Adoption of Improved Chickpea Varieties

in the Central Highlands of Ethiopia

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Introduction

In spite of its importance, chickpea productivity is still very low in Ethiopia. The national average yield of chickpea landraces, under farmers' production system, is not more than 8.8 q ha^{-1} (CSA 2004). On the other hand, the potential yield of the crop under improved management system is four to five folds of the national average. A number of factors contribute to the low productivity of chickpea. The major constraints are low yield potential of local cultivars (e.g., the Ethiopian Desi chickpea types, with small seed size and undesirable texture, are low in productivity.), poor cultural practices, and susceptibility of landraces to biotic and abiotic stresses. Wilt or root-rot complex, aschochyta blight, stunt virus, fungal seed attack, African boll warm, and bean bruchides are among biotic factors that greatly contribute to low productivity or production loss of chickpea. Yield limiting abiotic factors are drought, waterlogging, and frost. Unavailability of improved seed is also another factor for low productivity.

Chickpea is widely grown in the central highlands of Southwest, West, and East Shewa; East and West Gojam; South and North Gonder; and South and North Wello.

Over the last two decades, on-farm trials, demonstrations, and popularization of improved chickpea production technologies (improved varieties and management practices) have been undertaken at several chickpea producing areas to promote technologies and enhance adoption. Research centers and bureaus of agriculture and rural development promoted the technologies. The bureau of agriculture and rural development is responsible for a wide promotion of agricultural technologies. However, despite the efforts made so far in technology generation and dissemination, comprehensive information on the level of adoption of improved chickpea technologies is lacking.

Production status

Food legumes cover about 10% of the area under crop production and share nearly 13% of total annual crops production (CSA 2004). Among food legumes, chickpea is widely cultivated in the central and northern parts of the country. Area under chickpea production increased from 138,000 in 1982 to 154,000 ha in 2004 (Annex I), accounting for 14% of the area allocated to food legumes.

There was fluctuation in the average growth rate of area and production of chickpea over the last two decades. In the early 1980s, the area growth rate under chickpea was negative. Similarly, in the late 1980s and the early 1990s, the average growth rate of production was negative, mainly because of decline in area.

From 1992 to 2000, the average production of chickpea was positive, attaining the second highest growth rate (12%) among the food legumes (Annex II). The main reason for this increased production was not due to improved productivity but it was an expansion in area cultivated with these crops.

Production practices

Chickpea fields are selected based on their fertility status. The crop, being nitrogen fixer, is sowed on less fertile soils to improve fertility of the soils through crop rotation. On average, chickpea fields are ploughed two or three times, including the plowing to cover seeds during sowing. The frequency of plowing for chickpea is higher than other pulses (Annex III).

Chickpea is usually produced on Black Vertisol. Vertisols are known for excess water and drainage problems during the main rainy season (June–August). Thus, to overcome this problem, farmers sow chickpea late in the season and it is commonly produced on residual moisture. It is sowed from September to October through broadcast method. In some specific locations, it is sowed on flooded land when water retreats back to its axis point at the end of the rainy season.

Chickpea is weeded at least once through out the production season. It is mainly cultivated without applying fertilizers and herbicides. Nevertheless, pesticides are applied to control diseases or insects only when specific disease or insect epidemics occur in a specific location. In epidemic cases, the responsibility of applying insecticides or pesticides lies on the Ministry of Agriculture and Rural Development and NGOs. The government provides pesticides, sprayers, insecticides, and technical supports free of charge, whereas farmers contribute labor.

In the study zones, chickpea is cultivated as a sole crop. Inter-cropping chickpea with other crops is not practiced. In their cropping sequences, farmers rotate chickpea with cereals to improve soil fertility.

Improved chickpea seed varieties are not available at affordable price and at the right time and place, particularly in areas away from research centers. As a result, most farmers depend on local cultivars and seeds. Farmers who grow improved chickpea varieties depend on local exchange of seeds originated from research centers through on-farm testing, popularization, and demonstration activities. They also keep their own seeds for the next harvest.

Harvesting chickpea is very tedious. Chickpea is usually handpicked when it is ready for green pod consumption or dried. Its harvesting time extends from October to January for green pods and from February to March for dried grain. It is threshed using animal power.

Utilization

In the study area, chickpea grain is used for human food and its straw is used for animal feed. Its seeds are consumed in different forms. The most common forms are *Kolo* (roasted grain), *Nifro* (boiled grain), and *Wot (*sauce). In all the forms, it may be consumed alone or blended. In addition, at green pods stage, it is consumed without any processing. It also generates cash to farmers and makes profit to traders.

Marketing

Chickpea can be marketed at green pod stage or in the form of dried grain. The bulk of chickpea is usually sold unprocessed. In the study area, it is sold as dried grain and as green pod. The selling of green pod chickpea for direct consumption is becoming common in Addis Ababa and at roadside markets. Dried chickpea seeds are harvested for consumption, but the whole plant is picked and taken to the market at green pod stage.

According to farmers, selling chickpea at green pods stage is more profitable than selling dried grain (a bundle of chickpea loaded on a donkey fetches Birr 25 at Addis Abeba market.) One farmer estimated that 35 bundles could be harvested from a quarter of a hectare. This would generate a gross income of Birr 3500 ha^{-1} for a farmer. With average productivity of 10q ha^{-1}, a farmer can get a gross income of Birr 1800 ha^{-1} for the dried grain.

Although selling chickpea at green pod stage seems remunerative, only few farmers near urban areas are benefited. At this stage, the pods are perishable and cannot be transported long distances. Moreover, transportation costs may also down play on the benefits from the sale of green pods.

Farmers sell chickpea directly to consumers in local markets. Alternatively, they sell to small traders (assemblers) in rural areas or directly to wholesalers. Small traders may sell to consumers or to wholesalers located at production areas. Big traders take the grain to terminal markets and sell it either to retailers or wholesalers. The volumes handled by different channels are not known, thus require further investigation. The marketing channel for chickpea in the form of green pod stage is simple, i.e., retailers directly purchase from farmers and sell them to consumers.

Research and technology development

Chickpea research was started at Debre Zeit Agricultural Research Center in 1972. The objective of the research program was to alleviate production constraints and to contribute for increased productivity, to ensure sustainability of production, thereby increasing availability of food, and to improve the economic and social welfare of farmers. Other researchable areas were identified based on survey. 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 its major production constraints. Prevalence of diseases, insect pests; absence or limited use of modern inputs and inappropriate agronomic practices were found to be constraints of chickpea productivity. Lack of market incentives and post-harvest losses are also problems of chickpea production.

