	Seed production	Postharvest	Social science	Total
Barley	Eritrea	1.00	0	0	0	0	0	0	1.00
Barley	Ethiopia	9.10	3.00	2.60	3.60	0	0	2.80	21.10
Chickpea	Ethiopia	3.90	1.08	0.84	0.60	0.36	0	1.62	8.40
Chickpea	Sudan	6.00	4.80	0.60	5.40	0	0.60	1.20	18.60
Faba bean	Ethiopia	4.85	0.25	0.13	0.68	0	0.13	0.83	6.85
Faba bean	Sudan	2.80	2.24	0.28	2.52	0	0.28	0.56	8.68
Field pea	Ethiopia	4.85	0.25	0.13	0.68	0	0.13	0.83	6.85
Lentil	Eritrea	2.00	0	0	0	0	0	0	2.00
Lentil	Ethiopia	2.52	0.64	0.52	0.36	0.24	0	1.00	5.28

Recent data on the number of scientists (FTE) have been collected for ICARDA in three time periods: 1999, 2005 and 2009. The figures show that there has been a marginal increase (10%) in the manpower deployed in barley and faba bean and a marginal reduction (7%) in the manpower deployed in lentil research over the last decade. On the other hand, staffing in the chickpea programme remained more or less the same.

Comparison of even earlier data for barley (Aw-Hassan *et al.*, 2003a) suggests that the size of the ICARDA barley programme has been stable at about 4.5 to 5.5 FTE scientists since 1990. In 1980, the programme was somewhat smaller at 3.5 FTE scientists. Lentil improvement at ICARDA follows a somewhat different trajectory. Small staff investments in pathology, genetic resources and biotechnology drove an increase equivalent to 0.5–0.75 FTE scientists in the late 1990s that has been maintained over time. Project changes related to agronomy and postharvest projects have resulted in fluctuations and a small decline in staffing since 1999.

Varietal Output from the Barley, Chickpea, Faba Bean, Field Pea and Lentil Improvement Programmes

During the past 30 years, there has generally been an increasing trend in the total number of varieties released. About half of the total of 140 varietal releases occurred in the most recent 5-year periods (Table 12.2). Since 2001 releases have also showed fewer fluctuations over time as the incidence of zero-release events has declined. Enhanced stability in varietal output applies mainly to Ethiopia in barley, chickpea and faba bean.

Eritrea is characterized by few releases. Indeed, no chickpea varieties have been released officially, although it is believed that improved cultivars from Ethiopia and the Sudan have been smuggled across the border and are being planted by farmers.

Releases in the Sudan display a different temporal behaviour. They peaked in the late 1980s and the 1990s for both faba bean and chickpea. Three lentil varieties were also released in the Sudan in the 1990s. Given the apparently well staffed, pulse improvement programmes described in Table 12.1 for Sudan, the decline in recent activity in varietal release is puzzling.

The 38 barley releases in Table 12.2 mostly came from pureline selections of local landraces in Ethiopia and populations of local landraces in Eritrea. Seven varieties were selected from ICARDA-bred elite materials. The first of these was released only a decade ago in 2003. Three varieties were introductions from developed countries. Six were generated from national programme crosses. For one released variety, information on the role of national agricultural research system (NARS) is missing.

Although the barley programme in Ethiopia is a mature crop improvement programme, the path to maturity was non-linear and cannot be readily inferred from the varietal release information over time. Pureline selections from local

Table 12.2. Number of varieties released by crop and country over 5-year periods from 1980 to 2010.

Crop	Country	1980 or earlier	1981–1985	1986–1990	1991–1995	1996–2000	2001–2005	2006–2010	Total
Barley	Ethiopia	4	1	1	2	2	16	12	38
Barley	Eritrea	na	na	na	0	0	3	0	3
Lentil	Ethiopia	1	3	0	2	1	3	1	14
Faba bean	Ethiopia	4	0	0	3	1	7	6	21
Faba bean	Sudan	0	0	3	3	0	0	1	7
Chickpea	Ethiopia	3	1	0	2	2	5	6	19
Chickpea	Sudan	0	0	4	4	6	0	1	15
Chickpea	Eritrea	na	na	0	0	0	0	0	0
Field pea	Ethiopia	2	2	0	6	7	3	6	26
Total		14	7	8	22	19	37	33	140

na, prior to 1991 Eritrea was part of Ethiopia.

landraces were released as late as 2007, and intensive direct crossing and selection was carried out as early as the mid- to late 1970s.

