Adoption Studies on Improved Chickpea Varieties in Ethiopia

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2005

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Acknowledgement

We would like to sincerely thank all those who contributed to successful completion of this study, especially district agricultural office experts and development agents who helped in listing the chickpea growers and Mr Desalegan Wakayo and Mr Abebe Mengistie who served as enumerators. We are very grateful to the farmers who spared their valuable time in meeting us and enthusiastically responded to the survey questions.

Contents

Executive summary

Chickpea (*Cicer arietinum* L.) is one of the most important food legumes in Ethiopia contributing to about 17% of the countries' total pulse production. Ethiopia is the largest chickpea growing country in Africa, with a share of about 37% in area and 48% in production. During 2003/2004, Ethiopia produced 135,930 m t of chickpea from an area of 168,089 ha. There has been an increase of 12% in area and 34% in production since 1981/1982. Most of the chickpea production goes for domestic consumption. However, there has been substantial export of chickpea during the past five years, with maximum of 48,549 t (valued at US$14.7 million) during 2002 (FAOSTAT 2005).

Chickpea is an important source of dietary protein and minerals for many Ethiopians who cannot afford animal products. It is used in various forms, e.g., green seeds, dried seeds, dehulled-splits and flour. Chickpea straw is highly valued as animal feed. The farmers recognize the importance of legumes in improving soil fertility and thus grow chickpea and other legumes in rotation with cereals.

The Debre Zeit Agricultural Research Center (DZARC) has been the premier institute for chickpea research in Ethiopia. It has collaborated with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India, and the International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria, in chickpea improvement and released 10 chickpea varieties in Ethiopia. Of these, three (*DZ-10-4, DZ-10-11* and *Dubie*) were developed from its own breeding materials, five (*Mariye, Worku, Akaki, Shasho* and *Chefe*) from the breeding materials supplied by ICRISAT, and two (*Arerti* and *Habru*) from the breeding materials supplied by ICARDA.

This study was planned to assess the adoption of improved chickpea varieties in Ethiopia and the constraints to their adoptions. The survey was conducted in four districts (Ada-Liban, Akaki, Alem Gena and Gimbichu) of central Ethiopia that represents major chickpea production areas of the country. A multi-stage sampling procedure was used to select a total of 323 sample households from the four districts (50 from Ada-Liban, 50 from Akaki, 120 from Gimbichu and 103 from Alem Gena) and interviewed using a questionnaire. The data was analyzed using descriptive statistics.

The salient findings of the study are as follows:

- There was a wide variation among districts with regard to farmers' awareness of improved varieties. For example, the variety *Mariye* was known to 47% of the farmers in Ada-Liban, 26% in Akaki, 10% in Gimbichu and 2% in Alem Gena. Similarly, the variety *Sahsho* was known to 12% of farmers in Ada-Liban, 8% of farmers in Akaki and none of the farmers in Gimbichu and Alem Gena districts.
- The rate of adoption of improved chickpea varieties also varied widely from one district to another. It was the highest in Ada-Liban (66%), followed by Akaki (16%), Alem Gena (6%) and Gimbichu (5.8%).
- In general, there was slow adoption of the improved varieties. Among varieties, *Mariye* was the most widely adopted variety (11%), followed by *Shasho* (3%), *Dubie* (2.5%), *Arerti* (2%) and *Worku* (2%).

- There was a strong association between awareness of farmers about the improved varieties and their access to extension services. Relatively high level of awareness observed among farmers of Ada-Liban district was due to stronger technology promotion activities done by research and extension services [demonstration, on-farm verification trial, the farmer research group (FRG) programs and trainings] in this district.
- The effect of access to extension on varietal adoption was positive and significant. The farmers who had interactions with extension personnel or participated in extension activities (on-farm trials, demonstrations, visit to research centers, the FRG programs, etc,) are more inclined to adopting a variety than those farmers who had no access to extension activities.
- Important characteristics of improved varieties that were liked by farmers include drought tolerance (28%), high yield (25%), and early maturity (about 9%).
- The major factors that contributed to low rate of adoption of improved chickpea varieties were lack of awareness of improved varieties (21%) among farmers and the non-availability of the seed of improved varieties (27%).
- Chickpea seed was mainly produced and distributed by two public sectors – Ethiopian Seed Enterprise (ESE) and DZARC. The quantity of seed produced by these institutes was very small. No private sector was involved in chickpea seed production in Ethiopia.
- Farm size and area allocated to chickpea were positively related to the adoption of improved varieties, whereas the gender, education, and age of household head had no significant effects on the adoption of improved varieties.
- Most farmers did not apply any fertilizer to chickpea crop and did not follow recommendations of seed rates and sowing dates. However, most farmers weeded chickpea twice and rotated the crop with other cereals such as tef and wheat.

The following recommendations are made to enhance the adoption of improved chickpea varieties in Ethiopia:

- There is a need to enhance the awareness of the improved varieties among farmers. This can be achieved by conducting extensive farmer participatory on-farm trials/demonstrations of improved varieties, organizing farmer days, visit of farmers to research centers and demonstration plots, distributing seed samples of improved varieties, and using multimedia approach (radio, television, newspapers and magazine) for communicating the advantages of improved varieties.
- The seed supply of the improved varieties needs to be bettered. Private sectors and non-government organizations (NGOs) should be encouraged in chickpea seed production. Seed-villages, self-help groups and cooperatives, can be established for production, storage and distribution of seeds.
- Large-seeded varieties are preferred for green-seed consumption. However, the farmers are reluctant to adopt large-seeded improved varieties, as these are more prone to pilfering. There needs to be a community movement for the adoption of such a variety so that many farmers together grow that variety in a village/locality and the losses from stealing of plants are not high to a single field.
- There is also a need to improve marketing of chickpea grains and its products, so that the farmers can get maximum returns.

1. Introduction

Chickpea (*Cicer arietinum* L.) is an important cool-season food legume cultivated by smallholder farmers in Ethiopia. It provides the small farm households alternative sources of protein, energy, minerals and cash income. In addition, its residue is used as animal feed. Inclusion of chickpea in crop rotation helps in improving and maintaining soil fertility of the cereal-dominated farming systems of the country. In spite of its importance, chickpea productivity is very low. The national average yield of chickpea in Ethiopia under farmers' production condition is around 0.8 t ha^{-1} (CSA 2004). On the other hand, the potential of the crop under improved management condition is more than 3 t ha^{-1}. A number of limiting factors contribute to low productivity of chickpea. The major constraints are low yield potential of landraces and their susceptibility to biotic and abiotic stresses, and poor cultural practices. Among biotic factors, fusarium wilt, root rots, ascochyta blight, stunt virus, and pod borer largely contribute to low productivity of chickpea. Abiotic factors such as drought, water-logging and frost are important yield limiting factors. The Ethiopian *desi* chickpea types are not only low in productivity but also have smaller seed size. Inadequate availability of good quality seed of improved varieties is another important factor for low productivity.

Chickpea is widely grown in eight agro-ecological zones falling between 1400 to 2300 m above sea level where the mean annual rainfall ranges from 700 to 2000 mm (Bejiga and Eshete 1996). The major chickpea production areas of the country include the central highlands of southwest, west and east Shewa zones; east and west Gojam zones; south and north Gondar zones; and south and north Wello zones.

Over the past two decades, on-farm trials, demonstration and popularization of improved chickpea production technologies (improved varieties and management practices) have been undertaken in several chickpea producing areas to promote improved technologies and enhance their adoption. The technologies were promoted by the research centers and bureaus of agriculture and rural development. The latter institution is responsible for wider promotion of agricultural technologies. However, comprehensive information on the level of adoption of improved chickpea technologies is lacking. Hence, this study was aimed at assessing the level and extent of the adoption of improved chickpea varieties and associated management practices; and identifying factors that constrain the adoption of improved technologies.

2. Chickpea production status and practices

2.1. Chickpea production

Food legumes cover about 10% of the area under crop production in Ethiopia and contribute to nearly 13% of total annual crops production (CSA 2004). Chickpea is widely cultivated, particularly in the central and northern parts of the country. Area under chickpea increased from 138,000 ha in 1982 to 154,000 ha in 2004 (Table 1) accounting for 14% of area allocated to food legumes and 17% of the country's legume production.

Table 1. Area and production of the major food legumes in Ethiopia.

Crop	Year					
	1981/82	1985/86	1992/93	1998/99	1999/00	2003/04
	Area ('000 ha)					
Faba bean	348.91	280.19	298.2	296.71	359.15	381.99
Field pea	174.09	130.74	139.10	141.95	152.20	211.56
Chickpea	138.09	132.00	109.70	167.70	184.79	154.28
Lentil	70.42	44.86	44.80	47.90	72.22	52.06
Grass pea	32.29	65.46	70.40	95.05	110.58	82.71
Haricot bean	25.06	45.53	39.80	129.50	166.04	183.75
	Production ('000 t)					
Faba bean	469.94	233.33	312.10	285.82	388.68	426.89
Field pea	163.07	69.26	103.74	100.08	116.00	170.37
Chickpea	101.37	88.40	60.09	138.84	164.63	135.93
Lentil	51.60	25.87	25.03	28.38	49.77	35.28
Grass pea	21.37	41.73	44.16	78.62	107.48	78.96
Haricot bean	11.75	23.34	31.46	116.81	132.89	172.22

Source: CSA, various bulletins (1983–2004).

