Enhancing the productivity and production of chickpea in Eastern and Southern Africa

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Summary

The chickpea research and development activities were conducted in three Eastern and Southern African (ESA) countries namely, Ethiopia, Kenya and Tanzania with due involvement of NARES, ICRISAT-ESA, progressive farmers, NGOs and all the major stakeholders.

The major success was achieved on the fast track release of seventeen chickpea varieties in the three target countries viz., Ethiopia (7), Tanzania (4) and Kenya (6).

Three hundred and twenty eight farmers' participatory varietal selection (PVS) trials were conducted in Ethiopia (136), Tanzania (107) and Kenya (85); with an involvement of 16,782 farmers (Ethiopia 10,461, Tanzania 4,102, and Kenya 2,219). In addition, 2,392 field demonstrations (Ethiopia–2209, Tanzania–11, and Kenya–172) were organized to disseminate the best bet varieties and promising production technologies. During the FPVS, 40 released or pre-released varieties (Ethiopia–15, Tanzania–12 and Kenya–13) were included along with a farmer's variety as a check and the feedback were collected from the farmers and other major stakeholders. During the farmer participatory varietal evaluations and the field days farmers were asked to select preferred varieties along with preference criteria that resulted in recording of a number of preferred traits, which facilitated the short-listing of varieties for fast track release. In Kenya, the utilization of chickpea products was demonstrated and this elicited the feedback on most preferred chickpea based products. The farmers rated *githeri* and stew as the most preferred food preparations.

During the past seven years, a total of 111.5 tons breeder, 1,036.5 tons basic and 15,328.5 tons certified seed of farmer–preferred improved varieties were produced by various stakeholders. In ESA, 2685.0 tons seed were produced under TL II involving 22 varieties.

Several training programs were organized to improve the knowledge of farmers on chickpea production, crop and seed health, and seed processing aspects. A total of 13,218 farmers and 570 Extension staff participated in these training programs. One hundred and twenty four field days were conducted in target locations of Kenya (37), Tanzania (34) and Ethiopia (53) with the participation of 16,782 farmers. An information bulletin was published on improved chickpea technologies and seed production in Ethiopia (in both English and Amharic). Twelve participants took part in a one-month training course on "Chickpea Breeding and Seed Production" organized at ICRISAT-Patancheru during January–February 2008 and 2009. One two-weeks training course on "Pre-breeding and legumes improvement" was organized at ICRISAT-Patancheru during 2013 in which five researchers from ESA (Ethiopia [1], Kenya [2], Tanzania [2]) participated. One training program on chickpea agronomic management and germplasm maintenance was organized during 10–12 September 2013 in Nairobi with 23 participants from seven ESA countries. Two MSc students from Kenya and one from Ethiopia finished the research work and one more student from Ethiopia also submitted master's degree thesis.

Background

Chickpea provides a unique opportunity of enhancing legume production in Africa as it does not compete for area with other major legumes. Groundnut, cowpea, soybean and common bean are the wet season (rainy season) legumes, whereas chickpea is a dry-season (post-rainy season) legume. There is not much choice of legumes for growing on the residual moisture in the post-rainy season, the conditions and season in which chickpea is grown.

Chickpea is grown in ESA countries namely Ethiopia, Tanzania, Malawi and Kenya and to a little extent in Eritrea and Uganda. During the last decade, chickpea production has increased by 153%, and this change was mostly caused by the productivity gains (85%) and followed by area increase (37%). The productivity in ESA surpassed by more than 1.2 t/ha (Table 44).

Table 44. Area, production and productivity trends in ESA.

Year	Area (1000 ha)	Production (1000 tons)	Productivity (kg ha^{-1})
ESA			
2001–2003	360.8	240.6	667.1
2004–2006	378.8	268.2	707.4
2007–2009	380.6	355.6	936.0
2010	384.8	420.3	1092.1
2011	453.9	558.6	1230.9
2012	493.0	609.4	1236.3
Ethiopia			
2001–2003	187.1	166.2	889.5
2004–2006	197.8	196.8	990.9
2007–2009	213.3	275.1	1289.6
2010	208.4	322.8	1549.2
2011	231.3	400.2	1730.0
2012	239.5	409.7	1710.7
Tanzania			
2001–2003	67.0	29.0	432.5
2004–2006	67.0	31.5	474.8
2007–2009	52.9	29.9	634.3
2010	45.0	38.3	850.5
2011	74.8	71.2	951.2
2012	120.0	120.0	999.9

Data source: FAO 2012

Ethiopia is the major chickpea producer and exporter among the ESA countries. It occupies the fifth position in terms of both production and exports at a global level. During the last one decade, the release of high yielding and market-preferred varieties and their adoption, export demand and technical and policy support coupled with involvement of several stakeholders along the value chain resulted in increased production (119% ie, 186,801 to 409,733 t), productivity (78%, 958 to 1707 kg ha^{-1}) and export earnings (139%, $14.7 to 35.1 million) in 2012 over the base year (2002). The bulk of the chickpea in Ethiopia (92%) is grown in Amhara and Oromia regions (Table 45). Chickpea yields are at around 1.7 t/ha at the national level and hold the potential to further increase. All these developments resulted in diversification of target locations and entering in to new areas like Sirinka, Axum, Areka and Mechara for varietal dissemination.

Table 45. Crop yields in Ethiopia.