In general, the pulse improvement programmes show a greater reliance on the selection of elite materials and finished varieties and less emphasis on the release of pureline selections of local landraces. Released Desi and Kabuli chickpea in Ethiopia are predominantly selected from ICRISAT and ICARDA elite lines. In Sudan, all released chickpea varieties are either ICARDA-bred materials or are derived from ICARDA crosses. Direct introduction of elite germplasm from ICARDA figures prominently in lentil releases in Ethiopia. In contrast, genetic improvement in faba bean shows a wide range of activities in Ethiopia from the release of a few purified landraces to the direct utilization of ICARDA germplasm to the crossing and selections from ICARDA germplasm progenies. The Sudan has carried out breeding activities on faba bean since 1960. Most released varieties are the result of selection from its own crosses. Lastly, finished varieties from several international sources, including India and Australia, loom large in the production of released field pea cultivars in Ethiopia.

The varietal output data in Ethiopia are rich in information on the notable traits of released varieties. The majority of barley releases are tolerant to the major leaf diseases of scald and net blotch. Some show tolerance to shootfly and early vigour that translate into healthy early-season, stand establishment. Others are prized for their good malting quality and potential for making local beer. Still others show specific regional and wide seasonal adaptation and can be cultivated in both the meher and belg seasons in Ethiopia. Tolerance to drought and resistance to lodging are other desirable traits that are mentioned in several of the release descriptions. A few releases are characterized by good biomass production, tall plant height and soft straw that confer advantages in feeding livestock. In Eritrea, tolerance to drought is a very important trait in the selection of varieties from landrace populations.

For the grain legumes, disease resistance, early maturity and large seed size figure prominently, in addition to high-yield potential, as desirable traits in East Africa. Tolerance to waterlogging is frequently mentioned in the faba bean release descriptions. Resistances to rust and wilt are valuable traits in lentil where root rot can be a severe constraint to production. There is also a strong demand for *Ascochyta* blight and *Fusarium* wilt resistances in chickpea. Market-related criteria, such as seed size and colour, are prized in field pea. In general, tolerance to and escape from abiotic stresses, resistance to major diseases and desirable market characteristics are foremost considerations in these released pulse varieties. Like the barley-released cultivars, most of these modern grain-legume varieties can stake a claim to scoring well on two to three of these desirable traits.

Adoption of Improved Barley, Chickpea, Faba Bean, Field Pea and Lentil Varieties

The uptake of improved barley varieties is substantially higher than the adoption of released varieties of ICARDA-mandated grain legumes in Ethiopia (Table 12.3). The adoption estimate of 39% is calculated from a survey of 1278 barley-cultivating households in the three main growing regions in Ethiopia (Yigezu *et al.*, 2012b). The estimate from the elicitation of expert opinion was 29% for the adoption of improved varieties in the same regions and administrative zones where the survey was conducted and 23% for the country as a whole when marginal geographic regions in the Rift valley and the short-duration rainy belg season are considered. Extrapolating the difference between the survey and expert estimates gives an estimate of about 26% for a mixed-source national estimate. Aggregating up secondary data at the lowest administrative level, the ‘kebele’, generates a national estimate of 16%; however, the uptake of the leading household-survey cultivar, M-21, a recently released variety rapidly gaining favour with farmers in the Orimoya region, is barely visible in the secondary data (Yigezu *et al.*, 2012b). When more marginal producing regions and seasons are considered, that estimate could decline to 26% based on expert opinion in all geographic areas in the two growing seasons. Both estimates are also substantially higher than the 11% national estimate in the late 1990s (Aw-Hassan, *et al.*, 2003a). Therefore, barley improvement has made steady progress in modern varietal adoption in the recent past.