There was fluctuation in the average growth rates of area and production of chickpea over the last two decades. In the early 1980s the average growth rate of area under chickpea was negative. Similarly, in the late 1980s and in the first two years of 1990s, the average growth rate of chickpea production was negative mainly because of decline in area under chickpea. From 1992–2000, the average production growth rate of chickpea was positive attaining the second highest growth rate of 12% among the food legumes (Table 2). It was largely because of expansion in the chickpea area.

Table 2. Average growth rates of area and production of major pulses in Ethiopia.

Crop	Year		
	1981–1985	1985–1992	1992–2000
	Area (%)		
Faba bean	–4.39	0.78	–0.07
Field pea	–5.37	0.78	0.29
Chickpea	–0.90	–2.31	6.06
Lentil	–9.02	–0.02	0.96
Grass pea	14.13	0.94	4.29
Haricot bean	11.94	–1.68	16.85
	Production (%)		
Faba bean	–0.14	3.63	–1.26
Field pea	–0.17	5.05	0.05
Chickpea	–0.03	–4.82	11.96
Lentil	–0.14	–0.41	1.79
Grass pea	13.38	0.71	8.24
Haricot bean	13.72	3.73	18.74

Source: Dadi and Bekele 2003.

2.2. Chickpea production practices

Chickpea is usually grown on black vertisol. Such soils are known for excess water and drainage problem during the main rainy period (June–August). Thus, to overcome this problem farmers plant chickpea late in the season (September–October) commonly on residual moisture. It is planted from September to October through broadcasting seeds. In some specific locations, chickpea is planted on flooded land as water retreats back to the axis point at the end of the rainy season.

Chickpea is weeded at least once throughout the production season. Chickpea is mainly cultivated without application of fertilizers and herbicides. Pesticides are applied on chickpea fields to control diseases or insects only when a specific disease or insect epidemic occurs in a specific location. In epidemic cases, the responsibility of applying insecticides lies with the Ministry of Agriculture and Rural Development and NGOs. The government provides pesticides, sprayer and technical support free of charge while farmers are responsible for applying pesticides through contribution of labor.

In the study zones, chickpea is cultivated as a sole crop. In the cropping sequences, it is rotated with cereals to improve fertility of the soil.

Seeds of improved chickpea varieties are not readily available at affordable price at the right time and place, particularly in areas away from research centers. As a result, large proportion of farmers uses seeds of local cultivars available with them or their neighbors. Farmers who grow improved chickpea varieties depend on local exchange of seeds originating from research centers through on-farm testing, popularization and demonstration activities. They also keep their own seed from previous harvest.

Chickpea harvesting is done by manual labor, either for green pod consumption or for dry seed. Harvesting time extends from October to January for green pods and from February to March for harvesting dried grain.

2.3. Chickpea utilization and marketing

Chickpea utilization: In the study area, chickpea grain is used for human consumption and the straw is used as animal feed. Chickpea seeds are consumed in different forms, eg, *Kolo* (roasted grain), *Nifro* (boiled grain) and *Wot* (sauce made of finely or coarsely ground chickpea or other pulses). Chickpea seeds are also consumed at green pods stage without any processing.

Chickpea marketing: Chickpea is marketed at green pod stage or as dried grain. The bulk of chickpea is usually sold unprocessed. Sale of chickpea green plants for direct consumption of immature green seeds is becoming more common in cities and along roadside markets. Selling chickpea at green pod stage is reported to be more profitable than selling dried grain. A bundle of chickpea loaded on a donkey fetches 25 birr (US$2.85) at Addis Ababa market. One farmer estimated that 35 bundles could be harvested from a quarter of a hectare. This would generate gross income of 3500 birr ha^{-1} (US$398.65) for a farmer. Given average productivity of 1.0 t ha^{-1} farmer could only generate a gross income of 1800 birr ha^{-1} (US$205.02) if he sells in forms of dried grain. Although selling chickpea at green pod stage seems to be remunerative, only few

farmers close to urban areas benefit. At this stage, the pods are perishable and cannot be transported over long distances. Moreover, transportation costs may also reduce the total gain that is generated from sale of green pods.

Farmers sell chickpea directly to consumers in local markets or to small traders (assemblers) in rural areas, or directly to wholesalers. Small traders may sell to consumers or to wholesalers located in the production areas. Large traders take the grain to terminal markets and sell either to retailers or to wholesalers. The volumes handled by different channels are not known and require further investigation. The marketing channel for chickpea plants sold for green pods is simple, where retailers directly purchase from farmers and retail to consumers.

3. Chickpea research, technology development and transfer

3.1. Chickpea research and technology development

Chickpea research was started at DZARC in 1972. The overall objective of the chickpea research program is to contribute towards increased chickpea productivity, ensure sustainability of production, thereby increasing the availability of food and improving the livelihood of the farmers. Currently, research on chickpea is being undertaken at Debre Zeit, Adet, Holetta, Sinana, Debre Berihan and Sirinka agricultural research centers.

Since the inception of chickpea research, several efforts have been made to identify major production constraints of chickpea. Researchable areas were identified and prioritized based on survey information and feedback from stakeholders and partners. Diseases, insect pests, limited use of modern inputs, and inappropriate agronomic practices were found to constrain productivity of chickpea. Lack of market incentives and postharvest losses are also important problems of chickpea production.

Genetic improvement and associated crop management research were conducted to develop technologies to increase chickpea production. In the process of developing improved varieties, parallel genetic improvement programs were developed for *des*i and *kabuli* chickpea types.

Since 1978, the Ethiopian chickpea research program collaborated with ICRISAT and ICARDA and with sister national research organizations. The research program has benefited from the collaboration with the international agricultural research centers (IARC) and national organizations in terms of human resources development, information exchange and acquisitions of germplasm and advanced breeding materials. Since the launching of chickpea research program and collaboration with IARCs, the chickpea research program has released ten improved chickpea varieties. Among these, five (*Mariye, Worku, Akaki, Shasho* and *Chefe*) were developed using the breeding materials supplied by ICRISAT and two varieties (*Arerti* and *Habru*) from the breeding materials supplied by ICARDA (Table 3). A number of senior researchers and technicians received training at these IARCs and upgraded their skills and knowledge and this has contributed to the effectiveness of the chickpea research program.

Table 3. Improved chickpea varieties released in Ethiopia.

Cultivars	Year of release	Pedigree	Source
DZ 10-4	1974	-	Ethiopia
DZ 10-11	1974	-	Ethiopia
Dubie	1978	-	Ethiopia
Mariye	1985	K 850-3/27 x F 378	ICRISAT
Worku (DZ 10-16-2)	1994	ICCL 820104	ICRISAT
Akaki (DZ 10-9-2)	1995	ICCL 820016	ICRISAT
Arerti (FLIP 89-84C)	1999	X87TH186/ ICC 14198 x FLIP 82-150C	ICARDA
Shasho (ICCV 93512)	1999	ICCC 33 x (ILC 3395 x FLIP 83-13C)	ICRISAT
Habru (FLIP 88-42C)	2004	X85TH230/ILC 3395 x FLIP 83-13C)	ICARDA
Chefe (ICCV 92318)	2004	(ICCV 2 x Surutato 77) x ICC 7344	ICRISAT

3.2. Yield potential of improved chickpea varieties

The improved varieties have high yield potential and larger seeds than the local cultivars (Table 4). Some possess desirable seed color, which makes them more marketable as compared to grain from the local cultivars. For instance, *Shasho* and *Chefe* are *kabuli* type and have large seed size and sold at price premium. In addition, these varieties have good level of stress tolerance, wider adaptability and better nutritional quality than local cultivars. Along with the improved varieties, improved agronomic practices were identified and recommended.

The yields of improved chickpea varieties on the experimental and on-farm plots were much higher than the national average yield of chickpea (880 kg ha^{-1}). The yield gap between the experimental plots and farmers' fields for improved chickpea varieties is two to three folds of average chickpea yield. Thus, if adopted, the improved varieties along with their recommended management practices have the capacity to tremendously increase productivity of chickpea.

A number of improved agronomic practices were evaluated and recommended to farmers for chickpea production. For seedbed preparation, one deep ploughing in the dry season (March to May) and disking twice from mid-June to early-August and planting in mid- August to early-September are recommended. Early planting (July) is recommended in moisture stress areas. Two hand-weedings, 30 and 60 days after emergence, or application of glyphosate, 3–4 weeks before planting, at the rate of 4 L ha^{-1} followed by one ploughing are recommended for weed management.