Among others, genetic improvement and associated crop management studies were undertaken to minimize the effect of chickpea production constraints. The emphasis was to develop improved chickpea varieties. While generating improved varieties, parallel genetic improvement programs were developed for Desi and Kabuli types.

Since 1978, the chickpea research program has collaborated with International Crop Research Institute for Semi-Arid Tropics (ICRISAT), International Center for Agricultural Research in the Dry Areas (ICARDA) and with sister national research organizations. The research program has benefited from the collaboration of human resources development, information exchange, and acquisitions of germplasms and advanced materials for breeding programs. Since the launching of the research program and collaboration with international agricultural research centers (IARC), the program has released ten improved varieties. Among these varieties *Mariye, Worku, Akaki, Shasho, Arerti,* and *Habru* were developed using ICRISAT's breeding materials (Annex IV). Three varieties were also released through selection of breeding materials originated from Ethiopia.

A number of agronomic practices were evaluated and recommended to farmers for increased productivity. In preparing seedbed, one deep plowing in dry seasons (March to May), disking twice from mid June to early August, and planting from mid August to early September was recommended. In moisture stress areas, early planting (July) would increase yield. Hand weeding twice (30 and 60 days after emergence) or application of glyphosphate (three to four weeks before planting at the rate of four liters per hectare) followed by one plowing to cover the seeds is important.

Technology transfer

Effective extension services help farmers to get timely access to advices, information on technologies and on the use of modern inputs and application of improved agronomic, and crop protection practices. Chickpea technologies were extended to farmers through the following methods: The improved varieties were verified on-farm through participatory technology evaluation with farmers' involvement. Varieties were also popularized through regular extension activities and, in few cases, by NGOs. Farmers Research Groups (FRG) were established and participated in actual planning, execution, and evaluation of varieties around research centers. This mechanism helped farmers to have access to information and to be able to select varieties with desirable trait before their release. Some farmers visited research centers and requested seed varieties they wanted. A team of breeders, agronomists, and social scientists did on-farm technology testing, popularization, and evaluation. Research centers produce and distribute limited amount of improved seed varieties to farmers around the centers. Once farmers get early generation seed, they save seed for the next production. They maintain seeds not only to satisfy their own requirement but also to exchange them with other farmers. Seeds could be exchanged home to home in kind or at the market using monetary values.

Yield of improved varieties

The success history of chickpea research started with the release of two improved varieties (DZ-10-11 Desi type and DZ-10-4 Kabuli type) in 1974. Since the inception of the research program, ten improved varieties were released along with their recommended management practices, and they are made available for commercial use. Among these varieties, two (DZ-10-11 and DZ-10-4) were out of production due to their poor yield performance compared to the new varieties.

The improved varieties have high yield potential of four to five folds of the local cultivars. These varieties do not only excel the local varieties by their yield potential but also have better seed size (Their seed size is three folds of the local cultivars.) (Annex VIII). They possess desirable color, which makes them more marketable than local cultivar grains. For instance, *Shasho* variety is white seeded, which is the desirable color, and *Chafe* meets world market standard. In addition, the varieties have better stress tolerance, wider environment adaptability, and better food quality than local cultivars. Along with the improved varieties, improved agronomic practices were identified and recommended. These technologies have been evaluated on farmers' fields for their performance under farmers' management systems.

Experimental and on-farm plots yields are much higher than the national average for all selected varieties (Annex VIII). For instance, the yield gap between the experimental plots and farmers' fields for *Worku* chickpea variety 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 increase productivity of chickpea.

Seed multiplication

Seed availability is a critical factor in adopting improved chickpea varieties. At present, the Ethiopian Seed Enterprise (ESE) is the leading commercial seed producer. Its mandate is to multiply basic and certified improved seeds varieties. However, the amount of improved chickpea seeds produced and distributed by ESE is very small (Annex V). There was no continuous supply of seeds, and in some years, improved chickpea seeds were not distributed at all. Private seed producers are not also involved in production of improved chickpea seeds. The involvement of private sectors and cooperatives in the production and distribution of seeds would greatly assist in addressing the demand for improved chickpea seeds.

The Study Areas

The study areas are located in the central part of the country in Akaki, Alem-Gena, Ada-Liban, and Gimbichu, which are the main chickpea producing areas

The total area of the four districts is 356,948 ha. Statistical information from Districts Agricultural Offices (DAO) in 2004 cropping season reveals that more than 77% of the total area of the four districts is under cultivation. Grazing land and forests account for 5.32% and 6.4% of the study areas, respectively. Cereals account for 79.4% of the cultivated area, whereas pulses cover only 19%. Chickpea is the largest in both area and production, and it covers 33% of the total area under pulses (Annex X).

Ada-Liban

Ada-Liban is the largest of all surveyed areas. It is located to the south of Akaki. About 95% of this district is an intermediate highland with an average elevation of 1900 m. In this district, over 60% of the soil is Vertisol and 24.3% is Clay-loam, and is a typical soil for chickpea cultivation. Chickpea is considered as the third important pulse crop next to faba bean and field pea in the district. The average annual precipitation is over 800 mm. The minimum, mean, and maximum temperatures of the district are 11.11 ^{0}C, 19.61 ^{0}C, and 26.64 ^{0}C, respectively.

Akaki

Akaki is to the southeast of Addis Ababa. The minimum, mean, and maximum temperatures of the district are 13.7^{o}C, 19.8 ^{0}C, and 25.9 ^{0}C, respectively. Chickpea is the most important pulse crop in the district. The district has an average elevation of about 2000 m. About 90% of the soil is considered as Vertisol. Nearly half of the population is urban dweller. Chickpea growing farmers have better access to chickpea green pod markets.

Alem-Gena

Alem-Gena has about 2100 m average altitude. It is among the areas selected for chickpea specialization. Among pulses, chickpea is the most important crop grown but its average yield is not more than 7 q ha^{-1}. The main soil types are Vertisol and Alluvial. In Alem-Gena, chickpea is grown on the residual moisture and on the Awash River flood plain when the water withdraws at the end of rainy seasons.

Gimbichu

Gimbichu is located to the northeastern part of all the study areas. It has 2400 m average elevation. More than 50% of this area is classified as typical highland. The district has 75% Vertisols, and its average annual rainfall is 902 mm. Chickpea is one of the main pulse crops grown in the area.