Table 12.3. Adoption of improved cultivars in the ICARDA commodity mandate in East Africa in 2010 by crop, country and contribution of the IARCS.

			Percentage of area under the crop planted to:		Materials containing ICARDA germplasm or directly related to CG Center activities	
Crop	Country	Average area 2008–2010 (ha)	Local varieties	Improved varieties	Area (ha)	MV area (%)
Barley[a]	Ethiopia	969,000	61	39	132,000	40
Barley[b]	Eritrea	42,000	85	15	6,300	100
Chickpea[a]	Ethiopia	222,000	81	19	29,000	100
Chickpea[b]	Eritrea	6,000	98	2	120	100
Chickpea[b]	Sudan	21,000	0	100	21,000	100
Faba bean[a]	Ethiopia	537,000	89	11	3,650	17
Faba bean[b]	Sudan	77,000	13	87	0	0
Lentil[a]	Ethiopia	92,000	85	15	9,200	100
Field pea[b]	Ethiopia	225,000	98	2	0	0

[a]Nationally representative survey; [b]expert opinion.

With about 15–19% of area under improved varieties, the diffusion of modern chickpea and lentil cultivars is superior to the uptake of released materials for faba bean and field pea in Ethiopia. Adoption differences in chickpea and lentil on the one hand and faba bean and field pea on the other do not seem to be related to research output in the form of released varieties. All four crops are characterized by at least ten varieties in their opportunity set for adoption. Indeed, more varieties have been released in faba bean and field pea than in chickpea and lentil.

The improved varieties of the four pulse crops have one thing in common. Their cultivation is restricted to small geographic pockets in larger growing regions. This clustered spatial pattern is usually the result of well defined, project-related technology transfer programmes.

As a cereal with multiple uses, the prospects for improved varieties are brighter in barley than in grain legumes. First, barley has a substantially higher multiplication ratio than pulse crops where one planted seed seldom if ever generates more than 100 seeds of output. More output from the same weight of propagation materials potentially accelerates the diffusion of improved varieties. Secondly, local barley varieties are not suitable for brewing; therefore, as local and national brewing expands, the demand for improved malting barleys increases.

Eritrea lags behind Ethiopia in the adoption of barley and chickpea. Sudanese scientists reported very high levels of adoption of improved chickpea and faba bean varieties. Relatively small areas under cultivation with irrigation may partially account for these perceived levels that approach or equal full adoption.

The Highlands between 1700 and 3000 masl (metres above sea level) is the dominant agroecology for the cultivation of the ICARDA-mandated crops in Ethiopia. Their production relies on seasonal rainfall because they are rarely irrigated. Rainfed barley and chickpea in Eritrea is produced at a lower altitude in upland conditions. Faba bean and chickpea are irrigated in the Sudanese lowlands.

Within the highlands of Ethiopia, spatial variation in adoption of improved varieties is marked. For example, adoption of improved barley varieties in the three main highland regions varies from about 13% in Amhara to 53% in Orimiya (Yigezu *et al.*, 2012b). In several ‘weredas’ (districts) in Orimiya, adoption exceeds 75%, especially in areas that specialize in the production of malting barley.

In terms of production potential, barley can be divided into three recommendation domains in Ethiopia: high potential highlands, low potential highlands and the low moisture region. The high potential highlands contribute an area share of 75% and an adoption share of 85% which is greater than comparable shares for the two lower potential production domains but less than expected as improved varieties have also penetrated into areas of the lower potential regions.

Improved barley adoption varies by altitude. Barley is mainly cultivated between 2300 and 3200 masl. The household survey data show that this range of elevation accounts for 88% of growing area and 96% of adopted area. Altitudes below 2300 masl in Ethiopia are characterized by lower levels of improved variety adoption similar to the uplands in Eritrea.

About half of improved variety area is planted to two leading barley varieties in Ethiopia Miscal-21 (M-21) and Holker. M-21 is an improved malting variety that was released in 2006 (Table 12.4). It was bred and selected in Mexico in ICARDA's barley improvement programme hosted by CIMMYT. According to focus-group interviews in sampled communities, M-21 is prized for its high yield and desirable qualities for food and feed. In 2010, M-21 was increasing in area in 34 of the 35 communities where it was grown in the sample survey. It was claiming some area from traditional varieties but it was also replacing Beka, an early first-generation malting variety. Beka was introduced by EIAR from France in 1973.