Table 4. Improved chickpea varieties for Ethiopia, their important traits and agro-ecological areas of their adoption.

No	Variety	Year of release	Days to maturity	Growth habit	Seed color	100-seed weight (g)	Planting date	Seed rate (kg ha^{-1})	Adaptation area		Yield (t ha^{-1})
									Altitude (m)	Rainfall (mm)	
1	DZ 10-4	1974	111–135	Semi-erect	White	10.2	Early September	65–75	1800–2300	700–1100	1.6-2.2
2	DZ 10-11	1974	106–123	Semi-erect	Light Brown	13.0	Early September	70–80	1600–2000	700–1100	1.5-2.8
3	Dubie	1978	110–115	Semi-prostrate	Gray	22.0	Mid August to early September	80–90	1800–2300	700–1100	1.7-2.8
4	Mariye	1985	106–120	Semi-erect	Brown	25.5	Mid August	120–140	1500–2300	700–1300	1.8-3.0
5	Wroku (DZ 10-16-2)	1994	100–149	Semi-erect	Golden	33.0	Mid August	100–120	1900–2600	700–1200	1.9-4.0
6	Akaki (DZ 10-9-2)	1995	97–147	Semi-erect	Golden	21.0	Mid August	90–120	1900–2600	700–1200	1.8-4.0
7	Arerti (FLIP 89-84C)	1999	105–155	Semi-erect	White	25.7	Mid August	100–115	1800–2600	700–1200	1.6-5.2
8	Shasho (ICCV 93512)	1999	90–155	Semi-erect	White	29.9	Mid August	100–125	1800–2600	700–1200	1.6-4.6
9	Chefe (ICCV 92318)	2004	95–150	Semi-erect	White	35.4	Mid August	110–140	1800–2600	700–2000	1.2-4.8
10	Habru (FLIP 88-42c)	2004	91–140	Erect	White	31.7	Mid August to early September	110–140	1800–2600	700–2000	1.4-5.0

3.3. Chickpea technologies transfer

The availability of improved technology, access to information, modern inputs, resources and profitability of a technology at an acceptable risk are critical to adoption (Anderson and Feder 2003). Effective extension allows farmers timely access to advice and information on technology and how to use modern inputs and apply improved agronomic and crop protection practices. The improved varieties and production technologies were evaluated at farmers' fields through their participation. The improved technologies were also popularized through the regular extension activities and in few cases by the NGOs. The FRG were established near research centers. These groups actively participated in actual planning, execution of experiments and evaluation process of varieties and production technologies. This mechanism allowed farmers to have access to information and to select varieties with desirable traits. Some farmers paid visits to research centers and placed requests for seed of their preferred varieties. The research centers produced and distributed limited amount of the seeds of improved varieties to farmers around research centers. Once the farmers get the seeds of a new variety, they do save them for the next production. They maintain seeds not only to meet their own requirement, but also for exchange with other farmers. Seeds could be exchanged from any households in kind or in the market using monetary values.

Seed multiplication

Availability of seed is the critical factor for the adoption of improved varieties of any crop. The Ethiopian Seed Enterprise (ESE) is almost the sole commercial seed producer in Ethiopia. The Pioneer Hybrid International, the only private seed company in the country, produces only hybrid maize. ESE is mandated to multiply basic and certified seeds of improved varieties. However, the amount of improved chickpea seed produced and distributed by the ESE is very small (Table 5). There was no continuous supply of seeds and in some years improved chickpea seed was not distributed at all. The involvement of the private sector and cooperatives in production and distribution of chickpea seed would greatly contribute to meeting the increasing demand of improved chickpea seed.

Table 5. Amount of improved chickpea seed distributed by the Ethiopian Seed Enterprise (ESE) and the Debre Zeit Research Center (DZRC) (in tons).

Year	ESE	DZRC	Total
1989/90	-	68.9	68.9
1990/91	0.5	14.0	14.5
1991/92	49.2	17.0	66.2
1992/93	38.7	8.0	46.7
1993/94	417.2	10.0	427.2
1994/95	106.0	12.3	118.3
1995/96	0	13.6	13.6
1996/97	0	18.8	18.8
1997/98	0	14.5	14.5
1998/99	3	25.1	25.4
1999/00	6.7	43.7	50.4
2000/01	25.4	69.0	94.4
2001/02	-	56.1	56.1
2002/03	-	25.5	25.5
2003/04	-	30.7	30.7

Source: Extracted from various reports of the ESE and the DZRC.

4. Methodology followed for this study

The survey was conducted in the major chickpea production areas of Ethiopia. Emphasis was given to areas where improved chickpea varieties were popularized and expected to be widely used by farmers. Based on these criteria (i.e., importance of chickpea production and promotion of chickpea technologies), districts that substantially produce chickpea were identified in collaboration with extension specialists.

4.1. Description of the study area

Four districts in central part of Ethiopia were selected for the survey on adoption and impact of improved chickpea varieties. These included Ada-Liban, Akaki, Gimbichu in east Shewa zone and Alem Gena districts in southwest Shewa zone (Fig. 1). The physical features and climatic conditions of these districts are presented in Appendix I. These districts represent the major chickpea producing areas of the country. The total area of these districts is 356,948 ha (Appendix II). According to the information obtained from the Districts Agricultural Offices, more than 70% of the total area of the four districts was under cultivation in the 2004 cropping season. Grazing land and forest accounted for 5.3% and 6.4% of the land coverage, respectively. Of the cultivated area, 79.4% was under cereals and 19.0% under pulses. Among pulses, chickpea ranked first both in area and production and covered one-third of the total area of pulses (Appendix III).

Akaki: This is an adjacent district to the southeast of Addis Ababa, the capital city. The district has an average elevation of about 2100 m above sea level. About 90% of the soil is vertisol. Chickpea is the most important pulse crop and the farmers of this district have better access to chickpea pod market.

Ada-Liban: This has the largest area among the four districts surveyed. It is located to the south of Akaki district. About 95% of this district is an intermediate highland with an average elevation of 1900 m above sea level. Over 60% of the soil is vertisol and 24.3% of the soil is clay-loam and is typical soil for chickpea cultivation. Chickpea is the third most important pulse crop after faba bean and field pea.

Alem Gena: This has an average altitude of about 2000 m. Among pulses, chickpea is the most important crop grown in the district but its average yield is not more than 700 kg ha^{-1}. The main soil types are vertisol and alluvial soils. Chickpea is grown on the residual moisture and on the Awash River flooded plain when water withdraws at the end of the rainy season.

Gimbichu: This is located to the northeastern part of study area. It has an average elevation of 2400 m above sea level. More than 50% of the district's area is classified as typical highland. Seventy-five percent of this district has vertisol soil type. Chickpea is the main pulse crop grown in this district.

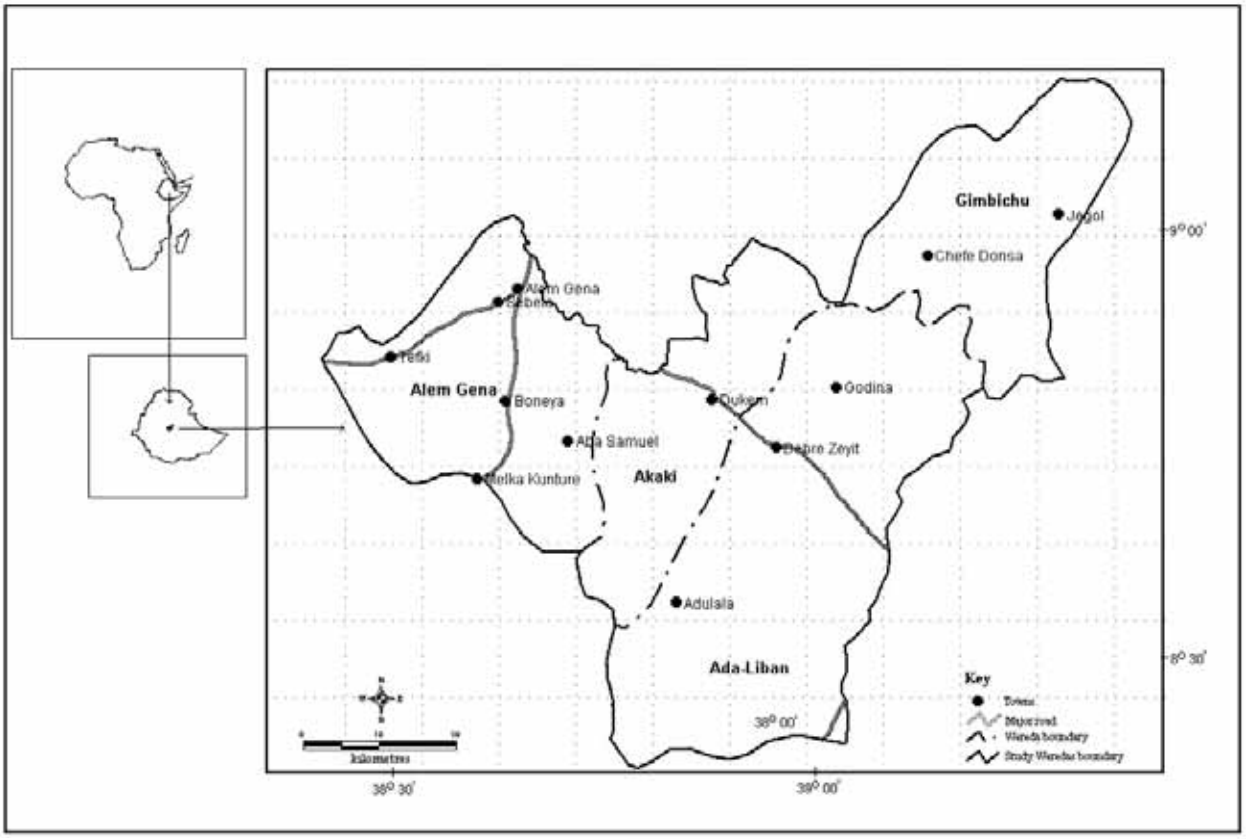

Figure 1. Map of study area.

