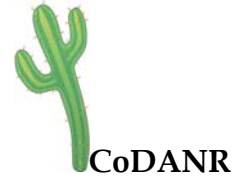




**Mekelle University**



**College of Dry Land Agriculture and Natural Resources**

PARTICIPATORY VARIETAL EVALUATION AND FAREMER BASED SEED  
PRODUCTION: A SUSTAINABLE APPROACH TO GARLIC SEED DELIVERY IN  
ATSBI WOMBERTA WEREDA, EASTERN TIGRAY.

By  
Tadese Teweldebrhan

A Thesis

Submitted in the Partial Fulfillment of the Requirement for The  
Master of Science Degree

In  
Dryland Agronomy

Advisor  
Fetien Abay (Ph.D.)  
Co Advisor  
Gebremedhin Woldewahid (Ph.D.)

May, 2009

# DECLARATION

This is to certify that this thesis entitled “Participatory Varietal Evaluation And Farmer-Based Seed Production: A Sustainable Approach To Garlic Seed Delivery In Atsbi Womberta Woreda, Eastern Tigray” submitted in partial fulfillment of the requirements for the award of the degree of M.Sc., in Dry Land Agronomy to the School of Graduate Studies, Mekelle University, through the Department of Dry Land Crop and Horticultural Science, done by Mr. Tadese Teweldebrhan Gilazgi, Id.No. FDA/GS0008/98 is an authentic work carried out by him under our guidance. The matter embodied in this project work has not been submitted earlier for award of any degree or diploma to the best of our knowledge and belief.

Name of the Student: Tadese Teweldebrhan Gilazgi Signature \_\_\_\_\_ date \_\_\_\_\_

Name of supervisor: Dr. Fetien Abay Signature \_\_\_\_\_ date \_\_\_\_\_

Name of co-supervisor: Dr. Gebremedhin Woldewahid Signature \_\_\_\_\_ date \_\_\_\_\_

# ACKNOWLEDGMENT

First and foremost I would like to express my deepest and heart felt thanks as well as my most sincere appreciation to my research advisors Dr. Fetien Abay and Dr. Gebremedhin Woldewahid for their consistent guidance, critical review and for commenting on the manuscript throughout the course of this research starting from proposal presentation up to the final thesis write up. Their ever readiness in providing assistance and advice greatly helped me to carry out the study. Without their help, it would have not been possible to complete the study.

My deep gratitude and acknowledges goes to International Livestock Research Institute (ILRI-IPMS) for providing me research fund support and arranging an important training on biometry. My deep gratitude and acknowledges also goes to Ethiopian Seed Enterprise for providing me the opportunity to pursue my graduate study.

I am greatly indebted to the farmers in the study area (Golgol Naele Village), Atsbi womberta wereda who shared with me their wisdom and experience. My special appreciation and acknowledgments are also extended to staff members of Atsbi womberta worda office of agriculture and rural development particularly Mr. Teklay, Mr. Quetsela, Mr. Tesfa-alem and Mr. Birhanu for their kind support during secondary data collection, farmers' field visit and their all-round help. My special appreciation and thanks also goes to Tigray seed multiplication and processing center staff members who have contributed directly or indirectly to the completion of this study.

Finally all my heartfelt and deepest appreciation goes to my beloved wife Senait Tesfay, my beloved parents, my beloved sisters, brother and friends whose staunch support, unreserved love and persistent encouragement and all-rounded assistance which was a substantial input to my inspiration and effort throughout the course of the research work.

Above all, I would like to thank the supreme Almighty God for providing me with patience and endurance to complete the study.

# ACRONYMS

ADLI - Agricultural Development Led Industrialization

BoARD - Bureau of Agriculture and Rural Development

CIAT - International Center for Tropical Agriculture

CIMMYT - International Centre for Maize and Wheat Improvement

CS - Certified Seed

CSA - Central Statistics Agency

CV - Coefficient of Variation

DAP - Diammonium phosphate

EIAR - Ethiopian Institute of Agricultural Research

ESE - Ethiopian Seed Enterprise

FAO- Food and Agriculture Organization

FBSPMS – Farmer Based Seed Production and Marketing Scheme

HIEP - High Input Extension Package

ICARDA - International Center for Agricultural Research in the Dry Areas

ILRI – International Livestock and Research Institute

IPMS- Improving Productivity and Market Success

IRD - Informal Research and Development

LSD – Least Significant Difference

MoARD – Ministry of Agriculture and Rural Development

NA – Not available

NCIC - National Crop Improvement Committee

NGO - Non-Governmental Organizations

NSC - National Seed Council

NSIA – National Seed Industry Agency

PA - Peasant Association

PHSE - Pioneer Hybrid Seed Ethiopia

ppm – Parts Per million

PVE - Participatory variety evaluation

$r^2$  - The coefficient of Determination

RCBD - Randomized Complete Block Design

SE – Standard Error

TBW - Total bulb weight

WOoARD- Woreda Office of Agriculture and Rural Development

# TABLE OF CONTENTS

	Pages
DECLARATION.....	II
ACKNOWLEDGMENT .....	III
ACRONYMS .....	V
PREFACE.....	XIII
ABSTRACT .....	XIV
CHAPTER I: INTRODUCTION .....	1
1.1 BACKGROUND AND ADAPTATION OF GARLIC .....	1
1.2 STATEMENT OF THE PROBLEM.....	5
1.3 PURPOSE AND SIGNIFICANCE OF THE STUDY.....	7
1.4 OBJECTIVE OF THE STUDY .....	8
1.5 RESEARCH QUESTIONS .....	8
CHAPTER II: LITERATURE REVIEW.....	9
2.1 THE ETHIOPIAN SEED SYSTEM.....	9
2.1.1 The formal seed system.....	9
2.1.2 The informal seed system.....	14
2.2 FARMER BASED SEED PRODUCTION .....	15
2.3 EXPERIENCES OF FARMER-BASED SEED PRODUCTION IN ETHIOPIA .....	16
2.4 PARTICIPATORY VARIETAL EVALUATION.....	18
2.5 THE GARLIC PLANT.....	21
2.5.1 Cultural management.....	21

2.5.1.1 Soil and climatic requirements .....	21
2.5.1.2 Selection of planting materials .....	21
2.5.1.3 Clove/Seed Preparation .....	21
2.5.1.4 Planting and Spacing .....	22
2.5.1.5 Irrigation .....	23
2.5.1.6 Fertility .....	23
2.5.1.7 Harvesting and post harvest operations .....	24
<b>CHAPTER III: MATERIALS AND METHODS .....</b>	<b>25</b>
3.1 DESCRIPTION OF THE STUDY SITE.....	25
3.1.1. Location and physical conditions .....	25
3.1.2 Farming system and crop types grown in the study area.....	27
3.2 TEST MATERIALS .....	28
3.2.1 Participatory Varietal Evaluation .....	28
3.2.2 Farmer Based Garlic Seed Production.....	29
3.3 EXPERIMENTAL DESIGN.....	30
3.3.1 Participatory Varietal Evaluation .....	30
3.3.3.1 Joint Experimentation.....	30
3.3.1.2 Experience Sharing and awareness creation of PVE.....	31
3.3.2 Farmer-Based Garlic Seed Production .....	32
3.3.2.1 Testing and demonstrating garlic seed production .....	32
3.3.2.2 Experience sharing and awareness creation of farmers participatory seed .....	38
production.....	38
3.4 DATA COLLECTION .....	39

3.4.1 Participatory varietal evaluation .....	39
3.4.2 Farmer-based garlic seed production.....	42
3.5 DATA ANALYSIS.....	43
CHAPTER IV: RESULTS AND DISCUSSION .....	44
4.1 GARLIC VARIETIES AND SEED SUPPLY AT TEGAHNE, ATSB I WOMBERTA WORED A.....	44
4.2 PARTICIPATORY VARIETAL EVALUATION .....	46
4.2.1 On-farm performance of the varieties: Researcher assessment.....	46
4.2.1.1 Variation in phenological traits .....	46
4.2.1.2 Variation in Vegetative Growth .....	48
4.2.1.3 Variation in Yield and Yield Components .....	51
Clove weight, number and diameter.....	53
4.2.1.4 Variation in marketable and unmarketable yield of cloves .....	54
4.2.1.5 Relationships between vegetative and yield parameters .....	59
4.2.2 On-farm performance of the varieties: Farmers' assessment .....	62
4.3 FARMER-BASED SEED PRODUCTION .....	65
4.3.1 Farmers Reflection .....	65
4.3.2 Suggested Protocol for Effective On-Farm Garlic Seed Production.....	66
4.3.2.1 Search for Garlic Varieties .....	66
4.3.2.2 Creating strong institutional support to develop farmers' capacity for .....	67
seed production.....	67
4.3.2.3 A Flexible Quality Control System .....	68
4.4 PROCESS IMPACT OF PARTICIPATORY VARIETAL EVALUATION AND FARMER BASED .....	68
SEED PRODUCTION .....	68

4.5. LESSONS LEARNT .....	71
CHAPTER V. CONCLUSIONS AND RECOMMENDATIONS.....	72
5.1 CONCLUSIONS.....	72
5.2 RECOMMENDATIONS.....	75
REFERENCE .....	76
APPENDIX .....	84
APPENDIX - 1 .....	85
APPENDIX - 2.....	85
APPENDIX - 3.....	86
APPENDIX - 4.....	86
APPENDIX - 5.....	87
APPENDIX - 6.....	87
APPENDIX - 7.....	88