From the perspective of the household survey of 1280 barley producers, experts markedly underestimated the economic importance of this recently released variety. Experts gave an estimate of 2–3% of area planted to M-21; the survey estimate was 9–11%. This difference partially explains why experts believed that the aggregate improved food varieties contributed more to improved varietal area than the total improved malting varieties. The split in expert opinion between these two types was about 14% for food and 9% for malting varieties. Comparable estimates on improved variety adoption from the household survey were 18% for food and 21% for malting varieties.

The second leading barley variety is also a malting variety. Holker is valued for its high yield, attractive price and its desirable food quality. Although released in 1979, it still seems to be spreading in the Ethiopian Highlands, albeit at a slow pace. Holker was bred at EIAR. Research in Kenya contributed to its pedigree.

None of the improved food varieties could stake a claim to more than 5% of area in the household survey but the two most popular, HB 42 and HB 1307, merit a brief description. HB 42 was the leading food variety. Its economic importance was equivalent to slightly less than 10%, or about 32,000 of the 330,000 ha of total area sown to improved barley varieties. Aside from its high yield and attractive price, it is valued for its large-sized grain.

Of all the released barley food varieties, HB 1307 has the most promising adoption prospects. Respondents in 12 of 13 communities where it was grown believed that it was expanding in area. Heavy yield, desirable grain colour and tolerance to lodging were cited as its strong points. It was released in 2006, and experts appeared to be aware of its potential. They placed it slightly ahead of HB 42 in adopted area.

Although released more than two decades apart, HB 42 and HB 1307 were both selected from EIAR crosses. Of the five top-ranked improved varieties in adoption, three were bred nationally and two were bred internationally. Collectively, they account for about 70% of adopted area. The remaining 30% is contributed by 14 other improved varieties that were usually identified by name in the household survey. These varieties tended to be pureline landrace selections and were more regional and location specific than the top five, which seemed to be characterized by wider adaptation.

Perceived adoption of two of the improved pulse varieties in Ethiopia also exceeded 5% in Table 12.4. Arerti is the most widely diffused modern variety of chickpea. It is an early-maturing, *Ascochyta*-resistant elite line from ICARDA. Alamaya is the leading improved lentil variety. It too is an elite ICARDA line, in this case incorporating rust resistance in a heavy-yielding background.

In Sudan, the leading varieties are Basabeer (BB7) in faba bean and Burgeig in chickpea. The share of their adopted area is believed to exceed 30% in each crop. Although breeding food legumes in Sudan started in 1960, information on the pedigrees of these leading varieties was not reported.

No improved faba bean or field pea variety was adopted on more than 5% of cultivated area in Ethiopia. Only 3 of 19 released faba bean varieties and 3 of 26 released field pea varieties were perceived as being cultivated in farmers' fields in 2010. For faba bean, West Shewa was the administrative zone with the highest level of adoption at only 7% of cultivated area. For field pea, the adoption level in the zone with the fastest uptake was even lower at 3% in Gurage.

Table 12.4. Economically important improved varieties of commodities in the ICARDA mandate in East Africa in 2010 by crop, country and ecology.