Figure 1: Map of the Study Districts

Methodology

Data collection and analyses

A multi-disciplinary team of researchers consisting of social scientists, breeders, and agronomists conducted the study. Initially, the team used selected 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.

Then, samples of chickpea growing farmers were surveyed. The farm household head that actually makes the day-to-day decisions on farm activities, technology adoption, and input use was taken as the basic sample unit. Kebeles[1] were taken as sample frames. A multi-stage sampling procedure was used to identify the required number of sample farmers. In the first stage, Districts (Ada-Liban, Akaki, Gimbichu, and Alem Gena) were selected purposely on the bases of importance of chickpea in the production system and promotion of chickpea technologies. In the second stage, all kebeles known for good chickpea production were listed in consultation with experts from district agricultural offices. Once the complete lists of main chickpea producing kebeles were identified, sample kebeles were selected using simple random sampling. In the last stage, chickpea producing farmers were identified and listed in consultation with kebele leaders. A systematic random sampling technique was applied to select sample farmers from a list of chickpea producers. About 323 sample chickpea producers were drawn from the population of chickpea growers. Sub samples of 50 households from Ada-Liban, 50 from Akaki, 120 from Gimbichu, and 103 from Alem-Gena were interviewed.

Analysis was done using descriptive statistics, such as averages, frequencies, appropriate t-tests, ANOVA, and cross-tabulations, to test hypotheses. A logit model was estimated to determine factors affecting adoption of improved chickpea varieties. This 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

[1] Kebeles are the lowest administrative unit responsible for tax collection and administrative aspect.

The dependent variable (log-odds ratio), used for identifying factors determining adoption of improved chickpea varieties, is the natural logarithm of the ratio of the probability that a 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.

Hypotheses

Education

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

Access to extension

Outputs of research endeavors reach the end users of agricultural technologies through various out reach programs and agricultural extensions. The first step towards technology adoption is popularizing available technologies to make farmers aware of the technology. Therefore, access to extension services was expected to affect adoption positively.

Sex of household head

Gender is an issue that should be considered from technology generation to popularization. Quite often, women are marginalized in extension services and market information. Hence, there is a high probability that female-headed households know little about improved chickpea varieties. It is hypothesized that the probability of adoption will be higher for male-headed households than female-headed households.

Access to input

Access to improved seed varieties vary among farmers in different districts. Some farmers have better access than others do due to their proximity to research centers and informal seed exchange areas. Access to input is also an important socio-economic variable that determines adoption of improved varieties. Access to seed was hypothesized to lead to high probability of adopting improved varieties.

Farm size

Farm size is an indicator of the economic status of a household. Technology adoption can some times be a risky venture. Risks associated with technologies can be climatic or market. Climatic risk happens because of unfavorable climatic conditions. Market risk occurs if the output cannot penetrate the market because of preferences of consumers. Therefore, poor farmers are more risk-prone than the relatively rich ones. This is because the riches have a better buffering capacity than the poor do. Hence, a positive relationship is expected between farm size and decision to adopt improved varieties.

Chickpea area

Farmers who allocate proportionally large area of land for chickpea consider chickpea as an important crop in their crop mix. It is expected that such groups are likely to invest on chickpea technologies. Hence, a positive relationship is expected between the proportion of farmland allocated to chickpea (chickpea area/total crop area) and adoption decision of farmers.

Oxen

In the study area, oxen are almost the only sources 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 a pair of oxen to prepare their land well and sow on time. Therefore, the number of oxen owned by a farmer is assumed to be positively correlated with the decision of farmers to adopt the improved chickpea varieties and its intensity of use.

Age

Previous adoption studies have shown that the age of a household head (i.e., 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, young farmers are found to be more flexible in their decisions than old framers. They may be more willing to bear risks due to their longer planning horizons and better schooling than the old generation. Second, old farmers may have more experiences and resources that will give them more possibilities for trying a new technology than the young. Here, we hypothesize that the age of farmers influences their adoption decisions. The direct effect could be positive or negative.

Socio-Economic and Institutional Characteristics

Demography and resource ownerships

Socio-economic characteristics of farm households are important for technology adoption as they have impact on farmers' decision-making. The socio-economic characteristics treated in the study are family size and composition, sex, and educational level of household heads. The size of land and livestock owned are also considered in relation to socio-economic characteristics.

In Ada-Liban, about 6% of the interviewed households were female-headed, but in Akaki, Gimbichu, and Alem-Gena, they account for 4% of the interviewees (Table 1). In female-headed households, plowing either is done by son (s) or hired laborer. 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. Average number of male members of a household who are within 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. Average number of female members in that age group is 1.95 in Ada-Liban, 1.64 in Akaki, 1.45 in Gimbichu, and 1.67 in Alem Gena (Table 1).

Table 1. Demographic characteristics of sample households, 2003

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

About 22% of the households heads interviewed in Ada-Liban, 45% in Akaki, 33% in Gimbichu, and 24% in Alem Gena were illiterate (Table 2). Several household heads in Ada-Liban (49%), Akaki (25%), Gimbichu (49%), and Alem-Gena (32%) could read and write. About 29% household heads in Ada-Liban, 31% in Akaki, 19% in Gimbichu, and 43% in Alem Gena had completed at least primary school. Comparing number of illiterate and literate household heads in the four sub-study areas shows that there is a significant difference among the sub-study areas at 5% level (Table 2). The level of education is higher in Ada-Liban, Gimbichu, and Alem Gena than in Akaki[2].

Table 2. Level of education of the household heads (%)

Level of education	Ada-Liban (n=50)	Akaki (n= 50)	Gimbichu (n=120)	Alem-Gena (n=103)	Total (n= 325)
Illiterate	22.4	44.9	32.5	24.0	30.2
Read and write	49.0	24.5	48.7	32.0	39.7
Primary school complete	20.4	12.2	13.7	18.0	15.9
Junior secondary school complete	6.1	12.2	2.6	10.0	7.0
Secondary school complete	2.0	6.1	2.6	15.0	7.0

A key indicator of economic status of farm households is the type, quantity, and quality of resources they own. Labor, land, and livestock size constitute the major types of resources that can be used to generate income by smallholder farmers. The average farm size in Ada-Liban, Akaki, Gimbichu, and Alem-Gena was 2.05, 2.20, 1.80, and 2.84 ha, respectively (Table 3). Comparing average landholding per family member gives a clear picture of land resource availability in the study areas. 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 4). 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.