## LIST OF TABLES

	Pages
Table 1-Annual seed sales by the Ethiopian Seed Enterprise (2003-2007) .....	13
Table 2- ESE seed production under FBSPMS (2002 - 2006).....	18
Table 3- Soil physical and chemical properties of the experimental site before planting.....	25
Table 4- Characteristics of the varieties used in the study, Tegahne irrigate site, Golgol .....	29
Table 5- Emergence success of different garlic varieties in Tegahne irrigate site, .....	46
Table 6- Days to maturity of different garlic varieties in Tegahine irrigate site, .....	47
Table 7- Plant Height (cm) and leaf number (leaves/ plant) of different garlic varieties.....	49
Table 8- Leaf length (cm) and leaf diameter (cm) of different garlic varieties.....	50
Table 9 – Cured (sun dried) bulb yield (qt/ha) of different garlic varieties in .....	52
Table 10 - Total bulb weight (g) and mean bulb weight (g) of different garlic varieties.....	53
Table 11 - Mean clove weight (g), clove number (cloves/ bulb), and clove diameter (cm) ....	54
Table 12 - Clove size categories (g/plot) of different garlic varieties .....	57
Table 13 - marketable (g) and unmarketable (g) cloves of tested varieties.....	58
Table 14 - Simple correlation coefficient(r) for vegetative and yield parameters of garlic .....	60
Table 15 - Pair- wise ranking of farmers selection traits.....	63
Table 16- Matrix ranking garlic varieties by group of farmers .....	64
Table 17 - Pair wise ranking garlic varieties by group of Farmers .....	64
Table 18– Cured garlic bulb yield (kg per hectare).....	70

## LIST OF FIGURES

	Pages
Figure 1- Traditional extension versus participatory technology development .....	19
Figure 2- Map showing the location of Ethiopia (A), Tigray (B), Atsbi womberta (C) and....	26
Figure 3- Garlic seed planting in farmer-based seed production plot .....	34
Figure 4- Chemical spray to prevent garlic rust in farmer-based seed production plot in .....	36
Figure 5- Discussion on garlic decision of maturity (a) and garlic harvesting (b).....	37
Figure 6- Discussion on farmer-based garlic seed production plot at farmers' field day in ....	38
Figure 7- Participatory variety selection on testing and evaluation of garlic varieties .....	42
Figure 8- Variation in Cured (sun dried) bulb yield (qt/ha) of tested garlic varieties .....	52
Figure 9- Clove size categories (g/plot) of tested garlic varieties .....	57
Figure 10- marketable (g) and unmarketable (g) cloves of tested varieties .....	59

# Preface

This study comprise two components: Research component which is the participatory varietal evaluation (PVE) considered as a path way for Farmers Based Seed production. In order to provide a fast truck solution Farmer based seed production was also initiated using the locally available garlic variety. The overall purpose of this thesis is to provide information of farmers' participation on garlic variety evaluation and seed production.

It reviews the approaches in both components and draws the experience of the joint experimentation as a learning by doing approach in the specific target area. Participatory varietal evaluation is a viable method for identifying growers' preferences, limitation and the potential of varieties. Farmer-based seed production is also viable and hold potential for improving the availability and accessibility of improved varieties.

I hope that this study will contribute to the existing experience of farmers' participation on variety evaluation and seed production, particularly amongst plant breeders and policy makers, in regarding farmers as potential and enthusiastic partners in crop improvement and seed development

Tadese Teweldebrhan.

# ABSTRACT

*Garlic is a newly introduced but potential vegetable crop in the highlands of Tigray. However, there was no information on the agronomic performance of improved garlic varieties and approaches in garlic seed production. Thus, the research was initiated with the objectives to evaluate the performance of improved garlic varieties and to introduce farmer seed production. Ten volunteer garlic seed growers were participated in seed production. Four improved varieties viz Tsedey 92, Bisheftu Netch, G-99-2 and G-161-2 and one local variety Rie local were evaluated under participatory varietal evaluation trial. PVE was conducted on farmers' field using the randomized complete block design with four replications, taking a farmer as replicate. Significant differences ( $p < 0.05$ ) among varieties were recorded for plant height, number of leaves per plant, leaf length, leaf diameter, total bulb weight, bulb yield per hectare, clove diameter, weight of clove, clove categories, marketable and unmarketable clove, emergence success and days to maturity. Bulb yield per hectare showed positive and significant correlation with most parameters except with medium and small clove categories. This suggested that increment in bulb yield was a result of increase in plant vigor expressed in plant height, number of leaves per plant and leaf diameter. Farmers' overall evaluation indicated that the varieties Tsedey 92 and Bisheftu Netch were found promising under Atsbi Womberta wereda condition. Farmers, which are participated in the community based garlic seed production improved their availability and access to garlic seed and they also demonstrated and applied how garlic seed production monitored strictly throughout the entire crop growth period, from planting through to harvesting, and storage.*

**Key word-** *Participatory approach, Seed production, Garlic*

# CHAPTER I: INTRODUCTION

## 1.1 Background and adaptation of garlic

Garlic (*Allium sativum* L,  $2n=16$ ) belongs to the family Alliaceae and is the second most widely used *Allium* next to onion (Rubatzky and Yamaguchi, 1997). According to Etoh and Simon (2002), it is originated on the northwestern side of the Tien-Shan Mountains of Kirgizia in the arid and semi arid areas of central Asia (Kazakhstan). There is evidence that it has been in use in Egypt before 2000 B.C, In India and China for more than 5000 years. China, the largest consumer of garlic in the world today (Kamenetsky and Rabinowitch, 2001).

Garlic is one of the most ancient cultivated herbs, and is vegetatively propagated from cloves (Salomon, 2002). This mode of clone propagation allows the production of a uniform crop that preserves quality traits, such as flavour and the nutritive properties of the plant. Garlic is used as a seasoning in many foods worldwide, without garlic many of our popular dishes would lack the flavor and character that make them favorites. Garlic's volatile oil has many sulfur-containing compounds that are responsible for the strong odor, its distinctive flavor and pungency as well as for its healthful benefits (Salomon, 2002).

Medicinal activity seems to be highest in fresh garlic or garlic oil with high alliin content. Alliin, which has antibiotic and antifungal properties, is made by the enzyme alliinase that breaks down alliin to alliin. Heating or cooking garlic inactivates the enzyme, but chopping 10 minutes before cooking will allow alliin to form (www.healthnotes.com., 2002). The bulb contains about 1.4% of the fresh weight as alliin (Brewster, 1994). The pungent flavor of garlic

is caused by a chemical reaction that occurs when the garlic cells are broken. The flavor is most intense shortly after cutting or chipping. This chemical reaction cannot occur after garlic is cooked. This is why roasted garlic is sweet rather than pungent (Linda, 1997).

Garlic is one of the best studied medicinal plants that its antibacterial and antiseptic property is well known. It contains remedies against headache, bites, worms and tumours (Keusgen, 2002). Experiments in Germany, for instance, have shown that certain compounds in garlic block the blood platelets from forming into blood clots, which could cause heart attacks (coronary thrombosis) and strokes (Rabinowitch and Currah, 2002). Proponents advise eating a raw clove of garlic a day to boost the immune system (Siegel et al., 2000).

World garlic cultivation was increased from 771,000 ha of land in 1989/90 to 1,204,711 ha of land in 2007 with total production from 6.5 million to 15.68 million tons, and productivity from 8.43t/ha and 13.02 t/ha, respectively ([www.faostat.fao.org](http://www.faostat.fao.org)., 2007). In Ethiopia, the total area under garlic production in 2006/07 reached 9,266 hectares and the production is estimated to be over 683,000 quintals (MoARD, 2007). In Tigray Region in northern Ethiopia, garlic is grown in semi-arid areas with low annual rainfall that varies greatly in space and time in terms of its amount and distribution, and with limited irrigation water sources. The area coverage of garlic in the year 2006/2007 was 1,104 ha, with a production of 76,176 quintals (BoARD, 2007).

Despite its importance and increased production, garlic productivity, in many parts of the world, is low due to genetic and environmental factors affecting its yield and yield related traits (Nonnecke, 1989). Numerous production problems accounted for the low yield of garlic in Ethiopia: Lack of proper planting material, inappropriate agronomic practices, absence of

proper pest and disease management practices and marketing facilities are the prominent ones. Farmers, in the study area, are found to acquire seed from various sources including their own saved seed and local market but none of the improved varieties are popular among farmers in Tigray. Garlic seed has huge problem both in supply, and quality. As a result farmers are paying more for poor quality seed and traveling as far as long distance to acquire seed. Improving the supply of the seeds as planting material of the nutritionally important and high value crops is the most effective way to sustain health and income of farmers. Seed is one of the most important components to ensure food security.

Seed supply system security refers to access by farmers to adequate, good quality seed of the desired type at the right time (FAO, 1994). Seeds<sup>1</sup> provide the greatest good at minimal cost - they stand between survival and starvation. Formal and informal seed sectors are the two major components of a seed supply system. An effective seed system can only operate if there is a functional informal seed sector as well as formal seed sector; both are essential and complementary to insure an effective seed security strategy (Scowcroft, 1997).

Most smallholder farmers living in drought-prone regions of Africa continue to rely on informal farmer-to-farmer exchange to obtain seed of crop varieties and over 90% of smallholder farmers' requirements are met through these channels. Public and private seed companies supply no more than 20% of seed of most food crops (Larinde, 1996).