4.2. Data collection method and analysis

A multi-disciplinary team of researchers consisting of social scientists, breeder and agronomist, from DZARC, conducted the study. Initially, the researchers used participatory rural appraisal tools such as semi-structured interviews, group discussions with farmers, extension personnel and input suppliers to understand the context in which chickpea technologies were promoted and adopted.

This was followed by a sample survey of chickpea growing farmers. The farm-household head, who actually makes the day-to-day decisions on farm activities, technology adoption and input use, was taken as the basic sample unit. The kebeles (the lowest administrative unit responsible for tax collection and administration) were taken as a sample frame to select sample household head. A multi-stage sampling procedure was applied to identify the required number of sample farmers. In the first stage, districts (Ada-Liban, Akaki, Gimbichu and Alem Gena) were selected purposively using the criteria indicated earlier. In the second stage, in consultation with experts from district agricultural offices who have good knowledge of kebeles, all kebeles known for chickpea production were listed. Sample kebeles were then selected using a simple random sample selection method. In the last stage, chickpea producing farmers were identified and listed in consultation with kebele leaders. A systematic random sampling technique was applied to identify sample farmers using a list of chickpea producers. A total sample of 323 chickpea

producing farmers was drawn from the population of chickpea growers in the selected kebeles. Sub-samples of 50 households from Ada-Liban, 50 from Akaki, 120 from Gimbichu and 103 from Alem Gena districts were interviewed using a questionnaire.

Analysis was done using descriptive statistics including percentages, frequencies, measure of controls, frequencies and variation, appropriate t-tests, ANOVA and cross-tabulations to test hypotheses. A logit model was estimated to determine factors affecting adoption of improved chickpea varieties. The logit regression model has the following functional form (Maddala 1992):

$$\log \frac{p_i}{1-p_i} = \beta_0 + \sum_{j=1}^{k} \beta_j x_{ij}$$

where, $\log \frac{p_i}{1-p_i}$ = log-odds ratio

β_0 = Constant term

β_j = Coefficients

x = Independent variables

i = Farmer number i

The dependent variable (log-odds ratio) in the model for identifying factors determining adoption of improved chickpea varieties is the natural logarithm of the ratio of the probability that the farmer adopts the improved varieties (p_i) to the probability that he/she will not ($1 - p_i$). The log-odds ratio is a linear function of the explanatory variables.

Independent variables in the model

The independent/explanatory variables that were hypothesized to affect adoption of improved chickpea varieties are summarized and presented in Table 6.

Table 6. Description and definition of explanatory variables used in the logit model.

Sl No	Variables	Variable description or definition
1.	Age	Age of household head in years
2.	Education	Educational level of the household head (Dummy variable: Education = 1 if the household head is literate (read and write) and 0 otherwise)
3.	Access to extension services	Access to extension services (Dummy variable 1, if the farmer has participated in at least one of the activities (on-farm trial, demonstration and the FRG, verification and/or demonstration trials and special trainings) and 0, otherwise)
4.	Gender of household head	Dummy variable: 1 if the household head is male and 0 if the household head is female
5.	Farm size	Farm size in hectare
6.	Access to input	Access to improved seed (Dummy variable: 1 if farmer has access to improved variety and 0 otherwise)
7.	Chickpea area	Proportion of area allocated for chickpea production in hectare
8.	Oxen	Number of oxen owned by the household

Hypothesis

Education: The higher the level of education of a person the more open he/she will be for new ideas and ways of doing things. Hence, in this analysis, it was hypothesized that the rate of adoption of improved chickpea varieties is higher among literate household heads than their illiterate counterparts.

Access to extension: Research outputs reach the end users through various outreach programs and agricultural extension. The first step towards technology adoption is popularization or introduction of available technologies to farmers. Therefore, access to extension services was expected to positively affect adoption.

Gender of household head: Gender is a relevant issue from technology generation to popularization. Quite often women are marginalized in terms of access to extension and market information. Hence, there is a high probability that female-headed households know relatively little about the improved chickpea varieties. It is, therefore, hypothesized that the probability of adoption will be higher for male-headed households than female-headed households.

Access to input: Access to seeds of improved varieties vary among farmers located in different districts. Some farmers have better access than others due to their proximity to research centers or because they are close to locations where informal seed exchange is better developed. Access to input is an important socioeconomic variable that determines adoption of improved varieties. Access to seed was hypothesized to lead to higher probability of adopting improved varieties.

Farm size: The farm size is an indicator of the economic status of a household. Technology adoption can sometimes be a risky venture. Risk associated with technologies can either be climatic or market risk. Climatic risk happens when the user of the technology loses yield because of unfavorable climatic conditions. Market risk occurs if the output cannot penetrate the market because of factors such as preferences of consumers. Poor farmers are more risk averse than the relatively rich farmers are, because the latter have a buffering capacity. Hence, a positive relationship is expected between farm size and decision to adopt improved variety.

Chickpea area: Farmers who allocate large area of land for chickpea consider chickpea as an important crop in their crop mix. It is expected that such group is more likely to invest on chickpea technologies. Hence a positive relationship was expected between chickpea area and farmers' adoption decision.

Oxen: In the study area, oxen are almost the only source of draught power for land preparation. The quality and timeliness of land preparation and timely planting of chickpea depends on the number of oxen owned. Farmers need at least one pair of oxen to be able to prepare their land well and plant on time. Therefore, the number of oxen owned by a farmer is hypothesized to be positively related to the decision of farmers to adopt the improved varieties of chickpea.

Age: Past adoption studies have shown that the age of household head (ie, the decision maker) influences adoption decisions. The relationship between age and technology adoption could be negative or positive. Empirical findings suggest two possible reasons for this relationship. First, the young farmers have been found to be more flexible in their decisions than the older farmers. They may be more willing to bear risk due to their longer planning horizons and because they have more schooling than the older generation. The second line of argument is that the older

farmers may have more experience and resources, which will allow them more possibilities for trying a new technology. Here we hypothesize that the age of a farmer will influence adoption decision of farmers. The direction effect could be positive or negative.

5. Socioeconomic and institutional characteristics

Demographic characteristics and resource ownerships

Socioeconomic characteristics of farm households are important for technology adoption because they influence the farmers' decision making. The socioeconomic characteristics described in this section are household characteristics such as family size and composition, sex and educational level of household heads. The size of land and livestock owned are also considered.

In Ada-Liban, about 6% of the interviewed households were female-headed and in Akaki, Gimbichu and Alem Gena, female-headed household accounted for 4% of the interviewees (Table 7). Among female-headed households, plowing is done either by sons or hired laborers. The average family size is 7.16 persons in Ada-Liban, 7.74 persons in Akaki, 7.20 persons in Gimbichu and 7.85 persons in Alem Gena district. The average number of male members of the household who are in the economically active age group (15–60 years) are 2.74 in Ada-Liban, 2.45 in Akaki, 2.21 in Gimbichu and 2.33 in Alem Gena. The average number of female members in that age group was 1.95 in Ada-Liban, 1.64 in Akaki, 1.45 in Gimbichu and 1.67 in Alem Gena (Table 7).

Table 7. Demographic characteristics of sample households in the study area .