		Yields (kg ha^{-1})	
AEZ	Area (ha)	Current	Achievable yields
Amhara	130,381	1,726	with best adoption condition is 3,500 kg ha^{-1}
Oromia	90,757	1,795	
Tigray	11,604	1,252	with medium adoption condition is 2,200 kg ha^{-1}
SNNPR	5,896	1,126	
National	239,512	1,711	

The above trends gave a filip to include chickpea in Ethiopian Commodity Exchange's trading, formation of multi-stakeholder (Agriculture Transformation Agency, PepsiCo, Inc., USAID, and WFP) and *EthioPEA* Alliance. This also included the receipt of golden cup award by DZARC-EIAR from the Ethiopian Prime Minister for best performance in promoting chickpea technologies in Ethiopia, and for organizing an 'International workshop on harnessing chickpea value chain for nutrition security and commercialization of small holder agriculture in Africa' to share Ethiopia's success story both regionally and internationally.

Tanzania and Kenya are the upcoming countries with new varietal releases (6–Kenya, 4–Tanzania) and increasing production. The major chickpea growing areas in Tanzania are Lake Victoria basin (76%), followed by Western Zone (15%) and Northern Zone (14%). In 2011 alone, chickpea worth $11.5 million was exported from Tanzania. Chickpea is indeed a bonus crop in Kenya and Tanzania. After harvest of maize and wheat in Kenya or maize and rice in Tanzania, the land is normally left fallow until the next cropping season (rainy season). Chickpea is planted immediately after the harvest of cereals and grows under the residual moisture thus giving farmers a second crop (where only one crop would traditionally be grown) and a source of income as well as nutrition. In Kenya, chickpea is mostly grown in the rift valley and parts of eastern Kenya, in about 81,620 ha with a huge potential for an increased area for wheat, maize and rice growing agro-ecologies as a rotation crop.

Further, the policy makers and people' representatives in Kenya are also in favor of drought tolerant chickpea, and have earmarked the constituency development fund to promote this crop. Further potential is envisaged with the enthusiasm and support from the newly established county governments. The bulk of chickpea produced in Eastern Africa is consumed locally, adding to the nutrition of people. Moreover, Ethiopia and Tanzania export a substantial amount of its chickpea produced (49,500 t–Ethiopia; 21,376 t–Tanzania). Chickpea has more diversified uses than any other food legume. The green leaves are used as leafy vegetable and are superior to spinach and cabbage in terms of mineral content. The green immature seed is used as a snack or vegetable. Selling green pods for green grains is highly profitable as these are sold for about $1–1.5 per kg and weigh 2–3 times higher than dry grains. The dry seed splits and flour are used in a variety of other preparations like Bhagia, *githeri*, stew, *mandazi*, cake, *samosa*, doughnuts, buns, *chapati* and grits.

Locations and partners

Three ESA countries were involved along with the target districts/locations as mentioned in Table 46.

Table 46. Project locations and partners for chickpea research in ESA.

Country	NARS partner	Region/Zone/ Province	Region/Zone/County	District/division
Ethiopia	DZARC-Debre Zeit, EIAR	Oromia	East Shewa zone	Gimbichu, Lume, Ejere, Alema Tena, Ada
			Oromia special zone	Sebeta, Holeta Genet
			Bale zone	Sinanna, Goro, Ginir, Agarfa, Gasera, Adaba
			West Harraghe zone	Mechara, Tulo, Oda Bulto, Habro
			South West Shewa zone	Sodo Dachi, Seden Sodo
			West Shewa zone	Ambo, Olonkomi, Ginchi, Dendi,
			Arsi zone	Huruta, Sire, Arsi Robe
		Amhara	North Shewa zone	Minjar-Shenkora, Moretna-Jirus, Basona Werena, Debre Birhan, Ensaro, Merhabete, kawat, Tarmaber, Deneba, Ankober, Bereh
			West Gojam zone	Awubel, Enemay
			North Gondar zone	Dembia, West Belesa, East Belesa, Delgi, Gonder Zuria
			North Wello zone	Dawunt, Weldia, Habru, Guba Lafto
			South Wello zone	Tehuledere, Kalu, Legambo
			Oromia Special zone	Dawa Chefa
		SNNPR	Wolaita zone	Damot Gale, Boloso Sore
			Gurage/Silte zone	Silte, Sodo
			Gamo Gofa zone	Kucha
		Tigray	Central zone	Tahitay Machew, Lailay Machew,
			North West zone	Tahitay koraro
Tanzania	LZARDI, Ukiriguru	Lake Zone	Mwanza region	Misungwi, Kwimba, Magu
			Shinyanga region	Shinyanga, Kishapu, Kahama
Kenya	Egerton University-Njoro and KARI	Formerly Rift Valley province	Bomet, Nakuru, Naivasha, koibatek, Kerio valley, Nakuru counties	Siongoroi, Longissa, Sigor, Eldama Ravine, Njoro, Lare, Mulot, Soy
		Eastern Kenya	Embu	Karaba

Key achievements

Crop improvement

Variety development

During the seven years of TL II, a number of advanced generation breeding materials generated at ICRISAT-Patancheru were received by ICRISAT-Nairobi and EIAR/Debre Zeit-Ethiopia in the form of international chickpea screening nurseries and other evaluation trials (Table 47). Suitable varieties were identified with a high yield potential combined with market-preferred grains and tolerance to biotic (Fusarium wilt, Ascochyta blight, pod borer) and abiotic stresses (drought and heat). After preliminary evaluation in Kenya, elite materials were shared with the NARS programs in Tanzania (LZARDI-Ukiriguru) and Kenya (KARI-Njoro and Egerton University).

Table 47. Details of nurseries evaluated and best genotypes identified.