<sup>1</sup> In the present context, the term "seed" is used to denote the sexual or asexual reproduction of plants. Conventionally, however, only sexual reproduction are referred to as seed, while materials for asexual reproduction are referred to as other planting materials, e.g., cuttings, buddings, roots, stems, or any other vegetative plants part that can be used for propagation. However, the term "seed" is used throughout the present research to mean planting material because seed comprises the largest portion of all planting material used by farmers worldwide, and because it is a convention used for the sake of brevity throughout the literature.

It is therefore important to give due recognition to the informal sector, a low-cost source of seed and to use it as a vehicle for providing resource-poor farmers with improved seed of modern varieties at affordable prices (Lanteri and Quagliotti, 1997).

The farmer-based seed enterprises are of a participatory nature: they mobilize and involve small farmers in target environments, they multiply well-adapted and farmer-preferred varieties at local levels and the production is market oriented, as it is linked to seed demand from local and nearby communities. Because of this, costs for local production, transport, marketing and distribution are low, and seed prices can be kept down.

The quality of the seed produced by farmer based seed production meets relevant quality standards, which are those appropriate to farmer requirements, but does not necessarily meet formal standards (Bishaw et al., 2008). The schemes are considered to contribute to a sustainable seed supply by improving availability and access. This is ensured through farmers' empowerment and their proper ownership of seed businesses. And lastly, the farmer based seed enterprises are targeted to evolve to privately owned small- to medium scale seed enterprises and such small seed enterprises are expected to be technically feasible and economically viable in producing and marketing quality seed within the local community (Bishaw et al., 2008).

On the other hand selection of adapted crop variety is the first step in the production of a good seed. The variety must be selected from a list of recommended or local varieties. Apart from its adaptation, the variety should have high yield potential, tolerance to biotic and abiotic stresses, good marketability and high consumer preferences. Unless the variety meets the requirements of

farmers and consumers, it is less likely to be widely adopted and, therefore, the demand for seed can not be addressed (Bishaw et al., 2008).

Fetien and Bjørnstad (2008), reported that to provide and develop specifically adapted and high yielding varieties in such variable rainfed environments like in Tigray, joint experimentation has to be initiated through farmers experimentation and own innovation.

Taking this issue as starting point to think and discuss for solving the problem in a sustainable manner, the idea of evaluating of an adapted and best preferred varieties together with the farming community and introducing farmer based garlic seed production at the grass root level is of paramount importance. It is a springboard to create availability, access to and use of quality seed to increase production and productivity. Thus, investigation under specific agro-ecologies is very important to come up with relevant approaches and recommendations on introducing farmer based garlic seed production and evaluating garlic varieties.

## 1.2 Statement of the problem

In many situations, formal seed supply has been unable to meet farmers' needs, due to its limited supply capacity, a focus confined to only a few crops, or because it supplies inappropriate varieties. This, along with concerns for farmer participation and local knowledge, partly explains the growing interest in supporting small-scale farmers' seed production (Shawn, 2005). To increased use of seeds of improved varieties and to achieve sustainable agricultural development in the country, the Ethiopian government has identified improving the efficiency of the seed system is one of the most effective means of meeting the Millennium Development

Goals (Yonas et al., 2008). Ethiopian Seed Enterprise (2000) seed marketing study indicated difference between demand and supply. The potential size of the certified seed market in the country ranges from 0.75 to 1.0 million quintals per year, while the current size of the penetrated market is about 0.2 million quintals per year. Clearly this shows the formal seed sector cannot ensure farmers easy access to seeds of improved varieties (Yonas et al., 2008).

In Tigray region in general and in Atsbi womberta wereda in particular, the use of improved seed is in its infancy. Currently, the formal sector is not in a position to meet the seed demand of the region, where the informal sector accounts for 80%-85% through local seed exchange (BoARD, 2004). Seed of local varieties can be obtained through farm saved, farmer to farmer seed gift or exchange and local market. Seed of improved varieties can be purchased from the bureau of agriculture and rural development or the Ethiopian seed enterprise. However, the formal system is unable to satisfy the seed demand of the region and the small amount provided are only the grain crops. As a result, farmers remain associated with locally produced seed and their local varieties.

Scarcities of proper planting material and weak seed supply system of unknown values and seed source are the major factor that constrains yield and expansion of garlic production. It is because of no research priority is given to identify the cause of poor quality seed and poor agronomic managements; the yield of garlic is low and erratic in the region. Its production is, therefore, relied on own saved seed of local varieties, farmer to farmer exchange and local market within and outside the region. There is no formal seed distribution and research on garlic.

A possible option for addressing the constraint is to mobilize farmers to produce good quality seed. One of the possible ways to address this is to initiate farmer-based seed production scheme which builds on the local knowledge, decentralized seed production and marketing at local levels. Participatory Variety evaluation will also contribute to efficient technology dissemination through identification of varietal niches and plant attributes preferred by farmers.

### 1.3 Purpose and Significance of the Study

The overall purpose of the study was to conduct joint experimentation and evaluating of garlic varieties and introducing farmer based garlic seed production. The intervention will benefit farmers with improved availability and access to garlic seed and varieties. The joint experimentation will build up the capacity of the community in seed production techniques, by participating farmers in the research activities, giving training on garlic seed production and arranged field visit on garlic seed plots. The feedback from this will benefit the national garlic research process. It will also provide direct information to the technology transfer process of BoARD by highlighting promising varieties that address the needs of agricultural populations.

## 1.4 Objective of the Study

The main objectives of this study are to:

1. Evaluate the performance of improved garlic varieties with farmer participation at Tegahne, Atsbi Womberta Woreda.
2. Introduce farmer-based garlic seed production scheme to the area and document farmers' perception on farmer-based garlic seed production practices.

## 1.5 Research Questions

The main questions addressed by the research are:

1. Do farmers accept (select) improved high yielding garlic varieties?
2. Does the existing informal seed supply address the garlic seed demand?

## CHAPTER II: LITERATURE REVIEW

### 2.1 The Ethiopian seed system

#### 2.1.1 The formal seed system

The formal seed system developed more than 50 years ago to increase agricultural productivity though its penetration is relatively weak. Currently the share of the formal seed system is estimated to be about 10-20% while the rest (80-90%) is covered by the informal system (Bishaw et al., 2008). In addition the formal system works mainly for major cereal and pulse crops like maize, wheat, teff, and beans. The story is quite different for vegetable seeds, which are mainly imported.

Ethiopia's formal seed system has passed several transformations since its inception. With the establishment of breeding programs at Jimma Agricultural School (now Jimma University) and Alemaya College of Agriculture (now Haremaya University) in 1942 and 1954 respectively, the formal seed system began improved seed production and distribution to farmers. In the 1966 with the establishment of the Institute of Agricultural Research (now Ethiopian Institute of Agricultural Research) the formal system expanded its activities and national seed council (NSC) was set up by the national crop improvement committee (NCIC) to formulate recommendations for seed production and supply of released varieties from the national research programs (Belay, 2002).

In 1974, the derg regime came to the power and established new large scale state farms, organized farmers' cooperatives and producers and also launched farmers' resettlement projects. These developments led to increased demand for modern agricultural inputs, particularly improved seeds. While provision of other agricultural inputs from local and foreign sources was possible, improved seed supply was lacking as there was no organized system in the country until the government established the Ethiopian Seed Corporation (now the Ethiopian Seed Enterprise) in 1979. Initially, the ESE was given responsibility for supplying seed to the entire farming community through local production or imports from abroad. Although its activities were largely skewed to the state farms and cooperatives at the expense of small farmers, the establishment of the ESE did lead to the advent of an organized seed production and supply system. Since then, the ESE has remained the main seed producer and supplier in the formal sector (Bishaw et al., 2008).

Among the many priorities for an effective seed system is the ability to produce, multiply, and distribute seed that are bred for optimal performance under different agroecological conditions. This is of critical importance to Ethiopia, host to 18 major agro-ecological zones and 49 sub-zones, according to the Ministry of Agriculture and Rural Development (Dawit et al., 2006). The agroecological zonation is based primarily on two indicators: length of growing period (number of days with sufficient moisture for plant growth) and thermal zones (combination of temperature and elevation). For the most part, however, the seed system in Ethiopia provides improved varieties for three groups of these agro-ecological zones: low, medium and high altitude crop-growing areas; four durations to maturation: extra-early, early,

intermediate, and long maturing varieties; and other context-specific attributes such as yield, drought tolerance, and disease resistance (Dawit et al., 2006).

#### 2.1.1.1 The regulatory framework

In 1992 the first National Seed Industry Policy was issued by the government focusing on the plant genetic resources conservation and development; crop variety development, testing and release; seed production and supply; seed import and export; and reserve seed stock (Bishaw et al., 2008).

The regulatory organ in the Ethiopian seed system is the Ministry of Agriculture and Rural Development. In 2004, Proclamation No. 380/2004 gave MoARD the authority to supervise all government organs dealing with seed regulation, seed production and seed distribution. Several proclamations were issued to legally enforce and implement various activities underlined in the national seed industry policy. They included the Plant Protection Decree (No.56/1971), the Plant Quarantine Regulation (No.4/1992), the Plant Breeders' Rights Proclamation (No. 481/2006), the access to Genetic Resources and Community Knowledge and Community Rights Proclamation (No.482/2006), and the National Seed Proclamation No. 206/2000. Moreover, major stakeholders were also reconstituted into new legal entities through various proclamations and regulations including the EIAR (Proclamation No. 79/1997), the Institute of Biodiversity Conservation (IBC, Proclamation No. 120/1998) and the ESE (Regulation No. 154/1993). The national seed policy and regulatory frameworks were realigned with rural development policies and strategies issued by the government in 2001.