Table 3. Average farm size per households (ha), 2003

Study area	N	Minimum	Maximum	Mean	SD
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	1.63	8.50	2.23	1.15

Table 4. Average farm size per individual household member by wereda (ha), 2003

Sub-study area	N	Mean	SD	F-value
Ada-Liban	50	0.33	0.18	
Akaki	49	0.29	0.14	8.7***
Gimbichu	120	0.27	0.17	
Alem Gena	101	0.38	0.18	
Total	320	0.32	0.17	

**** Significant at 1% level*

In the study areas, mixed farming is practiced, and each household owns at least one or more types of livestock. Livestock provide traction and manure to crop production and in return, crop production is a source of feed for livestock.

[2] A comparison of proportion of illiterates and literates in Ada-Liban, Gimbichu and Alem Gena showed that there is no statistically significant difference among the woredas at 10% level.

Livestock is also an important source of fuel for the family members. Moreover, through the sale of livestock and livestock products, the farm household earns cash. Household ox ownership ranged from 2.3 to 3.5 in Gimbichu and Ada-Liban, respectively (Table 5). On average, all farm families had less than two cows.

Table 5. Livestock ownership of farm families, (2003)

Livestock	Ada-Liban (n=50)	Akaki (n=50)	Gimbichu (n=120)	Alem-Gena (n=103)	Total (n=323)
Cows	1.4 (0.8)	1. 7 (0.1)	1.3 (0.9)	1.7 (1.2)	1.5 (1)
Oxen	3.5 (1.3)	3.4 (1.8)	2.3 (1.3)	3.1 (1.5)	3.2 (1.4)
Heifers	0.8 (0.8)	1 (0.8)	0.8 (0.9)	1.(0.1)	0.9 (0.9)
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)

Note: Figures in parenthesis are standard deviations

Access to extension services

Agricultural extension services are rendered with the aim of transferring technologies and improved production techniques to farmers to increase the level of productivity and total production. Previous studies have revealed that strong extension services have a positive impact on technology adoption (Tesfaye *et al.* 2001). However, low performance of extension services has resulted in low rate of adoption of technologies (Hailu *et al.* 1998; Alemu *et al.* 1998). Poor extension service leads to lack of awareness of technologies among farmers. Studies have revealed that technology adoption can be hampered by lack of awareness (Adam and Dawit 2002).

The percentage of farmers who have participated in extension related activities, such as, on-farm verification trials, demonstration trials, special training programs, and farmer research groups, was 23.7% in Ada-Liban, 6.5% in Akaki, 2.6% in Gimbichu, and 3.1% in Alem-Gena (Table 6).

Table 6. Access to extension services on chickpea (2003)

Extension services	Ada-Liban (n=38)	Akaki (n=46)	Gimbichu (n=116)	Alem- Gena (n=99)	Total[b] (n=275)	χ^2
Participated in extension related services (%)	23.7	6.5	2.6	3.1	5.0	
Have not participated in extension related services (%)	76.3	93.5	97.4	96.9	87.00	24.96^{***}

Note: Weighted average

A Chi-Square (χ^2) test was applied to check if the two variables, i.e., District (Sub-study areas) and access to extension services were independent. The results indicated 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 the three sub-study areas. The contingency coefficient (a coefficient that measures the strength of the relationship between the two variables indicated above) 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 (development) agents. About 42% in Alem-Gena, 40% in Akaki, 27% in Ada-Liban and 16% in Gimbichu reported that they contact with extension agents every week (Table 7). Several sample farmers (43% in Ada-Liban, 35% in Gimbichu, 24% in Alem Gena and 20% in Akaki) 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 with no contact with extension agents was about 11% in Alem Gena, 8% in Ada-Liban, and 6% in Gimbichu.

Table 7. Frequency of farmers contact with extension agents (%), 2003

	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

Credit availability plays a crucial role in technology adoption. Quite often, small farmers who are the target of this study are economically too weak to afford most of the external inputs. Studies conducted so far (Tesfaye *et al.* 2001; Beyene *et al.* 1991; and Alemu *et al.* 1998) have showed that cash shortage is one of the causes of low rate of technology adoption. Cash shortage is prevalent among smallholder farmers particularly during the main cropping season when previous year's harvest is near exhaustion and this is the time where cash is required to purchase inputs. Ideally, this gap needs to be filled by timely availability of credit with fair terms of conditions, including an affordable interest rate.

The empirical result of this study shows that about 14% of the farmers 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[3] 13 in Ada-Liban to Birr 200 in Gimbichu (Table 8). According to the interviewed farmers, sources of credit were District Agricultural Office (DAO) and individuals.

Table 8. Amount of credit obtained for chickpea production by District (in Birr)

Woreda	Year	N	Minimum	Maximum	Mean	SD
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

[3] 1 US dollar is equal to 8.78 birr

Adopting Improved Varieties and Management Practices

Improved practices

Mostly, the productivity of chickpea at national level remained stagnant. One of the main attributes, beyond biotic limitations, is limited application of improved technologies. A number of improved management practices were developed and promoted. Improved management practices, such as, planting date, land preparation, site selection, 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 plant chickpea in September, after the end of the rainy season. The planting time practiced by farmers is not in line with research recommendations. The recommended seeding rates for the improved chickpea varieties are 90–120 kg ha^{-1} for small and 120–150 kg ha^{-1} for large seed varieties. There is a difference between the recommended and the practiced seeding rates by farmers.

Fertilizer is one of the important inputs to increase productivity; 100 kg ha^{-1} Diamonium Phosphate (DAP) is recommended for chickpea production. Not all the sample farmers applied any fertilizer for chickpea production. The frequency of land preparation is four, with a range of one to seven times plowing. Chickpea was weeded twice by 90% of the farmers. It is one of the legumes known for its contribution in soil fertility maintenance. About 92% of the farmers rotate chickpea with other cereals, mainly tef and wheat as preceding and following crop.

The national average productivity of chickpea is 8.8q ha^{-1} and seed size of the landraces is about 13 grams per hundred seeds. However, with the development of improved varieties, it is now possible to produce about 25–35 q ha^{-1} grain yields with a desired seed sizes. Improved management practice has equally shown yield step up in many of the cases. Research findings showed that there is yield increment of 35% to planting date, about 10% to seeding rate, about 10% to fertilization and greater than 50% to seed bed preparation (Million 1994).