Location	Nursery	No. of genotypes		Best lines identified	
		Desi	Kabuli	Desi	Kabuli
ICRISAT-Nairobi	Heat tolerant	61	62	ICCVs 07101, 07112, 07104, 07110, 07114	ICCVs 07304, 07308, 05312, 07306, and 05315
	Large seeded	84	60	D018, D047, D018, D064, D040, D065,D028,D021	K001, K014, K026, K022, K036, K004, K041, K010, K027, K016
	MABC lines	22		MABCs 2, 8,22, 17, 21, 19, 4, 10, 14,9, 1, 16, 15	
	ICSN-desi and kabuli	20	20	ICCVs 93954, 11103, 11114, 11112, 11107, 11104	ICCVs 92311, 11312, 11308, 11317, 11313
	Ascochyta	42		ICCVs 10516, 10514, 10510, 10505, 10512, 11505, 11520, 11503, 11507, 11506, 11519	
Ethiopia: EIAR-Debre Zeit	Large seeded	84	60	D047, D051, D058, D046,D056, D052	
	Breeding lines	225		41 high yielding and 12 large seeded with Fusarium wilt resistance identified and most promising ones are ICCVs 08111, 07104, 09118, 09108,10107, 10108, 10109,10103, 10102, 08105 and 08104	
	Drought tolerance	69		ICC 1397, ICC 11819, ICC 4872, ICC 1392,	
Egerton University - Kenya	Ascochyta tolerance	30		ICCVs 11505, 11519, 11515, 11510, 11512	
	Heat tolerance	35	35	ICCVs 07103, 07110, 07113, 07114, 07304	ICCVs 01303, 03404, 05315, 07313
	Pod-borer resistance	81	62	ICCV 07104, D064, D049, D036, D021, ICCV 08107	ICCV 08307, K031, K038, K007, K034
	MABC-drought	22		MABCs 2, 8,22, 17, 21, 19, 4, 10, 14,9, 1, 16, 15	
	Desi and Kabuli	97	117	28 promising lines identified	
LZARDI-Ukiriguru, Tanzania	Desi and Kabuli nurseries	97	117	ICCVs 97406, 07304, 97126, 97031, 97128, 97125	ICCVs 07112, 07110, 07114, 97306, 00302, 97406, 92311
	Large seeded	84	60	D 050,D 049, D 018	K 041, K 012, K 013, K 009, K 020, K 029

Based on the evaluation of 84–desi and 60–kabuli genotypes at ICRISAT-Nairobi, very good genetic diversity for larger seed size was observed among the kabuli genotypes, from which potential genotypes with significantly higher seed mass than the current high yielding varieties (like ICCV 92318) coupled with higher grain yield were selected (Table 48).

Table 48. Promising new generation large-seeded kabuli types evaluated in Kenya.

Name	Days to 50% flowering	Days to 75% maturity	100 seed mass (g)	Yield (kg ha^{-1})
K032	48	106	61.7	3,458
ICCV 08313	42	104	51.5	3,181
K034	44	113	49.7	3,595
ICCV 08308	42	110	48.7	3,748
K025	47	109	48.5	3,094
K021	50	107	47.5	3,863
K026	43	111	47.0	3,494

Over the years of on–station evaluation of advance breeding lines under TL II and TL I in Ethiopia, the best lines were identified based on yield, seed size and yield attributing traits (Tables 49 and 50).

Table 49. Performance of top 12 accessions selected from advanced breeding lines in Ethiopia.

Selected accessions	Yield (kg ha^{-1})	Days to 50% flowering	Days to 75% maturity	Plant height (cm)	100 seed weight (g)	Harvest index (%)
D 047	4,320	44	105	32.5	23.2	62.5
ICCV 08111	4,220	44	105	40.4	37.9	49.8
ICCV 08108	4,075	45	108	42.2	27.0	63.0
D 051	3,725	46	99	35.7	23.7	56.0
D 058	3,437	36	108	35.0	25.0	48.4
ICCV 08105	3,396	45	101	36.2	35.7	48.2
ICCV 08104	3,325	44	103	36.7	35.0	51.0
D 046	3,113	47	106	38.0	34.0	46.7
D 056	3,045	39	100	33.3	32.8	55.7
D 052	2,954	49	110	36.0	25.5	42.3
Desi local check	4,025	52	111	38.0	31.0	52.7
Kabuli local check	3,429	42	107	41.0	39.4	42.5

Table 50. Multi-locational performance of selected genotypes in Ethiopia.

Genotype	Akaki	Chefe Donsa	Debre Zeit	Mean
ICCV 10107	3,520	4,550	3,930	4,000
ICCV 09108	3,030	4,380	4,340	3,917
ICCX-060039-F3-P65-BP	3,500	4,130	4,070	3,900
ICCV 07104	3,050	4,630	3,820	3,833
ICCV 08111	3,480	4,360	3,440	3,760
ICCV 10108	3,290	4,210	3,240	3,580
ICCRIL-03-0208	3,330	3,690	3,450	3,490
ICCX-060039-F3-P38-BP	2,510	4,190	3,700	3,467
ICCV 10109	2,470	4,240	3,570	3,427
DO 51	2,950	3,920	3,340	3,403
ICCV 10103	2,990	3,930	3,280	3,400
ICCV 10102	2,550	3,620	3,790	3,320
ICCV 97105	2,990	3,780	2,840	3,203
ICCX-060039-F3-P44-BP	2,840	3,560	3,210	3,203
Natoli	3,130	4,070	3,880	3,693
Minjar	2,510	4,100	3,310	3,307
Local Check	2,850	3,340	3,530	3,240
Mean	2,889	3,934	3,514	3,446
LSD	539	366	368	244

Based on the on-station evaluation of advance breeding lines under TL II phase-II in Tanzania, best lines were identified based on the yield, seed size and yield attributing traits (Tables 51 and 52).