This shows the commitment and interest of the government to strengthening the seed system in the country.

#### 2.1.1.2 Performance of the formal seed system

Ethiopia's formal seed system has experienced several transformations since inception. Although extensive research conducted in Ethiopia over the years has generated many improved cultivars, seed supply remains limited in Ethiopia, especially for small-scale, resource-poor farmers. And even where supply is commonly regarded as adequate as in the case of hybrid maize, the number of varieties that are suitable for different agroecological conditions and farming systems remains limited (Dawit et al., 2006).

The ESE remains the major public sector seed producer and supplier in the country. The Ethiopian seed enterprise annual seed sale (Table- 1) indicated that the size of the penetrated market is less than 200,000 quintals per year. The gap between demand and supply shows that the formal seed sector cannot ensure farmers easy access to seeds of improved varieties. The role of private seed companies did not expand as expected. Even though, the participation of the private sector is increasing in seed production especially they are exclusively engaged in hybrid maize, their role in the marketing and distribution directly to end-users is limited. The involvement of foreign companies is low: Pioneer Hi-Bred Seeds Ethiopia's share in the hybrid maize seed market is limited (Bishaw et al., 2008).

**Table 1-Annual seed sales by the Ethiopian Seed Enterprise (2003-2007)**

Crop	Annual seed sales (quintals)				
	2003	2004	2005	2006	2007
Wheat	91393	138913	64234	115886	75006
Barley	1580	4198	3710	10022	6355
Teff	1620	1329	2072	3529	5816
Maize	59124	50204	48792	46650	54747
Sorghum	-	95	443	140	278
Millet	-	12	37	26	234
Haricot bean	2300	2170	2486	4370	2238
Faba bean	315	495	1076	2231	2720
Field pea	247	2230	3269	796	1388
Soybean		157	30	812	1705
Lentil	31	327	7293	1883	664
Chickpea	207	358	2158	2208	1346
Linseed	337	670	497	586	289
Rapeseed	23	407	126	49	707
Sesame		438	339	486	67
Cotton		6936	8	238	179
Total	157,177	208,951	136,721	189,993	153,809

Source: Adapted from Yonas et al. (2008)

### 2.1.2 The informal seed system

Globally, the informal seed systems remain important and it supplies around 80 % of planting material each season in the world. Informal seed systems dominate in the fields, and the vast majority of seed is either stored on farm, or obtained from local sources. An understanding of informal seed system is crucial for any reform efforts in crop improvement (Shawn, 2005). This is perhaps most obvious in the area of seed supply, especially when considering reforms to seed supply. In the past, many national seed programmes ignored informal seed systems.

The predominant modernising perspective assumed that formal seed supply should eventually replace farmer systems over time, due to the poor seed quality and inefficient seed delivery of the latter. However, the relatively recent perspective on “integrated seed supply” is becoming more popular in reform initiatives. This perspective is pragmatic, avoiding the promotion of one system over the other, but rather seeking to combine the strengths of each system in order to arrive at a more effective, equitable, dynamic seed supply. Integration could involve supplying germplasm, strengthening local seed production and storage skills, or facilitating communication linkages (Shawn, 2005).

Improving farmer based seed production schemes and revitalizing informal seed supply for local crops and varieties is crucial for the development of the seed sector in the country. Supporting the informal seed sector will help to maintain genetic resources and to increase productivity so as to attain food security and improve farmers’ livelihoods (Bishaw et al., 2008). Some attempts have been made to improve seed supply by working with farmers through contractual seed production with Farmers’ Producers Cooperatives and through

farmer-based seed production and marketing units, which was set up first by the NSIA and lately by the ESE and regional BoARD.

## 2.2 Farmer based seed production

Farmer-based seed production can be initiated by establishing small-scale farms which can produce sufficient improved seeds to satisfy the needs of the local community. Such farms can be managed privately by groups of farmers or under community control. The decentralized seed farms could be supplied annually with foundation seed from the research stations/seed industry, and could concentrate their activities on seed multiplication and marketing to the community (Bishaw and Gastel, 2008).

Local level seed production and dissemination activities have a wide range of objectives, including preserving genetic diversity, improving dissemination of modern varieties, improving seed availability (time, place, quantity), and reducing seed cost and dependence on external sources. Local level seed production projects can be grouped into three categories: (a) seed production using contract growers, (b) seed exchange schemes, and (c) farmer seed enterprises. The last approach, being commercially oriented, appears to be the most sustainable. Farmer seed enterprises or community-based seed production offer four main advantages over other approaches: (i) sustainability, by being market driven; (ii) decentralization of seed production to cater for regionally specific varietal preferences; (iii) possibilities for establishing linkages to formal institutions, and (iv) production of good quality seed (Soniia, 2008).

Community-based seed enterprises are important to increase crop production and ensure food security at local village level by: Introducing improved crop varieties and associated

technologies (ensuring technology transfer to farmers), multiplying quality seed of improved and local varieties to communities (improving quality of on-farm saved seed), supplying the actual village seed demand, reduced seed price, brings a business approach to on-farm seed production and assist in crop diversification to increase rural income and improve farmers livelihood strategies (Bishaw and Gastel, 2008).

### 2.3 Experiences of farmer-based seed production in Ethiopia

Farmer-based seed production is used more to describe any form of seed production and supply conducted with or by farmers, with great differences in scope and ownership. Several approaches are used by stakeholders involving farmers in local seed production, including genetic resources conservation, crop improvement, variety popularization and seed supply (Yonas et al., 2008).

Small-scale seed multiplication was started in the 1980s. ESE with smallholder farmers through Producers' Cooperatives (PCs) and it was discontinued in the early 1990s. Similarly, the national genebank also carried out some seed multiplication with smallholder farmers, to conserve local varieties. The former National Seed Industry Agency (NSIA) started a nationwide Farmer-Based Seed Production and Marketing Scheme (FBSPMS), in collaboration with the Regional Agricultural Bureaus through a five-year technical assistance project financed by the World Bank in 1997. The scheme was carried out in seven regions (Amhara, Benshangul Gumuz, Gambella, Harari, Oromia, SNNPR, and Tigray) to produce and distribute 144,000 tons of seeds of improved varieties and to involve 15,000 farmers during the fifth year (Yonas et al., 2008).

In 2002, the responsibility for the FBSPMS was officially transferred from the NSIA to the ESE. It was treated as a formal sector operation. A flexible pricing policy was introduced which is a 15% premium on the current grain price and basic seed also supplied at lower prices and allowed farmers to keep 10% of the seed produced for planting next season. The number of participating farmers increased over the years from 695 in 2002 to 2,541 in 2003 and 6,679 in 2004.

The share of seed produced by the farmer based production programme in 2006, reached about 35% of the total certified seed production by the ESE (Table-2). Within short period of time FBSPMS has accomplished several achievements such as the creation of awareness of the importance of improved varieties and seeds among stakeholders; the fast introduction, adoption and diffusion of new crop varieties; the increased availability, access and use of seeds; and the transfer of relevant knowledge about seed production to farming communities. The main achievement of the FBSPMS handled by the ESE can be considered the fast introduction of improved varieties and knowledge about seed handling to different farming communities. However, there are also critical technical, administrative and policy problems such as selected farm plots are small, fragmented with diversified cropping pattern; poor accessibility and communication; cropping history problems; use of high seed rates; and seed quality assurance.

**Table 2- ESE seed production under FBSPMS (2002 - 2006).**

Year	Region				Total
	Amhara	Oromia	SNNPR	Tigray	
2002					
ha	73	124	46	20	263
tons	111	172	80	33	3,96
2003					
ha	317	557	125	265	1,264
tons	576	1,160	157	411	2,304
2004					
ha	1,639	1,459	1,349	727	5,174
tons	1,558	1,399	1,283	691	4,932
2005					
ha	559	1,221	611	1,709	4,100
tons	1,118	2,258	1,005	2,027	6,408
2006					
ha	890	1,330	622	1,565	4,407
tons	2,119	1,855	1,176	2,544	7,694
Total					
ha	3,478	4,691	2,753	4,286	15,208
tons	5,482	6,844	3,701	5,706	21,734