	Districts				
Description	Ada-Liban (n=50)	Akaki (n=50)	Gimbichu (n=120)	Alem Gena (n=103)	Total (n=323)
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Family size	7.16	7.74	7.20	7.85	7.49
	(2.84)	(3.01)	(2.07)	(2.59)	(2.53)
Adult male, 15–60 years	2.74	2.45	2.21	2.33	2.36
	(1.62)	(1.43)	(1.09)	(1.28)	(1.30)
Adult female, 15–60 years	1.95	1.64	1.45	1.67	1.61
	(0.95)	(1.11)	(0.66)	(1.20)	(0.98)
Male children, 11–14 years	0.74	0.54	0.71	0.54	0.64
	(0.90)	(.84)	(0.77)	(0.80)	(0.81)
Female children, 11–14 years	0.88	0.52	0.57	0.51	0.59
	(1.21)	(0.83)	(0.68)	(0.75)	(0.29)
Male older than 60	0.00	0.04	0.12	0.11	0.84
	(0.00)	(0.20)	(0.35)	(0.31)	(0.29)
Female older than 60	0.08	0.10	0.067	0.14	0.96
	(0.27)	(0.30)	(0.25)	(0.34)	(0.30)
Children under 11 years	1.66	2.50	2.11	2.77	2.31
	(1.44)	(1.99)	(1.57)	(1.85)	(1.75)
Sex of household head (%)					
Male	94	96	96	96	96
Female	6	4	4	4	4

About 22% of the household heads interviewed in Ada-Liban, 45% in Akaki, 33% in Gimbichu and 24% in Alem Gena were illiterate (Table 8). About 49% household heads in Ada-Liban and Gimbichu, 25% in Akaki, and 32% in Alem Gena could read and write. Comparison of frequency of illiterate and literate household heads in the four sub-study areas indicates that there is a significant difference among the sub-study areas at 5% level (Table 9). The level of education was higher in Ada-Liban, Gimbichu and Alem Gena than in Akaki.

Table 8. Level of education of the household heads (%) in the study area.

	Districts				
Level of education	Ada Liban (n=50)	Akaki (n=50)	Gimbichu (n=120)	Alem Gena (n=103)	Total (n=315)
Illiterate	22.4	44.9	32.5	24.0	30.2
Can read and write	49.0	24.5	48.7	32.0	39.7
Completed primary school	20.4	12.2	13.7	18.0	15.9
Completed junior secondary school	6.1	12.2	2.6	10.0	7.0
Completed secondary school	2.0	6.1	2.6	15.0	7.0

Table 9. Educational level of household heads by district (%) in the study area.

	Districts				
Description	Ada-Liban (n=50)	Akaki (n= 50)	Gimbichu (n=120)	Alem Gena (n=103)	χ^2
Illiterate	22	44	32	23	
Can at least read and write	78	56	68	77	8.60^{**}

Contingency coefficient = 0.161; ** Significant at 5% level.

A key indicator of economic status of farm households is the type, quantity and quality of resources they own. Labor, land and livestock size owned by farm households constitute the major type of resources that can be used to generate income by smallholder farmers. The average landholding per household ranged from 1.80 ha in Gimbichu to 2.84 ha in Alem Gena district (Table 10). Comparison of average landholding per family member gives a clearer picture of land resource availability in the study areas. Landholding per family member was 0.27 in Gimbichu, 0.29 in Akaki, 0.33 ha in Ada-Liban and 0.38 in Alem Gena. A one-way analysis of variance (ANOVA) has revealed that there exists a statistically significant (at 0.05 level) difference in average landholding per family member among the sub-study areas (Table 11). Average landholding was significantly higher in Alem Gena than in Akaki and Gimbichu. Households in Ada-Liban own significantly higher (at 0.05 level) average landholding per household member than farm households in Gimbichu district.

Table 10. Average farm size per households (ha), 2003.

Study area	Sample size	Minimum	Maximum	Mean	Std. Deviation
Ada-Liban	50	0.50	4.00	2.05	0.65
Akaki	49	0.25	5.50	2.20	1.17
Gimbichu	120	0.38	6.00	1.80	1.06
Alem Gena	101	0.50	8.50	2.84	1.20
Total	320	0.25	8.50	2.23	1.15

Table 11. Average farm size per individual household member (ha), 2003.

Sub-study area	Mean	N	Std. Deviation	F value
Ada-Liban	0.33	50	0.18	
Akaki	0.29	49	0.14	
Gimbichu	0.27	120	0.17	8.665***
Alem Gena	0.38	101	0.18	
Total	0.32	320	0.17	

***Significant at 1% level.

In the study areas, mixed farming is practised and each household keeps at least one or more types of livestock, which provide traction and manure for crop production. Crop residue is a source of feed for livestock – an important source of fuel for the family. Moreover, the farm household earns cash income through the sale of livestock and livestock products. The average number of oxen owned by farm household ranged from 2.98 in Gimbichu to 3.46 in Ada-Liban (Table 12). On the average, all farm families had less than two cows.

Table 12. Livestock ownership of farm families, 2003.

Livestock type	Ada-Liban (n=50)*	Akaki (n=50)	Gimbichu (n=120)	Alem Gena (n=103)	Total (n=323)
Cows	1.40 (0.81)	1. 70 (0.99)	1.33 (0.87)	1.65 (1.23)	1.50 (1.02)
Oxen	3.46 (1.31)	3.36 (1.75)	2.98 (1.33)	3.14 (1.45)	3.16 (1.44)
Heifers	0.82 (0.83)	0.96 (0.83)	0.79 (0.86)	1.04 (0.94)	0.90 (0.88)
Bulls	0.64 (0.69)	0.90 (0.93)	0.65 (0.84)	0.79 (0.94)	0.73 (0.87)
Calves	0.86 (1.31)	0.98 (0.92)	0.70 (0.78)	1.01 (1.17)	0.87 (1.03)
Sheep	0.80 (1.91)	1.14 (1.70)	2.27 (0.92)	1.09 (1.86)	1.49 (2.37)
Goats	0.12 (0.52)	0.92 (2.06)	0.46 (1.43)	0.23 (1.06)	0.41 (1.36)
Donkeys	2.06 (1.19)	2.02 (1.19)	1.87 (1.20)	1.62 (1.15)	1.84 (1.19)
Horses	0.06 (0.24)	0.08 (0.27)	0.44 (0.50)	0.12 (0.32)	0.23 (0.42)
Mules	0.28 (0.50)	0.36 (0.53)	0.05 (0.22)	0.15 (0.39)	0.13 (0.40)
Poultry	4.46 (4.96)	4.50 (3.11)	3.94 (4.16)	4.56 (5.65)	4.31 (4.67)

*Figures in parenthesis are standard deviations.

Access to extension services

Agricultural extension services are rendered to disseminate technologies and improved production techniques so as to increase the level of productivity and thereby total production. Earlier studies (Zegeye et al. 2001) have revealed that strong extension services have a positive impact on technology adoption and conversely low capacity of extension services has been indicated to be one of the reasons for low uptake of technologies (Hailye et al. 1998; Beyene et al. 1998). Poor extension service leads to lack of awareness among farmers and studies also revealed that technology adoption can be hampered by lack of awareness (Bekele and Alemu, 2002).

Smallholders' access to agricultural extension services in the study areas is summarized and presented in Table 13.

Table 13. Access to extension services on chickpea, Ethiopia, 2003.

Extension services	Ada-Liban (n=38)	Akaki (n=46)	Gimbichu (n=116)	Alem Gena (n=99)	Total (n=275)	χ^2
Farmers participated in extension related services* (%)	23.7	6.5	2.6	3.1	5.0	24.96***

*The extension related services include demonstration, on-farm verification trial, and the FRG and trainings; ***Significant at 1% level.

A chi-square test was applied to test whether the two variables, ie, the (sub-study areas) and access to extension services were independent. Chi-square test results indicate that there is a systematic association between access to extension services and sub-study areas at 1% significance level. In other words, farmers around Ada-Liban had more access to extension services than farmers in the other three sub-study area. The contingency coefficient, a coefficient that measures the strength of the relationship between these two variables, was 0.278 showing that the relationship between the two variables is not very strong.

Access to extension services can also be measured by the frequency of contact between farmers and extension or development agents. About 42% in Alem Gena, 40% in Akaki, 27% in Ada-Liban and 16% in Gimbichu reported that the frequency of contact with extension agents was once a week (Table 14). A considerable proportion of the sample farmers (43% in Ada-Liban, 35% in Gimbichu, 24% in Alem Gena and 20% in Akaki districts) reported that they consult extension agents every month. In Akaki, 36% of the sample farmers reported that they had no contact with extension agents. The percentage of farmers who had no contact with extension agents was about 11% in Alem Gena, 8% in Ada-Liban and 6% in Gimbichu.

Table 14. Frequency of contact with extension agents (percentage of farmers reported), 2003.