Table 51. Performance of selected desi genotypes in Tanzania.

Genotype	Yield (kg ha^{-1})	100 seed weight (g)	Days to 50% flowering	Days to 75% maturity
ICCV 06107	3,802	30.1	46	81
ICCV 08106	3,802	33.2	45	83
ICCV 07109	3,594	28.7	46	84
D 050	3,542	29.5	48	83
ICCV 07108	3,542	33.6	46	86
ICCV 07115	3,542	25.7	44	81
D 049	3,490	25.9	44	82
ICCV 00108	3,490	21.1	48	84
ICCV 08103	3,438	34.3	46	83
D 018	3,385	27.4	49	84
Mean	3,186	28.6	48	83
LSD	434	1.1	1	1

Table 52. Performance of selected kabuli genotypes in Tanzania.

Genotype	Yield (kg ha^{-1})	100 seed weight (g)	Days to 50% flowering	Days to 75% maturity
K041	3,125	49.9	45	79
ICCV 95423	3,073	38.5	49	84
ICCV 92318	2,917	36.5	43	74
K012	2,865	50.2	46	79
K013	2,604	47.9	45	79
K009	2,500	45.5	43	77
K026	2,500	42.8	45	77
K029	2,500	56.0	47	83
ICCV 00305	2,448	29.9	49	85
Mean	2,259	44.2	47	80
LSD	382	2.4	3	2

Variety release

In three target countries of ESA, 17 varieties were released during the project period as per the details below (Table 53).

Table 53. Chickpea varieties released in ESA.

Country	Popular/local name	Pedigree/code	Type	Release year
Ethiopia	Monino	Acos Dubie	Kabuli	2009
	Minjar	ICCV 03107	Desi	2010
	Akuri	ICCV 03402	Kabuli	2011
	Kasech	FLIP 95–31C	Kabuli	2011
	Kobo	ICCV–01308	Desi	2012
	Teketay	CJG-74 x ICCL-83105	Desi	2013
	Dalota	ICCX–940002	Desi	2013
Tanzania	Ukiriguru 1	ICCV 97105	Desi	2011
	Mwanza 1	ICCV 00108	Desi	2011
	Mwanza 2	ICCV 00305	Kabuli	2011
	Mwangaza	ICCV 92318	Kabuli	2011
Kenya	LTD 065	ICCV 00108	Desi	2010
	LTD 068	ICCV 00305	Kabuli	2010
	Chania desi 1	ICCV 97105	Desi	2012
	Saina K1	ICCV 95423	Kabuli	2012
	Chania desi 2	ICCV 92944	Desi	2013
	Chania desi 3	ICCV 97126	Desi	2013

Identification of farmer- and market-preferred chickpea varieties

Three hundred and twenty eight farmers PVS trials were conducted in Ethiopia (136), Tanzania (107) and Kenya (85) with the participation of 16,782 farmers (Ethiopia 10,461, Tanzania 4,102 and Kenya 2,219). In addition, 2,392 field demonstrations (Ethiopia–2209, Tanzania–11, and Kenya–172) were organized to disseminate the promising varieties and production technologies. During the FPVS, 40 released or pre-released varieties (Ethiopia–15, Tanzania–12, Kenya–13) were included along with a farmer's variety as a check (Table 54). Farmers came up with a number of preferred varieties like Fusarium wilt and

Ascochyta blight (in Ethiopia), based on the criteria such as early maturity to avoid end season drought and reach the market while the prices are still high; vegetable type for local niche markets; high yield potential; profuse podding; large seed size for domestic consumption/local and international markets; and resistance to terminal drought.

A few genderwise differences in preference were observed, with men going for market traits such as grain size, and women opting for consumption and green pods (Table 55).

Table 54. Varieties used in PVS trials over 7 years.

	Variety		
Country	Desi	Kabuli	Check
Ethiopia	Natoli, Minjar, Matsewal, Kutaye, Dalota, Teketay	Ejere, Teji, Shasho, Chefe, Arerti, Habru, Acos Dubie (Monino), Yelibe, Kasech, Akuri, Kobo	Farmer variety
Tanzania	ICCVs 97105, 00108, 07112, 97114, 97128	ICCVs 00305, 97306, 96329, 92318, 95423, 92311, 95311	Dengumawe
Kenya	ICCVs 97105, 00108, 92944, 97126, 97114, 95415	ICCVs 00305, 97306, 96329, 95423, 96318, 92311, 92318	Ngara Local

Table 55. Farmer-preferred varieties in the three countries.

Country	Desi	Kabuli
Ethiopia	Natoli, Minjar, Kutaye	Habru, Ejere, Teji, Arerti, Yelibe, Akuri, ACOS-Dubie
Tanzania	ICCVs 00108, 97105, 97114, 07112, 97128	ICCVs 92318, 00305, 95423
Kenya	ICCVs 97105, 00108, 92944	ICCVs 95423, 00305, 97306, 92318

Seed systems

During the past seven years, 111.5 tons breeder, 1,036.5 tons basic and 15,328.5 tons of certified seed of farmer-preferred improved varieties was produced by various stakeholders. In ESA, 2685.0 tons of seed were produced under TL II (Ethiopia–1,998.1 t, Kenya 372 t, and Tanzania 315 t) involving 22 varieties (Tables 56-59).

Table 56. Various classes of quality seed produced in ESA (tons).