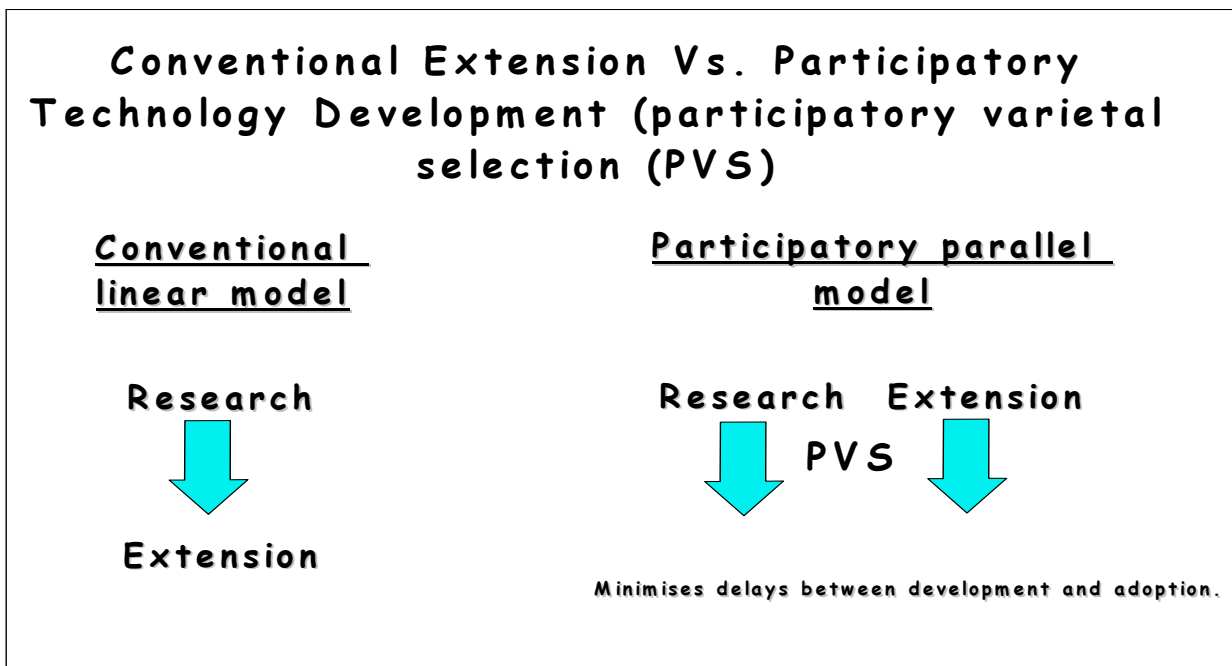
Note: SNNPR = South Nations Nationalities and Peoples Region

Source: adapted from data cited in Yonas et al. (2008)

## 2.4 Participatory varietal evaluation

In participatory varietal evaluation farmers select among the fixed varieties or the finished products of plant breeding under their own management (Witcombe et al., 1996). The participatory varietal selection approach has provided primary information to feedback into the varietal development program. Secondly, it also provides direct information into the technology transfer process by highlighting promising varieties that address the needs of local communities. A very important advantage of PVS is that the adoption of new cultivars is much faster than under the formal system, in which farmers are confronted with only a very restricted range of new cultivars. Also the spread from farmer-to-farmer through the local seed

system can be very fast, thus guaranteeing a further good adoption (Bellon and Reeves, 2002). According to Witcombe et al. (1996), it simply not re-labeling of the existing on-farm adaptive research.. There are a number of important reasons that differentiate the traditional on-farm adaptive research from the more participatory varietal selection approach. Traditional on-farm methods relied on released or recommended varieties but PVS includes varieties irrespective whether they are non-recommended or non-released varieties or are at pre-released stage if they meet farmers' criteria. Results from many PVS programmes in many countries and crops provide overwhelming evidence that farmers identified non-recommended, non-released varieties, and these varieties spread rapidly from farmer-to-farmer (Fetien and Bjornstad, 2008; Monty et al., 2000). Such a result is not possible with traditional approach which misses this opportunity (Monty et al., 2000). The PVS follows a parallel model of extension than the conventional model linear model of extension (Figure-1).



**Figure 1- Traditional extension versus participatory technology development**

Farmers being the end-users of agricultural technologies are the primary beneficiaries in a PVS programme. Benefits to farmers include: access to seed of a range of new varieties that are pre-selected to meet farmers' needs; new varieties may allow a farmer new options to make alternative and profitable cropping patterns. For instance, access to early maturing or drought resistant varieties may allow additional crops; new seeds may increase grain yield and offer a range of associated benefits such as superior cooking quality or more market price, higher fodder yield and better resistance to drought and insect-pests; farmers receive new seeds free for experimentations that they may be constrained to find themselves; and farmers get the seed of potential varieties earlier in the process of varietal development. This reduces the delivery gap between release and dissemination to farmers. The researchers benefit from the PVS process in the form of a feedback that helps them to re-orient their research programme to better meet farmers' needs.

In PVS, farmers conduct three types of trials. The first one is Mother trials, single replicate, all varieties trials and the trials are researcher-designed but farmer managed. The second is baby trials, single variety trials where new variety and local check are grown alongside under farmer management. The third is informal research and development (IRD), farmers evaluate new varieties in comparison to their local cultivars with little intervention from scientists, the evaluation is mainly by anecdotal means and adoption trends, this is very cost effective and an efficient means of dissemination of varieties since farmers are encouraged to keep and exchange seed of preferred varieties (Virk et al. 2003).

## 2.5 The Garlic plant

### 2.5.1 Cultural management

#### 2.5.1.1 Soil and climatic requirements

Garlic can be grown in different types of soil. However, sandy, silt and clay loam are recommended for commercial production. The soil should be fertile, rich in organic matter, well drained, capable of holding adequate moisture during the growing period, and having soil pH ranging from 6.8 to 7.2 (Janet, 2008). Garlic grows best within the warmer geographic areas having a mean monthly growing temperature ranging from 12°C to 24°C (Libner, 1989). Excessive humidity and rainfall are detrimental to both vegetative and bulb formation. The crop is therefore normally grown in low rainfall areas with irrigation during the early vegetable growth (Tindal, 1983).

#### 2.5.1.2 Selection of planting materials

The garlic bulb consists of numerous cloves, which is the main economic organ both for consumption and propagation. Fully matured and well-developed bulbs of medium to-large cloves should be selected as planting materials. These should be free from diseases and mechanical damage. A hectare of land will require about 700-1000 kg of seeds depending on the size of the bulbs and the distance of planting. Bulbs stored for planting should be maintained between 5°C and 10°C (Libner, 1989).

#### 2.5.1.3 Clove/Seed Preparation

The planting material is prepared first by separating the clove from one another. The cloves from the outer parts of the bulb are the best planting material. When there is a shortage of planting materials, the inner cloves can be used also but these should be separated from the

outer cloves. The planting materials are then soaked in an insecticide-fungicide solution for at least two hours to get rid of seed-borne pests and diseases. The cloves are air-dried before planting.

#### 2.5.1.4 Planting and Spacing

The average number of cloves within each bulb varies from less than 8 to greater than 15 depending upon the strain of garlic. Space plants 7 - 12 cm apart in the row. Cloves of small-bulbed strains may be planted as close as 7 cm apart, while large-bulbed strains will require as much as 12 cm between plants. Spacing between rows will depend on the method of planting and available equipment for cultivation. Single or multiple rows of plants are commonly used, with spacing between rows generally not less than 20 cm (Sims et al., 1976).

Plant cloves so that the distance from the soil surface to the top of the clove is 3 - 5 cm. The 5 cm planting depth is recommended for light or organic soils. Cloves planted too shallow are prone to injury during the winter and early spring. Garlic which is planted in the spring may be planted closer to the soil surface. Hand planting is the traditional method of planting garlic, however, several imported mechanical planters are now in use. Various home-built or modified mechanical planters have been tried with only moderate success.

Garlic cloves require a period of 6-8 weeks of cool weather after planting to vernalize the plant (Brewster, 1997; Dickerson, 1999). New cloves develop from the lateral buds in the axils of foliage leaves of the clove used for propagation. During the clove formation period, bulbing is influenced by the temperature of the stored dormant cloves as well as during plant growth before clove formation begins (Libner, 1989). Long days favor development so it is

preferable to plant during short periods to encourage maximum vegetative growth before bulbing occurs (Rice et al., 1990). Yield and quality of garlic bulbs vary with climate, region, altitude, soil and pH, cultural practices and variety of garlic (Engeland, 1991).

#### 2.5.1.5 Irrigation

Garlic has a relatively shallow and limited root system; therefore, soils should be maintained near field capacity during most of the growing period. Plants are easily stressed by insufficient moisture and also by water logging (Rubatzky and Yamaguchi, 1997). Garlic likes a slightly moist but not wet soil if the moisture content of the soil at the root level is below 50%, it is time to water the garlic. If it stays too wet, diseases such as fungus and blight can set in. Soil water deficits leaf expansion, which reduces the amount of solar radiation intercepted as well as uptake of nutrients, because of reduced transpiration rates (Pereira and Chaves, 1993).

#### 2.5.1.6 Fertility

Garlic grows well on fertile soils. N, P and K are referred to as the primary macronutrients because of the general probability of plants being deficient in these nutrients and because of the large quantities taken up from the soil relative to the other essential nutrients (Marschner, 1995). Garlic has a moderate to high fertilizer requirement with banding being a preferable application method. The *Allium* species have low nutrient extraction capacity than most crop plants because of their shallow and un-branched root system. They require and often respond well to additional fertilizers (Brewster, 1994).

The soil phosphorus and potassium levels should be determined by a soil test. Any phosphorus or potassium required should be broadcast followed by shallow incorporation into the soil.

The total amount of nitrogen required will vary with the soil type, the previous crop grown, the amount of organic matter present and the climatic conditions during the growing season. Garlic will generally require 70 - 125 kg/ ha of nitrogen (Sims et al., 1976). A small amount of nitrogen can be applied at planting time, and the remainder should be applied by split applications.