Crop	Country	Ecology	Variety name	Release year	Area coverage (% of ecology)	Total area of ecology ('000 ha)	Age
Faba bean	Ethiopia	Highland under rainfed conditions	CS-20DK	1977	3.34	15,650	33
			Degaga	2002	1.41	3,183	8
			Wolki	2007	2.04	55	3
Ethiopia total faba bean					11.29	18,888	
Faba bean	Sudan	Irrigated lowlands	Basabeer (BB7)	1993	35.00	27,000	17
			Hudeiba 93	1993	30.00	23,000	17
			Selaim-(SML)	1987	22.00	17,000	23
Lentil	Ethiopia	Highland under rainfed conditions	Alamaya	1997	14.43	6,977	13
			Teshale	2004	0.00	954	6
			Alem Tena	2004	0.00	156	6
			Adaa	1995	0.79	1,142	15
			Others		0.36	330	15
Ethiopia total lentil					15.58	9,559	
Lentil	Eritrea	Rainfed highlands	Bir Selam	2008	0	0	2
Barley	Ethiopia	Highlands under rainfed conditions	HB 42	1984	4.30	31,696	26
			HB1307	2006	2.50	16,284	4
			Aruso	2005	2.21	16,187	15
			Ardu1260-B	1986	1.67	7,367	24
			3336-20	1995	1.77	7,367	12
			Others	1975–2010	5.71	60,194	17.5
			Total food barley		18.15	139,095	
			Miscal-21 (M-21)	2006	10.6	87,625	4
			Holker	1979	7.95	81,712	31
			Beka	1973	2.59	19,289	37
			Total malting barley		21.14	188,626	
Ethiopia total barley					39.29	327,721	
Barley	Eritrea	Upland	Tekonda	2004	7.00	2,923	6
			Rahwa	2004	6.00	2,505	6
			Shishay	2004	2.00	835	6
			Total		15	6,263	
Chickpea	Ethiopia	Highlands under rainfed conditions	Arerti	2000	10.19	14,852	10
			Shasho	2000	5.63	3,482	10
			Habru	2004	0.88	4,683	6
			Natoli	2007	0.03	698	3
			Others	1974–2010	2.13	5,317	18
Ethiopia total chickpea					18.8	29,023	
Chickpea	Eritrea	Upland	Names not known	NK	2.00	118	NK
Chickpea	Sudan	Irrigated lowlands	Burgeig (ICCV 91-302)	1998	40.00	8,400	12
			Atmor (ICCV 89-509)	1996	15.00	3,150	14
			Shendi (ILC 1335)	1987	10.00	2,100	23
			Hawata (ICCV 92-318)	1998	10.00	2,100	12
			Salawa (FLIP 89-82C)	1996	10.00	2,100	14
			Matama-1 (FLIP 91-77C)	1998	10.00	2,100	12
			Wad Hamid (ICCV-2)	1996	5.00	1,050	14
Field pea	Ethiopia	Highlands under rainfed conditions	Adi (G22763-2C x 305PS210813-2)	1995	1.10	2,473	15
			Mohanderfer	1979	0.37	827	31
			Tegegnech	1994	0.06	124	16
Ethiopia total field pea					1.44	3,424	

NK, not known.

In general, data in the last column of Table 12.4 suggest that slow rates of varietal turnover are most problematic for the faba bean improvement programme in the Sudan where the varieties in farmers' fields were released 17–23 years ago. An ageing variety could also be a cause for concern for faba bean in Ethiopia as the most popular improved cultivar was released in 1977. However, the issue of slow varietal turnover is overwhelmed by the importance of increasing varietal adoption from a very low level. Prior to the release and adoption of M-21, slow varietal turnover was an increasingly pressing issue for the genetic improvement of malting barleys in Ethiopia. The rapid early acceptance of M-21 has quickened the pace of varietal turnover and has mitigated the seriousness of that issue, as age should be trending downwards over time with the substitution of M-21 for Beka.

Summary

Several empirical results in this paper provide grounds for optimism about the prospects for improved varietal change in the ICARDA-mandated crops in East Africa especially in Ethiopia. The uptake of improved varieties of barley has increased from about 10% of cultivated area in the late 1990s to about 39% today. Improved malting barleys account for most of the gains in adoption; however, released food barleys are also more readily finding a home in farmers' fields. The release of several ICARDA-related varieties in the 2000s has added to the dynamism of varietal production in EIAR's barley improvement programme. The rapid early adoption of M-21 is an emerging success story.

Better-staffed crop improvement programmes in Ethiopia in barley and in grain legumes and in the Sudan in grain legumes represent another encouraging development. Not only are the programmes strong in numbers, but also a high proportion of scientists have MScs and PhDs.