Country	No. of varieties	Breeder	Basic	Certified/QDS	Total
Ethiopia	11	41.9	715.8	12,454.7	13212.4
Tanzania	4	42.0	303.8	1,412.9	1,758.7
Kenya	7	27.6	16.9	1,460.9	1,505.4
Total	22	111.5	1,036.5	15,328.5	16,476.5

Table 57. Certified seed production by variety in Ethiopia (tons).

Variety	Tolerance to/special trait(s)	Produced directly by TL II	Produced through partnerships	Total
Arerti	*Ascochyta*, *Fusarium* wilt	1,628.4	8,440.0	10,068.4
Shasho	*Fusarium* wilt	199.8	1,178.4	1,378.2
Habru	*Ascochyta*, drought	99.9	760.5	860.4
Ejere	*Ascochyta*, drought	19.9	14.7	34.6
Teji	High yield in potential areas	19.9	10.3	30.2
Chefe		12.0	3.0	15.0
ACOS Dubie	Bold seed size	7.8	11.9	19.7
Kutaye		4.8	15.6	20.4
Natoli	High yield in potential areas	2.7	9.5	12.2
Minjar	*Ascochyta*, *Fusarium* wilt	2.0	4.2	6.2
Marye	Moisture stress	0.9	8.6	9.5
Total		1,998.1	10,456.7	12,454.7

Table 58. Seed production by variety in Tanzania (tons).

Variety	Special trait(s)	Breeder	Basic	Certified/ QDS	Total	Produced by TL II	Produced through partnerships
Ukiriguru 1	Wilt resistant	7.6	55.1	286.0	348.7	125.0	223.7
Mwanza 1	Wilt resistant	6.6	47.0	133.4	187.0	90.0	97.0
Mwangaza	Early, wilt resistant	5.7	47.7	67.5	120.9	50.0	70.9
Mwanza 2	Wilt resistant	6.9	27.5	141.0	175.4	50.0	125.4
Total		26.7	177.3	627.9	831.9	315.0	516.9

Table 59. Seed production by variety in Kenya (tons)

Variety	Special trait(s)	Breeder	Basic	Certified/ QDS	Total	Produced directly by TL II	Produced through partnerships
Chania Desi 1	Wilt resistant	1.6	10.5	149.8	161.9	131.9	30.0
Saina K1	Wilt resistant	0.7	4.7	116.2	121.6	98.2	23.4
Chania Desi 2	Heat tolerant	2.3	1.4	65.8	69.5	41.8	27.7
LTD068	Wilt resistant	2.2	0.23	39.3	41.7	28	13.7
Chania Desi 3		0.23	0	25.5	25.7	15.7	10.0
LTD065		2.4	0.11	61.3	63.8	50.3	13.5
ICCV 97306		0.23	0	7.61	7.84	6.1	1.7
Total		9.64	16.9	465.5	491.96	372	120

Seed production and delivery strategies

Various seed production and delivery strategies have been employed for the various seed classes. The most effective ones are summarized in Table 60.

Table 60. Effective seed systems identified for chickpea production in Ethiopia and Tanzania.

Seed class	Ethiopia	Tanzania	Kenya
Breeder Seed	Research centers	Research centers	Research centers
Foundation Seed	Farmers' coops, private sector, NGOs, Seed enterprises	Farmer-Field-Schools, private sector, NGOs	Private seed companies
Certified Seed	Specialized smallholder farmers	Farm organizations	Farm organizations
Quality Declared Seed	Farmers, farm organizations	Farmers, farm organizations	-

A total of 6,445 small to large size seed packs (2–30 kg) were distributed to farmers in the three countries namely Ethiopia, Kenya and Tanzania. In Ethiopia, eight seed grower associations namely Megertu Denkaka, Ude, Chala, Biftu, Hawi Boru, Lemlem Chefe, Memihir and Ensaro were very active in seed production and delivery. In Tanzania, NGOs and one private seed company named Kilimo markets were involved in seed delivery. In Kenya, links were established with the seed companies (Leldet seeds, Agrosay seeds, Faida seeds), farmers' cooperatives (in Bomet, Koibatek), farmer training and field schools (Koibatek and Bomet FTCs), NGOs (KENPAP) and community organizations (Cheptebo Community centre).

Adoption and impacts

During the phase I, baseline data was collected in Ethiopia, which provided important information on several aspects of chickpea value-chain on production, seed systems and marketing as given below.

Cropping pattern: Bread wheat and white teff were the most common crops produced among the 700 sampled households in Gimbichu (149), Lume–Ejere (300) and Minjar–Shenkora (251). In terms of crop area allocated to improved varieties, kabuli chickpea takes the lead (42.5%) followed by bread wheat (36%). Desi chickpea is the third most popular crop produced by 53.6% of the sampled households.

Crop yields: The average yield for kabuli chickpea was relatively higher in Minjar–Shenkora district (3285 kg ha^{-1}) compared to the other two districts (Gimbichu–2374 kg ha^{-1} and Lume–Ejre–2389 kg ha^{-1}), whereas for desi chickpea there seems to be no yield difference across the three districts (Minja–Shenkora–1877 kg ha^{-1}, Gimbichu–1913 kg ha^{-1} and Lume–Ejre–1988 kg ha^{-1}). Shasho (20.6%) continues to be the most widely grown kabuli variety among the chickpea farmers, followed by Ejere (11.7%) and Arerti (10%), respectively. Local desi remains as the most widely grown variety among chickpea farmers while only 4.3% grow improved desi. Of the total chickpea area in the survey regions, about 54.5% is allocated to local desi followed by Shasho (21%) and Ejere (11.9%).

Fertilizer used in chickpea was relatively much less than its use in wheat and teff. For kabuli, the average amount of DAP and urea used per ha amounts to 16 and 11 kg, respectively, whereas the amount used for desi chickpea was by far less (3.4 kg each of DAP and Urea). Manure application is also popular especially in Lume-Ejere and Minjar-Shenkora districts.