#### 2.5.1.7 Harvesting and post harvest operations

Bulbs begin to mature 4-6 months in temperate (Libner, 1989) and 4 months in tropics (Rice et al. 1990) after planting. The garlic plants are ready for harvest when the tops begin to dry out and collapse. At this time, irrigation is stopped 1-2 weeks before harvesting, as it is easier to pull or dig garlic out of dry soil than mud and will store better (ATTRA, 2001). Indices for maturity are softening of the main stem above the bulb and the yellowing of 75% of the leaves (Dickerson, 1999). After harvest, the bulbs should be cured or dried for 8-10 days (Tindal, 1983) before either marketing or storage to prevent deterioration. After curing, garlic will keep 6 to 7 months if it is stored at 32<sup>o</sup>F and 65 to 70% relative humidity. It is important to keep temperature and humidity constant. Any variation in either will initiate sprouting. Good air circulation is essential.

# CHAPTER III: MATERIALS AND METHODS

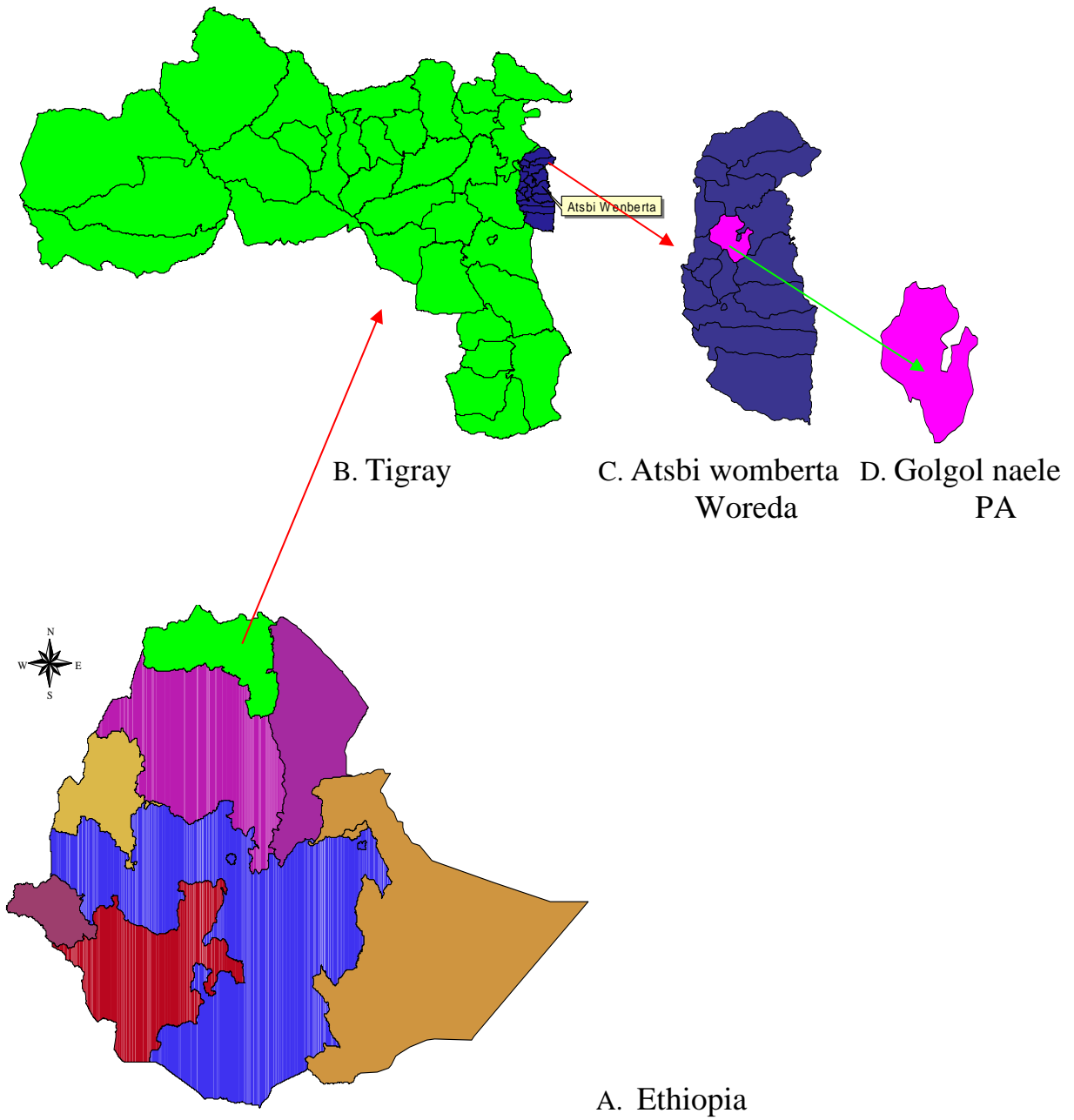
## 3.1 Description of the study site

### 3.1.1. Location and physical conditions

The experiment was carried out in Tegahne, eastern administrative zone of Tigray in Atsbi Womberta Woreda (lowest administration unit) under irrigation in 2008. The main Woreda town is Atsbi, about 70 km north of the capital of Tigray, Mekelle. Tegahne is located 2 km north of Atsbi town, which is situated between 13° 52' 53" and 13° 53' 37" N and between 39° 42' 05" and 39° 43' 57" E, covering an area of 13.56 km<sup>2</sup>. It is situated in an elevation of 2710 to 2899 masl. The climate is “Dega Dry” according to the recent agro-ecological classification, with average annual monomodal rainfall from July to September of 541 mm for the period 1901-2002. Maximum monthly average temperature is in June (27<sup>0</sup>C), whereas the minimum is in December (7.5<sup>0</sup>C). The major soil units include Leptosols (46%), Luvisols (26%) and Cambisols (26%)(Assefa, 2005). The soil of the PVE plots was classified as clay loam and the details are presented in Table-3.

**Table 3- Soil physical and chemical properties of the experimental site before planting in Tegahne irrigate site, Golgol naele, Atsbi womberta wereda (2008).**

Farmer	EC ds/m	PH	Soil texture %			Textural Class	total N %	Available		OM %	CEC Cmol(+)/Kg
			Sand	Silt	Clay			P ppm	K ppm		
Hailemariam	0.15	6.66	26.36	41.28	32.36	Clay Loam	0.11	3.625	73.36	2.745	21.7
Birhane	0.17	6.95	39.36	32.28	28.36	Clay Loam	0.06	5.805	50.095	2.89	18.9
Tsehaitu	0.18	7.055	31.36	43.265	25.36	Clay Loam	0.06	3.335	37.17	2.19	12.55
Mehari	0.09	6.64	27.36	42.28	30.36	Clay Loam	0.09	2.705	78.53	2.655	25.4



**Figure 2-** Map showing the location of Ethiopia (A), Tigray (B), Atsbi womberta (C) and Golgol naele peasant association, the study site (D).

### 3.1.2 Farming system and crop types grown in the study area

Agriculture is the main stay of the population of the Woreda. Mixed farming, crop and livestock production including apiculture is the major practice of the Woreda including the study sites. The predominant agricultural practice is traditional and subsistence farming. Despite the fact that agriculture is the main economy of the woreda, the production does not cover the food demand of the population. The productivity of the area has been significantly reduced not only because of the climate change and land degradation, but also the significant reduction of landholding due to population growth.

Livestock production is very important in the area, which enables them to buy the grains and other necessities they need. The area is known for high valued sheep and/or goat farming. It is also an important honey producing area where the highest price is paid too. There is an intervention to increase the honey production and provide as option for landless farmers. In general, they practice a mixed farming system, which combines rainfed crop production with small-scale livestock breeding. Most of the households can only feed themselves with their own crop production during a limited number of months of the year. In addition due to land pressure we see that fallow does rarely exist but crop rotation with legumes is more commonly practiced.

The cropping system in the Atsibi womberta area is dominated by diversified field crop production with limited horticultural crops production under irrigation, in which has recently tended to expand and having significant economic contribution. The major crops grown are barely, wheat, faba bean, field pea, teff, lentil, linseed, finger millet, and new introductions of

irrigated crops like potato, onion, garlic, cabbage, lettuce, swiss chard, beet root and highland fruits such like apple. Among the major crops grown in the wereda, barely covers the largest area (49.96%) followed by wheat (33.83%), faba bean (8%), field pea (4.27%) and Teff (3.87%). The average productivity of the major crops is 5-6 quintal per hectare. On the average a household produces support for about five to six months. Most members of the community should look for off-farm activities to feed their families all year round (BoARD, 2004).

### 3.2 Test materials

The research comprises two parts in a cluster: Part I - the participatory varietal evaluation and Part II - Farmer based garlic seed production.

#### 3.2.1 Participatory Varietal Evaluation

Four improved garlic varieties from Debrezeit Agricultural Research Center (DARC) and one local garlic variety were tested on farmer's field. Detail of the varieties is presented in Table-4. Before planting samples of each variety were weighed, and the mean bulb weight, mean number of cloves per bulb, and mean number of cloves per kg were determined (Table-4).