Improved varieties

Research has produced improved varieties that have the potential to increase productivity. Improved chickpea varieties are more productive than the local varieties. To adopt newly introduced varieties 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 of the end users of the technologies. Farmers' awareness about the available improved varieties is an important factor for the adoption to take place.

The improved variety *Mariye* is assumed the widely known variety. Only 16% of the sample farmers were aware of the existence and benefits of this variety. There is great variation among the districts in awareness about improved varieties. In Ada-Liban, 47% of the sample farmers know *Mariye*. The sample farmers, who know the existence of *Mariye,* were 26%, 10%, and 2% in Akaki, Gimbichu, and Alem Gena, respectively. *Shasho* was known to 12% of sample farmers in Ada-Liban, and to 8% of sample farmers in Akaki. Among the interviewed farmers, no body knew Shasho in Gimbichu and Alem Gena.

In Ada-Liban, 12% of the sample farmers knew about Dube, whereas this variety was known by 2% in Akaki and Gimbichu, and by 3% in Alem-Gena. In all sub-study areas, very small numbers of the respondents were aware of the existence of Worku, Akaki, DZ-10-11, Arerti, and DZ-10-4 varieties (Table 9).

Table 9. Awareness of farmers about improved chickpea varieties (%)

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	
Dube	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	

A Chi-Square (χ^2) test revealed that there is a systematic association between awareness of farmers about the improved chickpea varieties and their participation in extension related activities, which is significant at 1% level. It can be concluded that relatively high level of awareness of farmers in Ada-Liban is attributed to strong technology promotion activities done by research and extension services (demonstration, on-farm verification trial, farmer research groups, and trainings) in the District. However, the relationship between level of awareness and access to extension related services is not very strong.

Farmers in Ada-Liban have more exposure to technologies, and most of them have planted improved varieties at least once (Table 10). However, some of them, who have ever planted improved chickpea varieties, did not continue planting them. Adoption of a technology refers to a continued use of the technology on an area of land, which is large enough to contribute to the economy of the household. Here, the sample farmers who have planted improved varieties and continued growing at least one of the varieties are considered adopters. Farmers who never adopted and those who discontinued using improved varieties are categorized as non-adopters.

Table 10. Farmers planted at least one of the improved varieties (%)

Responses	Ada-Liban (n=49)	Akaki (n=50)	Gimbichu (n=120)	Alem Gena (n=100)	Total (n=319)
Yes	78	28	20	9.7	25
No	22	72	80	90.3	75

The highest rate of adoption[4] was observed in Ada-Liban (Table 11). In this district, about 66% of the sample farmers had adopted at least one of the improved chickpea varieties, whereas only 16% in Akaki, 5.8% in Gimbichu, and 6% in Alem-Gena adopted the improved chickpea varieties. The difference in the rate of adoption among the sub-study areas was highly significant. The high rate of adoption in Ada-Liban reflects the influence of exposure to technologies through on-farm evaluation and popularization. It also reflects the intensity of popularization of improved varieties and the availability of seed through informal seed system. A contingency coefficient which shows the strength of the relationship between rate of adoption and location indicates that the relationship was strong (Contingency coefficient = 0.481, Sig. = 0.000). This result is quite logical, given the relatively high rate of access to agricultural extension services with improved chickpea varieties in Ada-Liban. Farmers' proximity to Debre Zeit Agricultural Research Center could be another possible reason for the high rate of adoption in Ada-Liban. In general, the average rate of adoption of chickpea varieties in the study areas is quite low, about 18%.

Table 11. Rate of adoption of improved chickpea varieties, 2003

Sub-study area	Ada-Liban (n=49)	Akaki (n=50)	Gimbichu (n=120)	Alem Gena (n=100)	Total (n=319)	χ^2
Adopters	66.0	16.0	7.5	6.8	17.6	97.37***
Non-adopters	34.0	84.0	92.5	93.2	82.4	

Contingency coefficient = 0.481, Sig. = 0.000

Among the improved varieties, Mariye was the most widely adopted by the sample farmers (11%) followed by Shasho (3%), Dube (2.5%), Arerti (2%), and Worku (2%) (Table 12). Farmers adopt varieties better known in the area. The two varieties, DZ-10-4 and DZ-10-11, were released in 1970s. They are least known and almost not adopted by farmers.

Table 12. Farmers adopting specific chickpea varieties (%)

Variety	Adopters (n = 57)	Non-adopters (n = 161)
Mariye	11	81
Shasho	3	97
Dube	2.5	97.5
Arerti	2	98
Worku	2	98
Akaki	0.6	99.4
DZ-10-4	0.3	99.7
DZ-10-11	0.3	99.7

[4] Rate of adoption refers to percentage of farmers who have continued planting at least one of the improved varieties.

Beside socio-economic characteristics, 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. Characteristics of improved varieties favored by farmers include drought tolerance (28%), high yield (25%), and early maturity (about 9%) (Tables 13a-c). Other less important positive characteristics of newly introduced varieties are good food making quality (4%), good seed size (3%), frost tolerance (2%), insect pest tolerance (1%), and market demand (0.94%).

Table 13a. Characteristics of improved varieties as perceived by farmers (%), 2003

Variety	Yield			Feed Quality			Storability		
	High	Medium	Low	High	Medium	Low	High	Medium	Low
Dz-10-11	0.31	-	-	0.31	-	-	0.31	-	-
Dz-10-04	0.31	0.31	-	0.31	0.31	-	0.31	0.31	-
Dube	2.17	4.02	-	1.86	4.02	0.31	0.93	5.26	-
Mariye	13	3.41	0.6 2	7.43	6.81	0.93	7.74	8.05	1.24
Worku	0.62	2.79	-	0.93	1.86	0.31	1.24	1.86	0.31
Akaki	0.62	-	-	0.62	-	-	0.62	-	-
Arerti	0.62	0.93	-	0.62	0.31	0.62	0.62	0.93	-
Shasho	0.62	2.17	0.31	0.93	1.86	0.31	0.62	2.17	0.31
Local	5.88	10.53	0.62	7.74	6.50	0.93	9.29	7.43	0.62