Chickpea seed access: The first major source of seed for Arerti and Shasho varieties was the seed saved by the farmers followed by the producers' groups. About 47% of those who planted Arerti and 50% of those who planted Shasho used their own saved seed during the cropping season from 2006–2007 while about 33% and 26% planted the same variety sourced seed from producer marketing groups or cooperatives. Own saved seed again was a vital source of seed for Chefe (77%), Worku (71%) and local desi (84%) varieties while producer marketing groups also contributed for Ejere type (33%). The third

and fourth important sources of seed during the planting season from 2006 to 2007 were the local seed producers and local traders and agro-dealers, respectively. The first and second major reason why some farmers never adopted the improved varieties was lack of access to seed and fear of theft during the green stage. The third and fourth major reasons are related to the shortage of land and lack of cash to buy seed and lack of credit. Only 48% of sampled households use at least some purchased seed, perhaps due to the use of recycled seeds. The share of seed purchased for kabuli was about 48.9%, which was significantly higher compared to desi (3.1%). The average total labor used in person days was about 97 per ha for kabuli and 83 per ha for desi.

Chickpea utilization: Over 70% of kabuli chickpea and 55% of desi chickpea produced are sold in the market, suggesting the relevance of chickpea as a cash crop in the study area. Kabuli chickpea is the first crop primarily produced for the market compared to all other crops grown in the study regions. Desi chickpea takes the third rank in terms of share of produce sold in the market.

Crop-livestock interactions: About 10.5% of the sample respondents use crop residue as source of animal feed whereas about 5.5% use it as green fodder or grazing land.

Preferred traits for chickpea: The highest score was given to the Chefe variety by both men and women farmers, which was followed by Ejere. Female chickpea farmers prefer Arerti variety for their taste and high price in the market whereas the male farmers prefer the same variety for high price and grain yield. Shasho variety is highly preferred owing to its high price in the market, grain size and grain color by both male and female farmers. Male farmers prefer the Chefe variety for their grain color and size while the female farmers prefer them for their high price in the market, grain size and low cost of production. The preferred traits for Ejere variety by both male and female farmers are high price in the market, grain size and grain color. Generally, kabuli varieties are highly preferred for their high economic return in addition to their grain color and size. The characteristics of Worku variety mostly favored by male farmers include good taste and uniformity in maturity while female farmers prefer them for good taste, grain color and high price in the market.

Net-return of chickpea: Generally, kabuli varieties perform superior in terms of yield, compared to the other desi types. Among all the chickpea varieties, Arerti and Shasho varieties have the highest gross margin in terms of returns to land and management. The average return for Arerti and Shasho is about ETB 10,283 and ETB 9,496 per ha, respectively, whereas the improved desi has a net–return of about ETB 2,481 per ha (1 $ = 21 ETB).

Post-harvest handling and consumption: About 86.4% of farmers thresh their produce with animals on dung cemented surface and grass while about 13% of them thresh their produce with animals on dirt surface. About 74% of Shasho and Ejere varieties produced are sold in the market, thus ranking first among chickpea varieties in terms of market share. Arerti and local desi take the second and third rank in terms of share of produce sold in the market. The proportion of improved and local desi sold in the market was about 20% and 55%, respectively. About 10% of all kabuli varieties produced are saved as seed for the next cropping seasons while the share is a bit higher for the desi types. Among the kabuli varieties, the share of produce used for home consumption is highest for Chefe (39%) followed by Arerti (25%). On the other hand, about 68% of improved desi and 32% of local desi produced by sampled households are used for home consumption.

Chickpea marketing: About 37% and 64% of kabuli and desi chickpea farmers are involved in marketing, indicating its role as a source of cash. Within the kabuli category, the proportion of chickpea farmers involved in marketing of Shasho variety is the highest, followed by the Ejere type. The marketed surplus for the kabuli chickpea is a bit higher than the desi types. About 74% of the chickpea are sold in the main market. Urban grain traders are the first major buyers of chickpea in all the three districts, followed by the rural traders and rural assemblers.

Both producer and retail price are higher for the kabuli chickpea over the desi types. The annual average rate of growth (ROG) of kabuli retail price (4.5%) is more than double the desi retail price (2.3%). On the contrary, the ROG of desi producer price (3.68%) is much higher than the kabuli producer price (0.37%).

About 75% of traders recognized kabuli chickpea as having two grades (Grade 1 and 2). For desi chickpea, the majority of the sample traders in the primary markets (70%) recognized only one quality grade for the commodity. The major quality traits used in markets to classify the grading for chickpea include grain color, grain size, presence of foreign matter and broken and shriveled seeds. The survey results indicate that at all the market levels (except for desi in primary markets), quality seems to attract a price premium. On average, there was a margin of about ETB 27 ($ 1.29) per 100 kg for the kabuli chickpea variety and ETB 15 ($ 0.714) per 100 kg for the desi chickpea variety.

Gender aspect of chickpea production and marketing: In the study areas, men and women appear to make decisions regarding the sale of chickpea. Women are less familiar with the modern markets and feel powerless to influence them. They are hampered by the cultural norms, and lack of access to information on new technology, prices, demand, etc. Unlike their husbands, they are rarely given training in modern small-business management. In addition, they are hampered by the factors common to all: lack of adequate transport and communications services, inadequate equipment and facilities in market places and the presence of exploitative middlemen. Compared to women, men have easier access to technology and training, mainly due to their strong position as the head of the household and greater access to off-farm mobility. Moreover, men have easier access to credit than women do.