**Table 4- Characteristics of the varieties used in the study, Tegahne irrigate site, Golgol Naele, Atsbi womberta wereda (2008).**

No	Variety	Status	Year Of Release	Seed Source	Maturity	Bulb Colour	Qt/Ha	Mean Bulb Wt (Kg)	Mean Cloves/ Bulb	Mean Cloves /Kg
1	Rie (Local)	Farmer's cultivar	-	Market	138-142	White	NA	0.022	15.2	690.5
2	G-99-2	Pre-released	-	DZARC	110-120	Dull White	30	0.029	14.8	528
3	Bisheftu netch (W-014)	Released	2000	DZARC	132	White	79	0.042	10.75	291.4
4	G-161-2	Pre-released	-	DZARC	110-120	Dull White	36	0.027	15	557.2
5	Tsedey 92 (G-493)	Released	2000	DZARC	138	Purple White	85	0.040	9	246.5

Source: Debre Zeit Agriculture Research Center and data from this study 2008.

### 3.2.2 Farmer Based Garlic Seed Production

Participatory varietal evaluation is an entry point to the farmer-based seed production. It provides alternate choices for testing and selecting preferred varieties. For providing immediate response of existing shortage of garlic seed, Farmer Based Seed production was initiated with locally preferred variety sourced from Enba-Alaje woreda.

### 3.3 Experimental Design

#### 3.3.1 Participatory Varietal Evaluation

##### 3.3.3.1 Joint Experimentation

The experiment was conducted on farmers' field using Randomized Complete Block Design (RCBD) with four replications. Each farmer's field was considered as replication in order to address not only soil heterogeneity but also farmers' cultural practices. Test varieties were planted in collaboration with four volunteer farmers in Golgol naele peasant association (PA). The total number of plots were 20 and each have 3m<sup>2</sup> (2m x 1.5m).

In accordance with a standard local practice, cloves were separated from the bulbs and sorted and graded according to their size category. Selected cloves with a size of medium to large (1.5-2.5 g) were planted on the ridges of beds being bulbed during planting from well-cured and stored bulbs. Planting have been done in two rows per bed at spacing of 60 cm between rows and 10 cm between plants in the row, with planting depth of 4 cm by sticking the clove into the ridges by hand, the spacing between plots was 1 m.

Nitrogen and phosphorus were applied in the form of urea (46% N) and DAP (18%N and 46% P) at a rate of 100 kg/ha and 200 kg/ ha, respectively. DAP was applied at the time of planting whereas urea was splited and applied one-third during planting, one-third during active vegetative growth three weeks after plant emergence, and the rest five weeks after plant emergence or six weeks just before bulbing. At the time of planting, all fertilizers were incorporated in to the soil on the prepared ridges in bands to facilitate efficient fertilizer use by the roots. The 2<sup>nd</sup> and the 3<sup>r<sup>d</sup></sup> split applications of N was applied 5 cm away from the root zone. Weeding was done four times starting three weeks after plant emergence. Ridomil Gold

MZ 68 WG at the rate of 2.5 kg per hectare was used against garlic rust (*Puccinia porii*); it was sprayed twice at ten days interval.

Harvesting was done in May 2008 by digging up the individual plants and picked by hand. The harvested bulbs were windrowed in the field and were sun dried for ten days, folding the leaves over the bulbs to protect them from the sun. After a week of drying, tops and roots were trimmed. Yields obtained from the two central rows after curing in the sun, were weighed and recorded. Management of the research plot was done by farmers themselves but the researcher was responsible for monitoring and recording the data.

### 3.3.1.2 Experience Sharing and awareness creation of PVE

A sensitization workshop and familiarization meetings were held with farmers and development agent of the Woreda Office of Agriculture and Rural Development (WOoARD) at the beginning of the research process. Besides the initiatives made on community based seed multiplication initiatives, new (released and pre-released) garlic varieties were included in the participatory selection and evaluation. The method and time of data collection was jointly decided with farmers. They explained the importance of measuring bulb characteristic and stages.

Farmer's field days were arranged at different garlic crop growth stage: at vegetative and harvesting stages. In the first awareness creation workshop, farmer's field day participants were selected from potential garlic areas from five peasant associations (PAs), namely Hadnet, Felege-Weini, Haresaw, Gebrekidan and Ruba-Feleg and the number of participants was 72. During the first field day, farmers insisted that it would be difficult for them to select

unless they could see the bulb characteristics, despite the fact that bulbs of each variety from previous harvests were displayed together, researchers provided answers to farmers' queries and, farmers explained their reasons for the acceptance or rejection of a variety.

In the second village level farmer's field day, participants were selected from Golgol naele peasant association and their number was 14. At this evaluation, the crop was matured and it was harvesting time where farmers had a chance to see the bulb characteristics and discuss their impressions on the chosen varieties. The method used to attempt selection was matrix ranking and pair-wise ranking.

### 3.3.2 Farmer-Based Garlic Seed Production

Farmer-based garlic seed production was initiated by 10 volunteer seed growers each having 100 m<sup>2</sup> irrigated land. The researcher had facilitation role in accessing planting material (locally available garlic variety, from Enba-Alaje wereda), providing trained twice about seed production techniques before planting and harvesting and also there was a continuous follow up through out the intervention process.

#### 3.3.2.1 Testing and demonstrating garlic seed production

##### Selection of production plots

All selected plots were in cluster and far from other garlic cultivars to minimize contaminants. As the study was conducted in off season under irrigation and in the previous main season all plots were covered by barley, Faba bean, Field pea and cabbage. As result, the seed plots were free from varieties of the same crop species. This show the plots were properly isolated in

space and time from other varieties of the same species. The land selected for garlic seed production was also free of noxious weeds and seed/soil-borne diseases, that is why in the demonstration process there was no any noxious weeds (rather than common weeds) and seed/soil-borne diseases observed.

### Land and Seedbed Preparation

Land preparation was started early to ensure suitable tilth at planting and it ploughed by oxen three to four times. Seedbed thoroughly prepared, leveled and made furrow for good irrigation and for good water penetration, to allow easy insertion of the cloves and to create better bulb development. Among the participant farmers there was difference in proper land preparation, some farmers were lack to prepare their plot thoroughly.

### Planting Date, planting method and spacing

After land was ploughed, leveled and furrows prepared, planting was done on January 02, 2008 (Figure 3). cloves were separated from the bulbs and sorted and graded according to their size category, the cloves from the outer parts of the bulb are the best planting material, then selected cloves with a size of medium to large (1.5-2.5g) planted on the ridges of beds being bulbed during planting from well-cured and stored bulbs. The amount of planting material was 10 qt/ha, in accordance to the weight of individual cloves planted and the spacing used. The average number of cloves within each bulb was varies from 9 to 15 depending upon the garlic varieties.

Planting have been done in two rows per bed at spacing of 60 cm between rows and 10 cm between plants in the row, with planting depth of 4cm by sticking the clove into the ridges by

hand and cloves were planted in an upright position (pointed end up) to ensure good emergence and straight necks. .



**Figure 3- Garlic seed planting in farmer-based seed production plot in Tegahine irrigate site, Golgol naele, Atsbi womberta wereda (2008)**

## Post Emergence Management

### Irrigation

To determine the irrigation interval, the net irrigation depth was estimated with farmers by checking how much water is given per irrigation application with the local irrigation method and practice, related with the net irrigation depth ( $d_{net}$ , in mm) estimation. The net irrigation depth was assumed to depend only on the root depth of the crop and on the soil type. Considering garlic root depth (60 cm) and soil type of the test site (clay Loam), it is expected the irrigation water applied to the field can not be used by the plants. Part of the water may be lost through deep percolation and runoff. To reflect this water loss, the field application efficiency ( $e_a$ ) is used. Field application Efficiency (60%) and the gross irrigation depth is determined by calculating the irrigation water need (IN) in over the total growing season and calculating the number of irrigation applications over the total growing season, which is obtained by dividing the irrigation water need over the growing season, which is 600 mm and

the net irrigation depth per application, which is 20mm. Finally, the irrigation interval (INT, in days) was determined by estimating total growing season for garlic (which is 5 months) and number of irrigation applications over the total growing season (which is thirty applications) the irrigation interval is 5 days. In other words, the interval between two irrigation applications was recommended to be 5 days.

On the other hand farmers had different perceptions and decided to introduce their own irrigation interval. Their perception was associated with the negative effect of frequent irrigation on stunted growth and reduced yield of the crop. Accordingly, most of the irrigated plots were irrigated between 6 to 9 days interval and a few of them irrigated 12 to 15 days interval between two irrigation applications at the peak crop stage. This is a clear indication of joint experimentation where farmers managed the experiments and had the decision making power in introducing their management practices. It is also in agreement to other participatory research methodologies (Fetien et al., 2008)

### Fertilizer Application

From the pre-planting soil analysis result the soil contains 2.62% organic matter, 0.08% organic carbon, 3.87 ppm available P and 59.79 ppm available K. This showed a deficiency of nitrogen and phosphorus nutrients and less content of organic matter. To increase the nutrient content of the soil Nitrogen and Phosphorus, fertilizer were applied in the form of urea (46% N) and DAP (18%N and 46% P) at a rate of 100Kg/ha and 200 Kg/ ha respectively. DAP fertilizer were applied at the time of planting whereas urea was split and applied one-third

during planting, one-third at active vegetative growth (three weeks after plant emergence), and the rest five weeks after plant emergence or six weeks just before bulbing.

## Weed Control

Cultivation using hand hoeing for weed control and maintenance of beds was done three to four times starting two to three weeks (in different plots) after plant emergence and two to three additional weeding were done at three weeks interval. Most of the plots were free of weeds in whole of the season, but there was weed infestation in some plots due to lack of proper land preparation and proper weeding.