Table 13b. Continued

Variety	Drought tolerance			Disease resistance			Pest tolerance			Maturity		
	High	Medium	Low	High	Medium	Low	High	Medium	Low	High	Medium	Low
Dz-10-11	-	-	-	0.31	-	-	0.31	-	-	0.31	-	-
Dz-10-04	0.62	-	-	0.62	-	-	0.62	-	-	0.31	0.31	-
Dube	1.55	4.95	-	2.48	3.72	0.31	0.93	5.26	-	1.24	4.95	-
Mariye	8.98	8.05	-	11.46	4.95	0.62	9.29	6.19	4.95	9.29	6.19	0.62
Worku	1.86	1.55	-	1.86	1.55	-	1.55	1.86	-	1.86	1.55	-
Akaki	0.62	-	-	0.31	0.31	-	0.62	-	-	0.31	0.31	-
Arerti	0.93	0.62	-	0.31	0.62	0.62	0.62	0.31	0.62	0.62	0.62	0.31
Shesho	0.93	1.55	-	1.55	1.55	-	0.93	1.86	0.62	0.31	2.17	0.62
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 13.c Continued`

Variety	Grain size			Grain color			Taste			Price		
	Big	Medium	Small	Good	Fair	Poor	Good	Fair	Poor	High	Medium	Low
Dz-10-11	0.31	-	-	0.31	-	-	0.31	-	-	0.31	-	-
Dz-10-04	0.31	0.31	-	0.62	-	-	0.62	-	-	0.62	-	-
Dube	4.64	1.86	-	2.1 7	4 .3 3	-	4.02	2.48	-	2.17	4.33	-
Mariye	10.22	6.50	0.31	7.74	8.98	0.31	9.6	7.43	-	10.53	5.88	0.62
Worku	2.48	0.93	-	1.86	1.55	-	1.86	1.55	-	1.55	1.55	-
Akaki	0.31	0.31	-	0.31	0.31	-	0.62	-	-	0.62	-	-
Arerti	0.31	1.24	-	0.93	0.62	-	0.93	0.62	-	0.62	0.62	0.31
Shesho	2.48	0.62	-	2.17	0.93	-	2.79	0.31	-	1.86	1.23	-
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 discontinuing adopting varieties

Farmers who have once planted an improved chickpea variety and discontinued it were asked to give their reasons for discontinuing planting of improved chickpea varieties. Their reasons were lack of market demand (8%), disease problems (6%), and theft (people steal the green pods) (5%) (Table 14). Chickpea can be consumed at green pod stage. Large seeded varieties are preferred for green pod consumption. If chickpea is not attended day and night at green pod stage, it is likely that people passing close to chickpea fields may pick up chickpea for consumption. Thieves pick up small quantities at a time. Attending chickpea fields day and night requires additional labor. Thus, farmers are reluctant to plant large seeded improved varieties due to fear of theft.

Table 14. Reasons for discontinuing planting improved varieties (%)

Reasons	Arerti	Shasho	Worku	Akaki	Mariye	Dube	DZ-10-4	DZ-10-11	All improved varieties
Market problems	-	-	0.60	-	7.12	0.30	0.30	-	8.40
Disease problems	0.60	0.60	0.93	0.93	1.24	0.60	0.60	0.60	6.20
Theft	-	0.93	0.93	0.30	1.90	0.93	-	-	5.10
Storage problems	-	-	-	-	0.30	-	-	-	0.30

Non-adopters include not only those who have ever planted improved varieties and dropped them some time later but also those who have never planted them. According to farmers, the reasons why some farmers never adopted 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 theft (7%) (Table 15). Other less important reasons were lack of interest, high price of improved seeds, late maturity of the newly introduced varieties, and lack of money.

The main factors that contributed to low rate of adoption of improved varieties are supply problems. The amount of improved seeds varieties produced by research and Ethiopian Seed Enterprise is quite small. From 1998 to 2004, the amount of seeds produced and distributed each year ranged from 136 to 700q. It was only in 1993 and 1994 that 4272 and 1183 q were distributed, respectively. The amount of seeds distributed by the formal sector was too low and could cover less than 1% of total area planted by chickpea. Because of this, farmers depend on informal seed supply, i.e., through hosting on-farm experiments, demonstration, and popularization purposes.

Table 15. Reasons for not using improved varieties (%), 2003

Reasons	Percent (n =323)
Unavailability of seeds	27
Lack of awareness	21
Lack of market demand	13
Theft (green pods)	7
Lack of interest	6
Expensiveness	2
Late maturity	2
Fear of debt	1
Lack of money	1

Determinants of adoption

According to this study, there are farmers who have not adopted improved varieties. Their reasons may be unavailability of varieties, awareness of technologies, and attributes of technologies. Farmers do not adopt a technology if they are not convinced of its benefits, costs, and risks associated with it. There are also other technical, institutional, social, and economical reasons for adoption or rejection of new technologies.

Comparison of adopters and non-adopters with regard to the above variables was done using descriptive statistics. About 83% of the adopters and 68% of non-adopters were literate, i.e., they could at least read and write. In addition, a relatively high percentage of adopters had good access to agricultural extension related activities, such as, on-farm verification trials, demonstration plots, farmers research groups and training programs, i.e., about 21% for adopters and 2% for non-adopters.

The percentage of female-headed households in adopters and non-adopters group was low, about 5% and 4%, respectively. This shows that female-headed households in the community are low. About 58% of adopters of improved varieties are in Ada-Liban, 14% in Akaki, 16% in Gimbichu, and 12% in Alem-Gena. The average land size for adopters is 2.30 ha, whereas non-adopters have 2.20 ha.

The logit model used to examine the adoption of improved chickpea varieties is significant at 1% level (Table16), 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 explanatory variables together influence 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 a household head, farm size, access to extension services, proportion of chickpea area, and access to seed have the expected signs. Among these, the coefficient of access to extension services, access to seed, farm size and proportion of area allocated to chickpea variables significantly differ from zero, and therefore, they influence the adoption of improved chickpea varieties. The coefficient of sex of household head, education, age, and oxen variables are not significantly different from zero. Therefore, unlike our expectation, they have no effect on adoption of improved chickpea varieties.

Table 16. Factors affecting adoption

Variables in the Equation (factors)	Coefficient	SE	Wald	Sig.	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 services	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, Sig. = 0.000, Percentage of correct prediction = 86.7*

As expected, the effect of access to extension services was positive and significant. This implies that farmers who participated on on-farm trials, demonstration, and farmer research group (FRG), adopted improved chickpea varieties more than others did. Other independent variables being constant, the odds of adoption of improved varieties were nine times higher for farmers with access to extension than those with no access to extension. Access to seed is significantly correlated with adoption of improved variety. Formal seed sectors do not regularly provide chickpea seeds to farmers. Therefore, farmers depend on the informal seed supplies. There are farmers who sell improved chickpea seeds at farm-gates or at markets. Farmers near such areas who can afford to purchase seeds have better access to seed. The odds ratio associated with access to seed variable implies that having access to seed changes the odds ratio by factor of 20.