Ex ante impact assessment

An assessment of the potential long term benefits was undertaken (Ibrahim et al. 2011) using the baseline and follow up (2008 and 2010) information for the critical parameter estimates like yield superiority and adoption rates as well as prices. In order to account for the possible fluctuations, sensitivity analysis was incorporated. The economic surplus model (based on DREAM model) was applied to estimate the total benefits. With an annual chickpea production of 175,734 ton, chickpea price of $164/ton, a production benefit of 31%, a supply and demand elasticity of 0.9 and 1.4 respectively, maximum adoption of 75% and an annual increase of consumption of 2.6%, the economic surplus produced was estimated to be $111 million for 30 years. It was further estimated that the consumers would receive 39% of the benefit while the producers were entitled to 61%.

With the project costs of $22 million, the benefit cost ratio was estimated at 5:1. Further, an IRR of 55% was obtained thus indicating that it was a profitable investment. Even with the worst-case scenario ie, lowest benefit (15%), highest discount rate (13%), lowest elasticity and price, the benefit-cost ratio of 2:1 was still able to justify the investment.

The generated benefit was expected to eliminate the poverty conditions for more than 0.7 million people (both producers and consumers). However, this benefit can be considered as a lower boundary, since the calculation was made using conservative parameters. Moreover, if as expected, the farmers continue to grow the improved varieties beyond 2030, the returns on investments to this project will become even more significant.

Additionally, the technology spillovers to geographic regions that are not intentionally targeted by the research investment (neighboring countries) could significantly help in increasing the benefit. Similarly, since chickpea like other legumes have the capability of fixing nitrogen, it may also generate significant environmental and sustainability benefits that can help improve the ecosystem health in case the crop area expands beyond what was grown under the traditional varieties. The government is also benefited from the increased tax revenues received from both producers and consumers. Further studies on social economic impact are recommended. Thus, further investments in the chickpea and other legume research in Ethiopia is justified as a means of poverty alleviation.

Upgrading data collection: Tablet based household surveys were piloted in Ethiopia. In order to facilitate the third round of a panel survey, which was meant for adoption tracking, tablets were deployed to ensure that the process of data collection was efficient. After holding a brief introductory training on the open source app ODK that was used for the survey, a small team consisting of the ICRISAT staff in Nairobi converted the TL II survey instrument to ODK and further trained the enumerators and partners in Debre Zeit research station in Ethiopia. While the questionnaire content had to be retained due to the panel setting of the survey, the implementation on the tablet had to be carefully planned with an aim of maximizing the benefits. Therefore, crosschecks and automatic skips were implemented according to the initial set up. Furthermore, the restrictions on variable ranges and limitations on skipping answers were set up to ensure the highest possible data quality.

The initial feedback received during the training and field deployment was very positive. Prior concerns about the enumerators' ability to adjust to the electronic questionnaire and touchscreen were wiped out after the enumerators' first hands of experience. The enumerators confidently handled the tablet and farmers were fascinated by the new technology. Therefore, the tablet based data collection not only helped in improving the data quality but also ensured quicker availability of data as data entry was no longer necessary and the need for data cleaning was reduced. Finally, the investment costs for the tablets are estimated to be recovered after approximately 1000 interviews.

Capacity building

Training of farmers and Extension staff

Training was provided to 13,218 farmers (Ethiopia-7,980, Tanzania-2,409, Kenya-2,829) and 570 Extension staff (Ethiopia-205, Tanzania-171, Kenya-194) on various aspects of good agronomic practices for improved crop and seed production, FPVS, large scale demonstrations, seed storage and utilization technologies.

Field days, farmers' fairs

One hundred and twenty-four field days were conducted in Kenya (37), Tanzania (34) and Ethiopia (53) with participation of 16,782 farmers (Kenya-2,219; Tanzania-4,102; Ethiopia-10,461). During the field days, the farmers were asked to select preferred varieties along with their preference criteria. The comprehensive analysis from this activity facilitated the release of the new varieties in each country and helped in planning the seed production strategy. Farmers' preference criteria also provided feedback to the researchers and development personnel involved in chickpea. In Kenya, researchers along with human nutritionists also demonstrated the utility aspect of chickpea in the form of various products such as chapati, *githeri*, stew, *mandazi*, cake, *samosa*, doughnuts, buns, grits, and beverage and elicited the feedback on preferred products (*githeri* and stew).

Awareness activities

Awareness activities were conducted through radio, television, newpaper, popular articles and telephone conversations. PVS village network, demonstrations, annual farmer field days, rural seed fairs and agricultural shows were also used in creating awareness. In Kenya, policymakers were engaged in creating awareness. Proceedings of all the field days were broadcast on the public media (Ethiopian Television, Ethiopian Radio, Ethiopian News Agency, and newspapers) in Amharic, Oromifa and English. Television and radio broadcasts with live interviews and newspaper articles about new varieties became a regular norm throughout the project sites in Tanzania. Information bulletin on 'Improved chickpea technologies and seed production in Ethiopia' were prepared and shared with all the stakeholders. Manuals in seed production were also produced in Swahili (Tanzania). Flyers describing chickpea were printed in Amharic and Swahili and distributed to the farmers in the project sites (more than 10,000 flyers).

Training of scientists, research technicians

A one-month training course on "Chickpea Breeding and Seed Production" was organized at ICRISAT-Patancheru during January to February 2008 and 2009, involving 12 participants from ESA, ie, four each from Ethiopia, Kenya and Tanzania. One two-weeks training course on "Pre-breeding and legumes improvement" was organized at ICRISAT-Patancheru during 2013 in which five researchers from ESA (Ethiopia 1; Kenya 2; Tanzania 2) participated. One training program on chickpea agronomic management and germplasm maintenance was organized during 10–12 September 2013 in Nairobi with 23 participants from seven ESA countries. In addition, three staff from ESA were trained on electronic field books and data management at Wageningen through the Generation Challenge Program (GCP).