Frequency	Ada-Liban (n=49)	Akaki (n=50)	Gimbichu (n=120)	Alem Gena (n=100)	Total (n=319)
Every week	27	40	16	42	30
Twice a month	6	-	-	-	1
Every month	43	20	35	24	30
Twice in three months	2	-	-	1	1
Every three months	2	2	18	4	9
Twice in a year			3	2	2
Once in a year	4	2	13	10	9
Once in two years	4	-	-	-	1
Never	8	36	6	11	12

Credit availability

Availability of credit plays a crucial role in technology adoption because quite often, smallholder farmers cannot afford most of the external inputs. Studies conducted so far (Zegeye et al. 2001; Seboka et al. 1991; Hailye et al. 1998) have shown that cash shortage is one of the causes for low rate of technology adoption. Cash shortage is prevalent among smallholder farmers particularly during the main cropping season when income from the previous year's harvest is nearly exhausted and yet this is the period of the year when cash is required to purchase inputs. Ideally this gap is filled by timely availability of credit with fair terms and conditions including an affordable interest rate.

The result of this study shows that about 14% in Ada-Liban, 12% in Gimbichu, 5% in Alem Gena and 2% in Akaki obtained credit for chickpea production during the last three years. The amount of credit obtained ranged from Birr 13 (US$1.48) in Ada-Liban to Birr 200 (US$22.78) in Gimbichu (Table 15). According to the farmers interviewed, the sources of credit were the District Agricultural Office and Private Money lenders.

Table 15. Amount of credit obtained for chickpea production by district (in Birr)*.

Woreda/District	Year	N	Minimum	Maximum	Mean	Std. Deviation
Ada-Liban	2001	3	13.00	88.00	45.33	38.55
	2002	1	45.00	45.00	22.50	31.82
	2003	8	13.00	96.00	48.75	22.54
Gimbichu	2001	5	70.00	187.00	123.60	50.89
	2002	0	-	-	-	-
	2003	16	48.00	200.00	124.00	53.84
Alem Gena	2001	0	-	-	-	-
	2002	2	14.00	36.00	25.00	15.56
	2003	2	32.00	170.00	101.00	97.58

*1 US$ = 8.78 Birr.

6. Adoption of improved chickpea varieties and associated management practices

6.1. Adoption of improved cultural practices

By and large the productivity of chickpea at national level remained stagnant. Some of the main attributes beyond abiotic and biotic limitations identified are limited application of improved technologies. A number of improved management practices were developed and promoted. Improved management practices such as planting date, seeding rate, land preparation, etc, are not widely adopted by farmers. The recommended planting time for chickpea is at the end of August. It was found that 97% of farmers planted chickpea in September after the end of the rainy season. The recommended seeding rate for the improved chickpea varieties are 90–120 kg ha^{-1} for small seeded and 120–150 kg ha^{-1} for large-seeded varieties. There is difference in the recommended seeding rate and the seeding rate practised by farmers. Fertilizer is one of the important inputs to increase productivity; 100 kg ha^{-1} Diammonium Phosphate (DAP) is recommended for chickpea production. Most farmers did not apply any fertilizer to chickpea. The average frequency of ploughing is four and ranged from 1 to 7. Chickpea was weeded twice by 90% of the farmers. Chickpea is one of the legumes known for its contribution in soil fertility maintenance. About 92% of farmers rotate chickpea with other cereals, mainly tef and wheat, as preceding and following crop.

The national average productivity of chickpea is 0.8 t ha^{-1}. However, with development of improved varieties, it has now become possible to produce about 2.5 to 3.5 t ha^{-1} grain yield with desired seed sizes. Improved management practices have shown yield improvement in many cases. Research findings showed that there is yield increment of 35% due to planting date, about 10% to seeding rate, about 10% to fertilization and greater than 50% to seed bed preparation (Eshete 1994).

6.2. Adoption of improved chickpea varieties

Improved varieties that have the potential to increase productivity have been developed. For adoption of newly introduced varieties to take place, farmers need to be aware of the available varieties. Adoption is sometimes hampered not only by the inherent characteristics of the varieties themselves, but also by lack of awareness among the end users.

Table 16 shows percentage of farmers who have ever heard about the different improved chickpea varieties. There was wide variation among the districts in terms of awareness of farmers about the improved varieties. The improved variety *Mariye* was found to be the most widely known variety. It was known to 47% of farmers in Ada-Liban, 26% in Akaki 10% in Gimbichu and 2% in Alem Gena, with an overall average of 16% farmers in the four districts. The *kabuli* type variety *Sahsho* was known to 12% of farmers in Ada-Liban and to 8% of farmers in Akaki. None of the interviewed farmers knew this variety in Gimbichu and Alem Gena districts.

In Ada-Liban, 12% of the farmers knew the variety *Dubie*, whereas this variety was known to only 2% of farmers in Akaki and Gimbichu and to 3% of farmers in Alem Gena district. In all of

the sub-study areas, very small percentage of the respondents were aware of the existence of the varieties *Worku, Akaki, DZ-10-11, Arerti and DZ-10-4*.

Table 16. Awareness about improved chickpea varieties among farmers (in percentage).

Varieties	Ada-Liban (n=49)	Akaki (n=50)	Gimbichu (n=120)	Alemgena (n=100)	Total (n=319)	χ^2
Mariye	47	26	10	2	16	
Shasho	12	8	0	0	3.1	
Dubie	12	2	2	3	3.4	
Worku	4	0	0.8	4	2.2	35.35^{***}
Akaki	4	0	0	1	0.9	
DZ-10-11	2	2	0	0	0.3	
Arerti	0	2	0.8	2	1.2	
DZ-10-4	0	0	2	0	0.6	

***Significant at 1% level.

A chi-square test revealed that there is a systematic association between awareness of farmers about the improved chickpea varieties and the participation of farmers in extension related activities and the association is significant at 1% level. It can be concluded that relatively high level of awareness observed among farmers of Ada-Liban is due to stronger technology promotion activities done by research and extension services (demonstration, on-farm verification trial, the FRG programs and trainings) in this district. However, the relationship between level of awareness and access to extension related services is not very strong (*Contingency coefficient = 0.325, P = 0.001*).

Table 17 presents the proportion of farmers who have planted at least one of the improved chickpea varieties. Farmers in Ada-Liban have more exposure to technologies and relatively large proportion of them has planted the improved varieties at least once. Among those who have planted improved chickpea varieties, some did not continue planting them. Adoption of a technology refers to continued use of the technology on area of land sufficiently large enough to economically contribute to the economy of the household. Those sample farmers who have planted the improved varieties and continued growing at least one of the varieties are considered to be adopters. Those farmers who never adopted and those who discontinued using improved varieties are categorized as non-adopters of improved chickpea varieties.

Table 17. Percentage of farmers who have planted at least one of the improved varieties, 2003, by district.

Respondent	Ada-Liban (n=49)	Akaki (n=50)	Gimbichu (n=120)	Alem Gena (n=100)	Total (n=319)
Yes	78	28	20	9.7	25

The rate of adoption of improved chickpea varieties, estimated as percentage of farmers who have continued planting at least one of the improved chickpea varieties, was the highest in Ada-Liban (66%) followed by Akaki (16%), Alem Gena (6%) and Gimbichu (5.8%) (Table 18). The difference in the rate of adoption among the sub-study areas was highly significant. The fact that the adoption rate is higher in the Ada-Liban district reflects the influence of the exposure of

farmers to technologies through on-farm evaluation of technologies and popularization. It also reflects the differential information supplied to farmers about improved varieties and the differential availability of seed through informal seed system. A contingency coefficient which shows the strength of the relationship between the rate of adoption and the location indicates that the relationship was fairly strong (*Contingency coefficient = 0.481, P = 0.001*). Proximity of farmers to DZARC and good access to extension services could be possible explanation for the high rate of adoption of improved chickpea varieties in the Ada-Liban district. The average rate of adoption of chickpea varieties in the four districts surveyed was about 18%.

Table 18. Rate of adoption of improved chickpea varieties, 2003, by district.

Area	Ada-Liban (n=49)	Akaki (n=50)	Gimbichu (n=120)	Alem Gena (n=100)	Total (n=319)	χ^2
	66.0	16.0	7.5	6.8	17.6	97.37^{***}

Contingency coefficient = 0.481; ***P = 0.001.

Among the improved varieties adopted by the sample farmers, *Mariye* was the most widely adopted variety (11%) followed by *Shasho* (3%), *Dubie* (2.5%), *Arerti* (2%) and *Worku* (2%) (Table 19). The two old varieties, *DZ 10-4* and *DZ 10-11*, released in 1970s were least adopted (0.3%) by farmers.

Table 19. Percentage of sample farmers adopting specific chickpea varieties, all districts.

Variety	Adopters (n = 57)
Mariye	11
Shasho	3
Dubie	2.5
Arerti	2
Worku	2
Akaki	0.6
DZ 10-4	0.3
DZ 10-11	0.3

Beside socioeconomic characteristics of the farm household, inherent characteristics of the improved chickpea varieties and farmers' perception about the improved varieties have an effect on adoption and/or rejection of the varieties. Important characteristics of improved varieties that are liked by farmers include drought tolerance (28%), high yield (25%), and early maturity (about 9%) (Table 20). Other less important positive characteristics of newly introduced varieties were good food quality (4%), good seed size (3%), frost tolerance (2%), insect pest tolerance (1%) and market demand (0.94%).