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

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

Conclusion and Recommendations

In Ethiopia, chickpea is one of the important legumes in food and feed, generating cash, and soil fertility maintenance. The productivity of chickpea at national level remained stagnant due to limited use of modern production technologies. Great variation exists across different areas in adopting improved varieties. Areas near research centers and areas with better access to extension services are better than other remote areas. The variation signifies a gap in access to inputs and information about the improved varieties among areas and associated cultural practices. Thus, there is a need to improve input supply mechanisms. At present, input supply is limited or non-existent in remote chickpea producing areas.

Availability of improved chickpea seeds is a critical factor for adopting improved chickpea varieties developed by researches. Currently, very limited amount of seeds is produced and distributed to farmers. As a result, farmers depend on the informal seed suppliers. Thus, adopting improved chickpea varieties has lagged behind, mainly because of supply constraints, and unavailability of seed. Lack of awareness of farmers about improved varieties has also contributed to low rate of adoption of the improved varieties. Thus, the involvement of private sector and cooperatives in production and distribution of varieties is vital to reverse scarcity of seed and meet the demand for improved chickpea seeds. At present, large seeds producers, are reluctant to produce improved chickpea seeds. Thus, the problem of seed production and supply may persist unless appropriate action is taken through developing informal sectors. One possible solution is to organize seed producer farmers. Cooperatives may take responsibility in processing, distributing, and marketing seeds produced by seed growing farmers.

This study and others confirmed that extension activities influence adoption of new technologies. Farmers would not adopt an improved variety until they get awareness, and fully observe and comprehend their advantages. Thus, there is a need to strengthen extension services provided to farmers, and help them to be aware of the released varieties and their benefits. On-farm experimentation and evaluation of technologies do not only help in fine-tuning technologies to farmers' conditions but also allows farmers to be aware of the existence of technologies and to evaluate their performances. Therefore, participatory technology development approach should be enhanced.

Chickpea can be consumed at green pod stage. Large seeded varieties are preferred for green pod consumption. People passing near chickpea fields may pickup and consume it without permission from the owner. Guarding chickpea fields against people is labor consuming. It is also risky for a farmer to leave his/her field unattended. Therefore, farmers are reluctant to take initiatives to grow large seeded improved varieties. Thus, community-based joint actions are required to curb the risk and its effects and to help a farmer be secured from loss due to theft.

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Annexes

Annex I. Area and production estimates of main food legumes.

Crop	Year					
	1981/82	1985/86	1992/93	1998/99	1999/2000	2003/04
	Area ('000 ha)					
Faba bean	348.9	280.2	298.2	296.7	359.2	382.0
Field pea	174.1	130.7	139.1	142.0	152.2	211.6
Chickpea	138.1	132.0	109.7	167.7	184.8	154.3
Lentil	70.4	44.9	44.8	47.9	72.2	52.1
Grass pea	32.3	65.5	70.4	95.1	110.6	82.7
Haricot bean	25.1	45.5	39.8	129.5	166.0	183.8
	Production (q)					
Faba bean	4699.4	2333.3	3121.0	2858.2	3886.8	4268.9
Field pea	1630.7	692.6	1037.4	1000.8	1160.0	1703.7
Chick pea	1013.7	884.0	600.9	1388.4	1646.3	1359.3
Lentil	516.0	258.7	250.3	283.8	497.7	352.8
Grass pea	213.7	417.3	441.6	786.2	1074.8	789.6
Haricot bean	117.5	233.4	314.6	1168.1	1328.9	1722.2

Source: CSA, various bulletins (1983-2004)

Annex II. Average growth rates of area and production of main food pulses

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
Chick pea	-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
Chick pea	-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: Legesse and Adam, 2004

Annex III. Frequency of plowing and weeding of chickpea and other legumes

Crop	Frequency	
	Plowing	Weeding
Faba bean	1.8 (17)	1.3 (17)
Chickpea	3.2 (66)	1.1 (36)
Lentil	2.1 (14)	1.2 (5)
Grass pea	2.9 (71)	1.0 (24)

Figures in parentheses indicate number of respondents.
Source: Legesse et al. (2003)

Annex IV. Improved varieties released by chickpea research program

Cultivars	Pedigree	Source
DZ-10-4	-	Ethiopia
DZ-10-11	-	Ethiopia
Dubie	-	Ethiopia
Mariye	K-850-3/27 x F378	ICRISAT
Worku (DZ-10-16-2)	ICCL-820104	ICRISAT
Akaki (DZ-10-9-2)	ICCL-820016	ICRISAT
Arerti (FLIP 89-84C)	X87TH186/ ICC14198 x FLIP 82-150C	ICARDA/ICRISAT
Shasho (ICCV-93512)	ICCC-33 x (ILC3395 x FLIP 83-13C)	ICRISAT
Habru (FLIP 88-42C)	X85TH230/ILC3395 x FLIP 83-13C)	ICARDA/ICRISAT
Chefe (ICCV-92318)	ICCV-2 x Surutato 77) ICC-7344)	ICARDA/India

Annex V. Chickpea seeds distributed by ESE and Debre Zeit Research Center (q)

Year	ESE	Debre Zeit
1989/90	-	689
1990/91	5	140
1991/92	492	170
1992/93	387	80
1993/94	4172	100
1994/95	1060	123
1995/96	0	136
1996/97	0	188
1997/98	0	145
1998/99	3	251
1999/00	67	437
2000/01	254	690
2001/02	-	561
2002/03	-	255
2003/04	-	307

Source: ESE and Debre Zeit's reports of various years

Annex VI. Physical features and climatic conditions of the surveyed study area

Description	Ada-Liban	Akaki	Alem Gena	Gimbichu	All area
Altitude meters above sea level (min)	1600	1860	1800	900	900
Altitude meters above sea level (mean)	1900	2100	2000	2400	
Altitude meters above sea level (max.)	3100	3000	3385	2700	3385
Annual mean rain fall (mm)	802.42	1133.4	886.0	901.5	
Annual minimum temperature (^{0}C)		13.7	-	8.04	
Annual mean temperature (^{0}C)		19.8		15.45	
Annual maximum temperature (^{0}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	