In Ethiopia, varietal output in all five of the ICARDA-mandated crops has been sufficient to drive improved varietal change. Except for lentil, each crop improvement programme has released at least ten varieties since 2001.

The results have also shed light on multiple areas for improvement in generating improved varieties characterized by better adoption outcomes. For Ethiopia, poor past adoption performance in the four pulses is a cause for concern. The diffusion of improved varieties in chickpea and lentil is not substantially different from 10%; the adoption of modern faba bean and field pea cultivars is less than 5%. In contrast, the results in Chapter 8 on bean, called haricot bean in Ethiopia, show estimated adoption approaching or exceeding 40%. This difference begs the question: why is adoption of improved bean varieties, such as Awash and Nasir, substantially higher than farmer acceptance of released varieties of the other four economically important grain legumes in Ethiopia? In the same vein, why is modern variety adoption higher in chickpea and lentil than in faba bean and field pea when varietal output has been greater in the latter crops than in the former? Informative responses to these two questions could help redirect crop improvement and/or technology transfer strategies.

Barley in Ethiopia faces the common problem of low acceptance of improved varieties in a large-producing region. Nationally representative survey results are consistent with a difference in estimated adoption of about 40% in the two major-producing regions in the Ethiopian Highlands. Amhara lags far behind Oromiya in improved cultivar adoption. Arriving at a better understanding of the causes of these spatial differences in adoption could also be informative for fine-tuning plant breeding strategies and tactics.

The absence of released varieties since 2000 seems to be the most problematic issue for pulse improvement in the Sudan. As a result, first-generation improved varieties are not being replaced by more productive younger varieties in farmers' fields. Slow varietal turnover of improved varieties translates into stagnating outcomes for the faba bean crop improvement programme. Given fairly high staff numbers and education levels, a paltry performance in varietal release is puzzling.

Eritrea needs to make more of a commitment to agricultural research. Its staffing pattern seems too low to make sustained progress in varietal development, adoption and impact. Without more commitment, it will have to depend on varieties released in neighbouring countries.

The results also have two methods-related implications. First, expert opinion elicitation of cultivar-specific adoption estimates is best performed at a low level of spatial aggregation. It is easier to arrive at a consensus at a lower administrative level. Staying at a more aggregate level, such as an agroecology, would have led to higher and most likely more unrealistic estimates of improved cultivar adoption. Secondly, extension agents and non-governmental organization (NGO) transfer specialists should also be included in the pool of experts. In this study, experts may have been defined too narrowly to include only scientists.

Note

[1] This paper is a revised and abridged version of ICARDA's Objective 1 Report submitted to the DIIVA Project in June 2012 (Yigezu *et al*., 2012a).

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Appendix 12.1

Table 12.A1. Priority areas for survey on adoption/diffusion studies: areas of high potential and high likelihood of diffusion.

	Crops							
	Lentils and chickpeas		Faba bean and field pea[a]			Barley		
Location	HP	LM	LT	RS	BS	HP	LM	Belg[b]
Shewa								
North Shewa (Oromiya)	***				**	***		*
North Shewa (Amhara)			*					
Enewari								
West Shewa								
East Shewa	***	*						
SW Shewa					***			
Gurage zone				***				
Arsi	*			***		***		*
Gonder								
North Gonder	*		*	**		***		
South Gonder						**		
Bale	*					**		*
North Ethiopia								
Tigray		*					**	
North-east Ethiopia								
Afar region								
Wollo								
South Wollo	*							*
North Wollo							**	
East Wollo								
Hadiya zone								
Rift valley								
Gojam	*							

[a]The distribution of field peas is exactly the same as that of faba beans except that field peas are not grown in the black soil (vertisol) regions.[b]Belg is the local name of the shorter rainy season in Ethiopia which usually is received between March and April. ***,**,* represent high, medium and low levels of diffusion of the new crop varieties, respectively. Ranking (using the number of asterisks) is done only within each crop (column). Hence, three asterisks for faba beans show high adoption relative to other zones producing faba beans but it does not imply equality in the level of adoption of lentils in zones with three asterisks in the lentils column. HP, high potential; LM, low moisture; LT, low temperature; RS, red soil; BS, black soil.