Development of infrastructure facilities

Overall, the target countries' basic infrastructure facilities at the farm level were established/upgraded to ensure proper conduct of experiments and assured seed multiplication, as given below:

- KARI-Njoro: Existing irrigation facilities were renovated to produce seed under assured irrigation both during main and off-seasons.
- LZARDI-Ukiriguru: Land along with proper fencing was developed exclusively for chickpea yield trials/ nurseries and seed multiplication.
- EIAR-Debre Zeit: Irrigation facility for off-season variety evaluation and seed multiplication.

Degree students

Four MSc students (2-Kenya, 2 Ethiopia) and one PhD student from Ethiopia worked on various aspects of chickpea like heat tolerance, genetic diversity, nitrogen fixation, Helicoverpa and drought tolerance as given in Table 61.

Table 61. Degree students worked/working on chickpea research.

Name	Country	Program	University	Research area
Peter Kaloki	Kenya	MSc	University of Nairobi, Kenya	Identification of sources of heat tolerance in chickpea
Tadesse Sefera	Ethiopia	MSc	Haramaya University, Ethiopia	Genetic diversity analysis and DNA fingerprinting of chickpea varieties using simple sequence repeat (SSR) markers
Nigusie Girma	Ethiopia	MSc	Haramaya University, Ethiopia	Heterosis, Combining Ability and Heritability for Nitrogen Fixation in Chickpea (*Cicer arietinum* L.)
Nancy Njogu	Kenya	MSc	Egerton University	Genetic variability for resistance to *Helicoverpa armigera* in chickpea
Musa Jarso	Ethiopia	PhD	Haramaya University, Ethiopia	Development of molecular markers and use in Marker Assisted Back-Crossing for Development of drought tolerance in chickpea

Lessons learned

General (all countries)

- Mechanization is necessary for timely planting under the residual moisture conditions with very little planting window.
- Sensitization of policy makers is required for the quick dissemination of best bet varieties and other technologies.
- Farmers participation in varietal selection reduces the time required for varietal testing and possible high adoption of tested varieties before or after the formal release.
- In addition to yield, maturity duration and resistance to diseases, the seed traits most preferred by market (seed size, color and shape) were also given high weightage.
- The farmers' preferences for growing kabuli chickpea varieties largely depended on the price premium received over the desi type.
- Private seed industry is not very interested due to self-pollinated nature, no information on effective seed demand, low seed replacement rate and high transaction costs for transport, processing and storage.
- Off-season seed multiplication for faster spread and reducing the seed production cycle time.
- Individual farmers are often reluctant to become seed growers due to the lack of capabilities for seed processing and storage and difficulties in marketing. However, they were very keen to takeup seed production, provided suitable arrangements were made for assured procurement. Community Seed Producer Associations may be promoted and could have better access to seed processing, storage facilities and marketing.
- Sustainable seed production by smallholders will stand a better chance of success if complimented by functional seed and product markets. Project interventions should focus on smallholder-centered seed production and delivery systems that have a better chance of surviving beyond the lifespan of the project.
- Business-oriented smallholder farmers perform better in seed production, storage, and dissemination than the food security-oriented farmers; hence, these groups of farmers should be involved in seed systems.
- Limited number of researchers and technicians available in ESA also hamper the progress of varietal development and seed dissemination.

Country-specific

Ethiopia

- Active participation of Department of Agriculture staff was essential for the successful implementation of demonstrations both in number and in size.
- Farmers are still reluctant to follow best production practices and show low management syndrome to legumes.
- Poor product standardization and market unpredictability affects the growth of the seed sector.
- Shortage of initial seed of new varieties was a major bottleneck in promoting new varieties in Ethiopia.

- Off-season seed multiplication with supplemental irrigation facilitated faster varietal spread in Ethiopia. Thus, the infrastructure for irrigation needed to be strengthened.
- Still faces a weak level of private seed sector participation.
- Certification procedure for farmer-based seed does not exist.

Tanzania

- Generally, the farmers prefer desi types because traders are used to it and there is a high domestic demand for the desi types.
- There is a need for strengthening farmers' seed producer groups for seed production.

Kenya

- Identified to have higher drought tolerance compared to maize and beans, indicating high potential for area enhancement, particularly in the arid and semi-arid areas with vertisols.
- Sensitization of policy makers about the importance of chickpea in combating drought helped in getting their support and this has provided a boost to our efforts in enhancing the chickpea area.
- Better performance of chickpea under prevailing drought conditions created awareness among the farmers, policy makers, MoA staff and consequently a greater demand for seed.

Challenges/gaps and future directions

- Need for proper sowing machines for chickpea in a short window of soil moisture availability in Lake Zone of Tanzania after the harvest of maize/rice.
- Ascochyta blight is emerging as a major challenge in ESA especially in Ethiopia and Kenya.
- Demands for emerging technology for irrigation, double cropping, fertilization and relay cropping in Ethiopia to further increase the productivity.
- Lack of sick plots or artificial screening facilities in ESA for various diseases.
- Need for concerted efforts to enhance the adoption of integrated pest management (IPM) for pod borer control.
- Intensify the utilization of chickpea in the rural areas of Tanzania and Kenya.
- Expand cultivation of chickpea in traditional wheat growing areas of Kenya as a rotational crop.