Annex VII. Definition and description of explanatory variables used in the logit model

Variables	Definition and description
Age	Age of household head in years
Education	Educational level of the household head (Dummy variable: Education = 1 if the household head is literate and 0 is otherwise
Access to extension services	Access to extension services (Dummy variable: Extension = 1 if the farmer has participated at least in one of the extension activities, such as on-farm trial, demonstration and farmer research group, verification and/or demonstration trails and special trainings and extension = 0 if otherwise)
Sex of household head	Sex (dummy variable: Sex = 1 if the household head is male and sex = 0 if the household head is female)
Farm size	In hectare
Access to input	Access to improved seed (Dummy variable: 1 if farmer has access to improved variety and 0 if otherwise
Chickpea area	Proportion of area allocated for chickpea production in hectare
Oxen	Number of oxen owned by the household

Annex VIII. Improved chickpea varieties and their traits adaptation, and agro-ecological areas

Variety	Maturity period (days)	Growth habit	Seed color	100 seeds weight (g)	Planting date	Seed rate (kg ha^{-1})	Adaptation area		Average yield (q ha^{-1})	
							Altitude (m)	Rain fall (mm)	On-station	On-farm
DZ-10-4	111-135	Semi-erect	White	10.2	Early Sept.	65-75	1800-2300	700-1100	16-22	11-14
DZ-10-11	106-123	Semi-erect	Light Brown	13.0	Early September	70-80	1600-2000	700-1100	15-28	11-19
Dubie	110-115	Semi-prostrate	Gray	22.0	Mid august to early Sept.	80-90	1800-2300	700-1100	17-28	16-17
Mariye	106-120	Semi-erect	Brown	25.5	Mid august	120-140	1500-2300	700-1300	18-30	14-23
Wroku (DZ-10-16-2)	100-149	Semi-erect	Golden	33.0	Mid August	100-120	1900-2600	700-1200	19-40	19-29
Akaki (DZ-10-9-2)	57-147	Semi-erect	Golden	21.0	Mid August	90-120	1900-2600	700-1200	18-40	19-26
Arerti (FLIP89-84C)	105-155	Semi-erect	White	25.7	Mid August	100-115	1800-2600	700-1200	16-52	18-47
Shasho (ICCV-93512)	90-155	Semi-erect	White	29.9	Mid August	100-125	1800-2600	700-1200	16-46	20-42
Chafe (ICCV-2318)	95-150	Semi-erect	White	35.4	Mid August	110-140	1800-2600	700-2000	12-48	
Habru (FLIP-88-42c)	91-140	Erect	White	31.7	Mid august to early Sept.	110-140	1800-2600	700-2000	14-50	15-28

Annex IX. Land use and demographic description of the study districts

Area in hectares	Ada-Liban	%	Akaki	%	Alem-Gena	%	Gimbichu	%	Total	%
Total area	161056.33	-	59845.33	-	87272	-	48774	-	356947.66	-
Cultivated	119449.5	74.2	44784.08	74.8	76986	88.2	34804	71.4	276023.58	77.3
Grazing	6461.83	4.0	4569	7.6	3740	2.8	4215	8.6	18985.83	5.3
Total forest	15692.5	9.7	2656	4.4	2538	2.9	1951	4.0	22837.50	6.4
Public forest	325	-	4400	-	-	-	-	-	4725	
Government forest	2105	-	-	-	-	-	-	-	2105	
Bushes	10832.5	6.7	-	-	-	-	5853**	12.0	16685.5	4.7
Unused	39976.83	24.8	2630	4.4	-	-	-	-	42606.83	11.9
Water bodies	2231.5	-	756	1.3	1475	1.7	-	-	2231.5	0.6
Town/township	2732.5	1.7	2100*	3.5	909	1.0	-	-	5741.5	1.6
Others	5365.5	-	-	-	1622	1.9	1951	4.0	8938.5	2.5
Irrigated area	436.5	-	100	-	406	-	-	-	542.5	-
Total population	289508	-	127385*	-	173965	-	88302	-	679160	-
Rural population	190587	65.8	67385	52.9	142700	82.0	83052	94.1	483724	71.2

** =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*

Annex X. Cultivated area and grain yield by crop type in 2003/04 cropping season

Crop	District (area in hectares and productivity)												Overall mean of the four districts		
	Ada-Liban			Akaki			Alem Gena			Gimbichu					
	Area (ha)	q/ha	q	Area ha	q/ha	q	Area (ha)	q/ha	q	Area (ha)	q/ha	q	Area (ha)	q/ha	q
Cereals (all)	99841	17	1732106	34660	14	518524	57526	10.	627975	27198	17.2	551711	219136	13	2865136
Tef	60878	11	669658	18140	13	235820	29878	9	265914	8210	11.0	90318	117096	11	1261710
Wheat	33872	29	982288	16031	17	277336	21852	13	286261	18234	24.6	448015	89989	22	1993900
Barley	2300	14	32400	283	9	2745	4853	11	55324	438	16.8	7368	7874	12	97837
Emmer wheat	35	6	210	53	11	583	0	0	0	12	14.8	178	100	10	971
Sorghum	656	14	9750	27	24	432	261	16	4176	202	20.0	4040	1146	16	18398
Maize	2100	18	37800	67	16	1608	682	24	16300	112	16.0	1792	2931	19	57500
Pulses (all)	16765	12	216216	8620	12	111670	18818	7.	132516	7305	11.50	96317	51506	11	556719
Faba bean	6600	13	85800	416	10	2160	3861	10	38610	745	12.0	8940	11622	12	135510
Field pea	4230	10	59531	203	8	1624	1459	8	11672	452	13.0	5876	6344	12	78703
Chickpea	3100	14	43400	5057	14	70798	5995	7	41965	2711	14.7	39898	16862	11	196061
Lentil	809	4	3239	508	2	1016	4397	5	21985	1823	9.2	16767	7536	6	43007
Rough pea	541	15	8121	2352	15	35280	2930	6	17580	1529	14.7	22500	7351	11	83481
Fenugreek	35	5	175	52	6	312	176	4	704	268	7.0	1876	263	12	3067
Haricot bean	1450	11	15950	32	15	480	0	-	0	46	10.0	460	1527	11	16890
Oil crops	35	3	105	73	6	438	643	4	2572	21.5	8.0	172	772	4	3287

Source: Bureau of Agriculture and Rural Development of each district