As shown in Table 20, the high adoption of Mariye is explained primarily by high yield, grain size, and price, along with other desirable characteristic (like good taste, early maturity, etc) as perceived by farmers.

Table 20. Characteristics of improved chickpea varieties as perceived by farmers (percentage of respondent), all districts, 2003.

No.	Name of variety	Yield			Food quality			Storability		
		High	Medium	Low	High	Medium	Low	High	Medium	Low
1	DZ 10-11	0.31	-	-	0.31	-	-	0.31	-	-
2	DZ 10-04	0.31	0.31	-	0.31	0.31	-	0.31	0.31	-
3	Dubie	2.17	4.02	-	1.86	4.02	0.31	0.93	5.26	-
4	Mariye	13	3.41	0.6 2	7.43	6.81	0.93	7.74	8.05	1.24
5	Worku	0.62	2.79	-	0.93	1.86	0.31	1.24	1.86	0.31
6	Akaki	0.62	-	-	0.62	-	-	0.62	-	-
7	Arerti	0.62	0.93	-	0.62	0.31	0.62	0.62	0.93	-
8	Shesho	0.62	2.17	0.31	0.93	1.86	0.31	0.62	2.17	0.31
9	Local	5.88	10.53	0.62	7.74	6.50	0.93	9.29	7.43	0.62

Table 20. Characteristics of improved chickpea varieties as perceived by farmers (% respondents) … *Continued*

No	Name of variety	Drought tolerance			Resistance to disease			Tolerance to pest			Maturity		
		High	Medium	Low	High	Medium	Low	High	Medium	Low	High	Medium	Low
1	DZ 10-11	-	-	-	0.31	-	-	0.31	-	-	0.31	-	-
2	DZ 10-04	0.62	-	-	0.62	-	-	0.62	-	-	0.31	0.31	-
3	Dubie	1.55	4.95	-	2.48	3.72	0.31	0.93	5.26	-	1.24	4.95	-
4	Mariye	8.98	8.05	-	11.46	4.95	0.62	9.29	6.19	4.95	9.29	6.19	0.62
5	Worku	1.86	1.55	-	1.86	1.55	-	1.55	1.86	-	1.86	1.55	-
6	Akaki	0.62	-	-	0.31	0.31	-	0.62	-	-	0.31	0.31	-
7	Arerti	0.93	0.62	-	0.31	0.62	0.62	0.62	0.31	0.62	0.62	0.62	0.31
8	Shesho	0.93	1.55	-	1.55	1.55	-	0.93	1.86	0.62	0.31	2.17	0.62
9	Local	11.76	5.26	1.24	6.50	10.22	0.93	7.12	8.36	0.93	8.67	6.81	0.93

Table 20. Characteristics of improved chickpea varieties as perceived by farmers (% respondents) … *Continued*

No	Name of variety	Grain size			Grain color			Taste			Price		
		Big	Medium	Small	Good	Fair	Poor	Good	Fair	Poor	High	Medium	Low
1	Dz-10-11	0.31	-	-	0.31	-	-	0.31	-	-	0.31	-	-
2	Dz-10-04	0.31	0.31	-	0.62	-	-	0.62	-	-	0.62	-	-
3	Dubie	4.64	1.86	-	2.1 7	4.33	-	4.02	2.48	-	2.17	4.33	-
4	Mariye	10.22	6.50	0.31	7.74	8.98	0.31	9.6	7.43	-	10.53	5.88	0.62
5	Worku	2.48	0.93	-	1.86	1.55	-	1.86	1.55	-	1.55	1.55	-
6	Akaki	0.31	0.31	-	0.31	0.31	-	0.62	-	-	0.62	-	-
7	Arerti	0.31	1.24	-	0.93	0.62	-	0.93	0.62	-	0.62	0.62	0.31
8	Shesho	2.48	0.62	-	2.17	0.93	-	2.79	0.31	-	1.86	1.23	-
9	Local	3.41	12.07	2.17	8.36	7.74	1.55	5.26	10.53	1.86	6.19	10.22	0.93

Reasons for not adopting improved varieties

The farmers who planted an improved variety, but later discontinued were asked reasons for discontinuing cultivation of that particular variety. The reasons given by farmers for discontinuing a variety included poor market demand (9%), disease problems (6%), and fear of theft of plants for green pods (5%). Chickpea is widely consumed at green pod stage and large-seeded varieties are preferred. Theft and pilferage are common for the large-seeded improved varieties. Thus, the farmers are reluctant to plant large-seeded improved varieties due to fear of theft.

The important reasons for non-adoption of the improved varieties were lack of access to improved chickpea varieties or unavailability of seeds of improved varieties (27%), lack of awareness (21%), lack of market demand (13%) and fear of theft (7%) (Table 21).

It is evident from the seed distribution data presented in Table 5 that the amount of seed distributed by the ESE and the DZRC for chickpea varieties during the past 15 years (1998 to 2004) is quite small. It ranged from 14 to 90 t, except for the years 1993/94 and 1995/96 during which the seed distribution was 427 and 118 t, respectively. The amount of seed distributed by the ESE could cover less than 1% of total chickpea area in Ethiopia. Thus farmers largely depend on informal seed supply, on the seed they get by hosting on-farm experiments or demonstrations, and on the seed distributed for popularization purposes.

Table 21. Reasons for not using improved varieties (percentage of respondents), 2003.

Reasons	Percent (n =323)
Unavailability of seeds	27
Lack of awareness	21
Improved varieties have no market demand	13
Theft (of green pods)	7
Lack of interest (don't like them & didn't ask for it)	6
Seed too expensive	2
Improved varieties mature late	2
Fear of debt	1
Lack of money	1

6.3. Determinants of adoption of improved chickpea varieties

The results presented in Section 6.2 revealed that not all farmers have adopted improved varieties. The reasons for not adopting improved variables could be related to availability and awareness of the technology. Farmers may not adopt a technology if he/she is not convinced of the benefits, costs and risks associated with technology. Moreover, there are also other technical, institutional, social and economic reasons for adoption or non-adoption of new technology. Comparison of adopters and non-adopters with regard to these variables was done using descriptive statistics. Among the adopters of chickpea varieties about 83% were literate, ie, they could at least read and write. Among the non-adopters group only 68% were literate. In addition, a relatively higher percentage of adopters had good access to agricultural extension related

activities such as on-farm verification trials, demonstration plots, the FRG and training programs. The percentage of farmers who had good access to extension services was about 21% for adopters and about 2% for non-adopters.

The proportion of female-headed households in both adopters and non-adopters group was low, about 5% and 4%, respectively. This is because of low proportion of households headed by female in the community at large. About 58% of adopters of improved chickpea varieties were found in Ada-Liban and 14% of the adopters were in Akaki, 16% in Gimbichu and 12% in Alem Gena districts. The average land size for adopters was 2.30 ha whereas non-adopters had an average land holding of 2.20 ha.

This section presents the econometric analysis of the determinants of adoption of improved chickpea varieties. Table 22 presents the coefficients of the logit model for the adoption of improved chickpea varieties. The logit model used to examine the adoption of improved chickpea varieties is significant at 1% level, i.e., the overall goodness-of-fit measured by significance of chi-square statistic is very high (Omnibus Test of Model Coefficients). This implies that the explanatory variables considered in the model taken together influenced the probability of adopting improved chickpea varieties. In addition, the model correctly classified 87% of the sample farmers into adopters and non-adopters.

Among the independent variables, level of education of the household head, farm size, access to extension (as represented by participation in on-farm trails, FRG activities and demonstration programs), proportion of chickpea area, access to seed have the expected signs. Among these, the coefficient associated with the variable access to extension, access to seed, farm size and proportion of area allocated to chickpea are significantly different from zero and therefore influence the adoption of improved chickpea variety. The coefficient associated with the gender of household head, education, age and number of oxen are not significantly different from zero, therefore, have no effect on the adoption of improved chickpea varieties.

Table 22. Factors determining adoption of improved chickpea varieties.

Variables in the equation	Coefficient	Standard error	Wald	P	Exp (B)[1]
Age	-0.027	0.022	1.482	0.223	0.974
Sex of household head	-1.515	1.253	1.462	0.227	0.220
Education	0.041	0.580	0.005	0.944	1.042
Farm size	0.571	0.269	4.519	0.034	1.770
Access to extension	2.271	0.783	8.409	0.004	9.688
Access to seed	3.037	0.524	33.611	0.000	20.842
Chickpea area	2.888	1.302	4.920	0.027	17.961
Oxen	-0.432	0.195	4.912	0.027	0.649
Constant	-1.040	1.693	0.377	0.539	0.354

Note: 1 Exp (B) shows the predicted change in odds for a unit increase in the predictor.
Omnibus Tests of Model Coefficients: Chi-square = 70.716; Percentage of correct prediction = 86.7%.

As anticipated, the effect of access to extension on varietal adoption was positive and significant. This implies that farmers who had interaction with extension agents, i.e., participated in on-farm trials, demonstrations and the FRG programs adopted improved chickpea varieties more than those who had no exposure to extension messages. Holding other independent variables constant, the odds of adoption of improved chickpea varieties was more than nine times higher for those who had good access to extension than farmers who had no access to extension. Access to seed is significantly related to with the adoption of improved varieties. Formal seed sector do not regularly provide chickpea seeds to farmers. Farmers depend on the informal seed system. There are farmers who sell improved chickpea seed at farm-gate or in market. Farmers close to such areas and have cash to purchase seed have better access to seed than others. The odds ratio associated with the variable access to seed implies that having access to seed will change the odds ratio by factor of 20.

Farm size and area allocated to chickpea were positively related with the adoption of improved chickpea varieties, and their coefficients were significantly different from zero. Thus, the probability of adopting improved chickpea variety increase with an increase in farm size and proportion of cultivated area allocated to chickpea. The probability of adopting chickpea variety increases by a factor of 1.77 when farm size increases by 1 hectare. Similarly, the probability of adopting improved chickpea variety increase by a factor of 18 when area allocated to chickpea increases by one hectare.

It is difficult to explain the negative relation observed between oxen ownership and adoption of chickpea varieties. The coefficient of the variables education was not significantly different from zero. Hence, there is no evidence to suggest that this variable influences adoption improved chickpea varieties.

7. Conclusions and recommendations

In Ethiopia, chickpea is one of the important food legumes because of its use as food and feed, generating cash income and maintenance of soil fertility. The productivity of chickpea at national level remained stagnant due to limited use of modern production technologies. Great variation existed across different localities in the adoption of improved varieties – areas close to research centers and having better access to extension services are ahead of areas away from research centers. The variation observed in adoption of improved varieties implies variation in access to inputs and information about the improved varieties and their associated cultural practices. Thus there is need to improve input supply mechanism. At present input supply (especially seed) is limited or non-existent particularly in the remote chickpea producing areas.

Availability of improved chickpea seeds is found to be the critical factor for the adoption of improved chickpea varieties developed by the research system. Currently very limited amount of seed is produced and distributed to farmers. Farmers depend on the informal seed system. Thus, the involvement of private sector and co-operatives in production and distribution of chickpea seed is vital to meet the demand of improved chickpea seeds. At present, large seed producers are reluctant to produce chickpea seeds. Thus the problem of seed supply may persist unless

appropriate action is taken through developing informal seed production and supply. One possible means is to organize seed producing farmers, as co-operatives may take responsibility in processing, distribution and marketing seeds.

This study confirmed that extension influences adoption of new technologies. Farmer would not adopt an improved variety until they are aware and observe and comprehend their advantages. On-farm experimentation and evaluation of technologies on farmers' field not only help in fine-tuning technologies to farmers' conditions, but it allows farmers to be aware of the improved technologies and to evaluate their performances. Therefore, participatory technology development approach should be enhanced.

Chickpea is consumed at green pods stage. Large seeded varieties are more preferred for green pod consumption and are subjected to high risk of theft. Guarding chickpea fields against theft of green plants (for green seed) is labor intensive. Thus, farmers are reluctant to grow large-seeded improved varieties. Community based joint actions are required to spread the risk, so that an individual farmer does not loose much because of theft.

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Appendixes

Appendix I. Physical features and climatic conditions of the surveyed study area.

Description	Ada-Liban	Akaki	Alem Gena	Gimbichu
Altitude meters above sea level (min)	1600	1860	1800	900
Altitude meters above sea level (mean)	1900	2100	2000	2400
Altitude meters above sea level (max.)	3100	3000	3385	2700
Annual mean rain fall (mm)	802.42	1133.4	886.0	901.5
Annual minimum temperature (^{o}C)	-[1]	13.7	-	8.04
Annual mean temperature (^{o}C)	-	19.8	-	15.45
Annual maximum temperature (^{o}C)	-	25.9	-	23.87
Highland area (%)	5	2	12	52
Mid altitude area (%)	95	98	88	27
Soil type – Vertisol (%)	63.7	90	61	75

1 = Data not available.

Appendix II. Land use and demographic description of the study districts.

Area in hectares	Ada-Liban	%	Akaki	%	Alem Gena	%	Gimbichu	%	Total	%
Total area	161056	-[1]	59845	-	87272	-	48774	-	356948	-
Cultivated	119450	74.2	44784	74.8	76986	88.2	34804	71.4	276024	77.3
Grazing	6462	4.0	4569	7.6	3740	2.8	4215	8.6	18986	5.3
Total forest	15693	9.7	2656	4.4	2538	2.9	1951	4.0	22838	6.4
Public forest	325	-	4400	-	-	-	-	-	4725	-
Government forest	2105	-	-	-	-	-	-	-	2105	-
Bushes	10833	6.7	-	-	-	-	5853**	12.0	16686	4.7
Unused	39977	24.8	2630	4.4	-	-	-	-	42607	11.9
Water bodies	2232	-	756	1.3	1475	1.7	-	-	2232	0.6
Town/township	2733	1.7	2100*	3.5	909	1.0	-	-	5742	1.6
Others	5366	-	-	-	1622	1.9	1951	4.0	8939	2.5
Irrigated area	437	-	100	-	406	-	-	-	543	-
Total population	289508	-	127385*	-	173965	-	88302	-	679160	-
Rural population	190587	65.8	67385	52.9	142700	82.0	83052	94.1	483724	71.2

1 = Data not available; * =Personal estimation, (in the case of Akaki town population), ** = Threshing area, rivers, roads, villages, schools, churches (construction areas) marshy (601.5 ha) or water bodies (1630 ha) in Ada-Liban.

Appendix III. Cultivated area, productivity and grain yield of different crops in the 2003/04 cropping season, Ethiopia.

	District												Overall mean of the four districts		
	Ada-Liban			Akaki			Alem Gena			Gimbichu					
Type of crop	Area (ha)	Yield (t ha^{-1})	Production (t)	Area (ha)	Yield (t ha^{-1})	Production (t)	Area (ha)	Yield (t ha^{-1})	Production (t)	Area (ha)	Yield (t ha^{-1})	Production (t)	Area (ha)	Yield (t ha^{-1})	Production (t)
Cereals (all)	99841	1.7	173211	34660	1.5	51852	57526	1.1	62798	27198	1.7	55171	219136.25	1.3	286514
Tef	60878	1.1	66966	18140	1.3	23582	29878	0.9	26591	8210	1.1	9032	117096.0	1.1	126171
Wheat	33872	2.9	98229	16031	1.7	27734	21852	1.3	28626	18234	2.5	44802	89989.25	2.2	199390
Barley	2300	1.4	3240	283	1.0	275	4853	1.1	5532	438	1.7	737	7874.0	1.2	9784
Emmer wheat	35	0.6	21	53	1.1	58	0	0.0	0	12	1.5	18	100.00	1.0	97
Sorghum	656	1.5	975	27	2.4	43	261	1.6	418	202	2.0	404	1146.0	1.6	1840
Maize	2100	1.8	3780	67	1.6	161	682	2.4	1630	112	1.6	179	2931.0	2.0	5750
Pulses (all)	16765	1.3	21622	8620	1.3	11167	18818	0.7	13252	7305	1.2	9632	51506.50	1.1	55672
Faba bean	6600	1.3	8580	416	1.0	216	3861	1.0	3861	745	1.2	894	11622	1.2	13551
Field pea	4230	1.0	5953	203	0.8	162	1459	0.8	1167	452	1.3	588	6344	1.2	7870
Chickpea	3100	1.4	4340	5057	1.4	7080	5995	0.7	4197	2711	1.5	3990	16862.5	1.2	19606
Lentil	809	0.4	324	508	0.2	102	4397	0.5	2199	1823	0.9	1677	7536.5	0.6	4301
Rough pea	541	1.5	812	2352	1.5	3528	2930	0.6	1758	1529	1.5	2250	7351.5	1.1	8348
Fenugreek	35	0.5	18	52	0.6	31	176	0.4	70	268	0.7	188	263.0	1.2	307
Haricot bean	1450	1.1	1595	32	1.5	48	0	-	0	46	1.0	46	1527.0	1.1	1689
Oil crops	35	0.3	11	73	0.6	44	643	0.4	257	21.5	0.8	17	772.5	0.4	329

Source: Bureau of Agriculture and Rural Development of each district.

About ICRISAT

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a non-profit, non-political organization belonging to the Future Harvest Alliance of Centers supported by the Consultative Group on International Agricultural Research (CGIAR). Established in 1972, ICRISAT generates and shares cutting-edge technologies that support the livelihoods of more than 300 million people – the poorest of the poor in semi-arid areas of the developing world.

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411-2005