## Management of Seed-borne Diseases

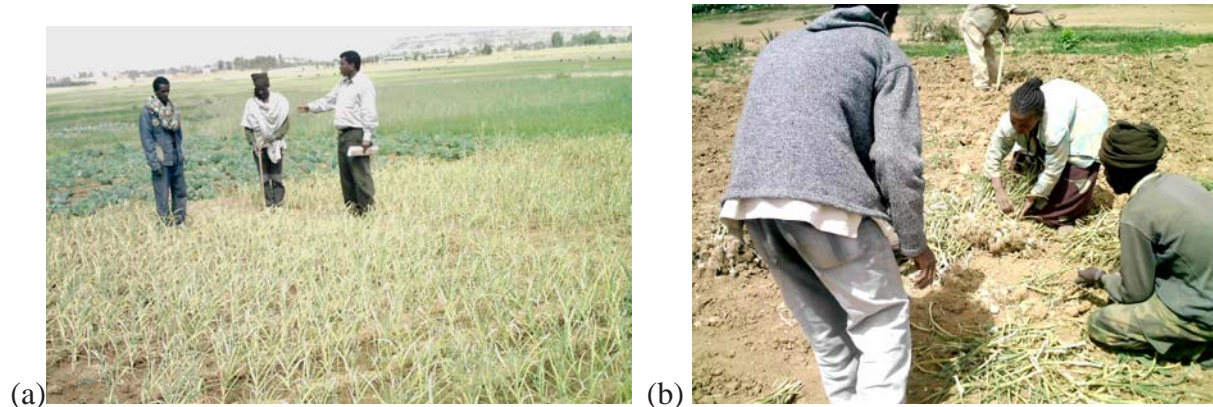
Ridomil Gold MZ 68 WG at the rate of 2.5 kg per hectare was used to prevent garlic rust (*Puccinia porii*) and it was sprayed twice at ten days interval (Figure 4). In all plots no any disease and insect observed. Off-season garlic production, spraying preventive fungicide, proper rotation and isolation are contributed to produce healthy garlic seed.



**Figure 4- Chemical spray to prevent garlic rust in farmer-based seed production plot in Tegahine irrigate site, Golgol naele, Atsbi womberta wereda (2008)**

## Decision of Maturity and Harvesting

Knowing when to harvest was a little tricky, since the tested varieties matured at different times and unlike onions, garlic doesn't signal maturity by breakdown of the neck tissue. Discussion with farmers was held to decide maturity of the crop (Figure 5a). Farmers in the study area start earthen down the soil one week before harvesting and they dug a couple of "test" garlic plants to make sure their cloves fill the skins. They begin harvesting from May 8 to May 21, 2008 when yellowing of 50% to 75% of the leaves and tops become dry (Figure 5b). Hand labor was used to harvest using hoe to dig the bulbs with the shoots still attached and loosen the soil underneath the bulb, carefully pulled up the entire plant by the shoot and knock off the soil then collected and windrow them in their home garden by placing the tops on top of the bulbs to protect them from the sun, and let the garlic dry in home garden for 10 days. The tops and roots are removed by hand with sickles.



**Figure 5- Discussion on garlic decision of maturity (a) and garlic harvesting (b) in farmer-based seed Production plot in Tegahne irrigate site, Golgol nae, Atsbi womberta wereda (2008)**

### 3.3.2.2 Experience sharing and awareness creation of farmers participatory seed production

Farmers from different PAs viz Hadnet, Felege-Weini, Haresaw, Gebrekidan and Ruba-Feleg within the district were visited garlic seed production farms (Figure-6) and 72 interested farmers were registered for garlic seed material and to participate in seed production in the next production season. In the second field day participants from Golgol naele peasant association were selected and discussion was held to assess farmers' perception on the over all performance of community based garlic seed production using workshops and the participatory tools which is focus group discussion. Seed demand survey was also assessed within the woreda and outside the woreda in Ganta afeshum, Kilde awlaelo and Enderta woreda.



**Figure 6- Discussion on farmer-based garlic seed production plot at farmers' field day in Tegahne irrigate site, Golgol naele, Atsbi womberta wereda (2008).**

## 3.4 Data collection

### 3.4.1 Participatory varietal evaluation

#### 3.4.1.1 Researcher Data

All data pertaining to growth and yield components were collected from randomly sampled 12 plants of two central rows of the plot. The different parameters and their method of collection were as listed below.

##### **1. Phenological traits**

- ❖ Emergence Success (ES): was determined and recorded to full emergence of plants in each plot as the number of days from planting to fifteen days ahead.
  
- ❖ Days to Maturity (DM): were recorded as the number of days from date of sowing to 70% neck fall shows the maturity of the plant.

##### **2. Growth parameters**

- ❖ Plant height (PH): the length measured in cm from the surface of the soil to the tip of the leaf at maturity.
  
- ❖ Leaf length (LL): the average length of the longest leaf, expressed in cm at maturity.
  
- ❖ Leaf diameter (LD): the average width of leaves expressed in cm at the widest part at maturity.

- ❖ Leaf number (LN): the total number of the healthy leaves per plant at maturity.

### **3. Yield and yield components**

- ❖ Bulb yield per hectare (BYPH): harvested cured bulb yield of the plot converted to hectare.
- ❖ Total bulb weight (TBW): the bulb weight of selected plants after curing.
- ❖ Mean bulb weight (MBW): the average mature bulb weight per plant after curing.
- ❖ Clove weight category (CWC): the weight of the cloves by size category in g.
  - Very small cloves (VSC): cloves with <1.0 g weight
  - Small cloves (SC): cloves with 1.0 to 1.49 g weight
  - Medium cloves (MC): cloves with 1.5 to 1.99 g weight
  - Large cloves (LC): cloves with 2 to 2.5 g weight
  - Very large cloves (VLC): cloves having >2.5 g weight
- ❖ Mean clove weight (MCW): the average weight of a clove after curing, measured in g.
- ❖ Clove number per bulb (CNPB): the number of cloves produced per plant.
- ❖ Clove diameter (CD): the average size of clove measured at the widest point of matured cloves measured using caliper.
- ❖ Marketable and unmarketable clove category (MC and UMC): Marketable and unmarketable cloves weight and numbers were recorded to evaluate the applied treatments. Marketable clove category includes cloves having one and greater than one gram clove weight ( marketable clove size > 2.0 g, acceptable marketable clove size

1.5-1.99 g and scarcely marketable clove size 1.0 g- 1.49 g) whereas unmarketable clove category includes cloves having less than one gram weight.

#### 3.4.1.2 Farmers' Data

Qualitative information was collected on garlic varieties using a semi-structured questionnaire, Focus Group Discussions (FGDs) and participatory tools (Crop and varietal diversity matrix and pair-wise ranking matrix).

Farmers' selection criteria were assessed using a semi-structured questionnaire with 30 farmers from Golgol naele Peasant association (PA). Farmers listed more than 10 criteria. Focus Group Discussions (FGDs) were held with 14 (10 male and 4 female) randomly selected farmers from Golgol naele Peasant Association (PA) (Figure-7). During the FGDs crop and varietal diversity matrix and pair-wise ranking matrix and.

To assess the crop and varietal diversity a matrix was prepared on a flip chart showing crop, variety, origin, use, maturity and others in the column. The matrix was filled based on the consensus reached by the farmers.

During the FGDs farmers' selection criteria was also assessed and farmers were encouraged to include their own selection criteria. They listed more than 10 criteria. Using pair-wise ranking matrix, both male and female participants prioritized and jointly agreed on six traits. Pair-wise ranking, one kind of Participatory Rural Appraisal technique, is a structured method for ranking the selection criteria in priority order in a consensus-oriented manner. All the 6 traits

were tabulated in a matrix scoring table, and each selection criterion was compared with each of the others in a pair-wise fashion. The rank assignments were determined from the number of times each selection criterion was preferred by the group (Lelo et al., 1995).

A matrix was prepared for the garlic varieties listed in the column and characteristics preferred by farmers in the row. The ranking procedure was explained to participants then each criterion was ranked from 1 to 5 (1 = very good, 2 = good, 3 = average, 4 = poor and 5 = very poor) for each variety, ranking was done on consensus where differences are solved by discussion (De Boef and Thijssen, 2006).



**Figure 7-** Participatory variety selection on testing and evaluation of garlic varieties in Tegahne irrigate site, Golgol naele, Atsbi womberta wereda (2008).

### 3.4.2 Farmer-based garlic seed production

Information on farmer-based garlic seed production was generated in relation to situation analysis, perception of farmers on garlic seed production and process impact of the seed production using a semi-structured questionnaire, Focus Group Discussions (FGDs) and

participatory tools (Seed network analysis). The details of the information that were recorded are given below.

### **1. Situation analysis of garlic seed production**

Situational analysis in garlic production was assessed using a semi-structured questionnaire with 30 farmers from Golgol naele Peasant association (PA). A seed network analysis was also conducted and farmers were grouped in groups of three. Each group was made to list the varieties grown and asked the source of the seed, to whom each farmer has given, and from whom has he demanded. Also the types of varieties demanded and supplied were listed down.

### **2. Perception of farmers on garlic seed production**

Focus Group Discussions (FGDs) were held with 14 (10 male and 4 female) randomly selected farmers from Golgol naele Peasant Association (PA). During the FGDs perception of farmers on garlic seed production was assessed and documented.

### **3. Process impact of the seed production (Innovation uptake)**

#### 3.5 Data analysis

The data collected were subjected to analysis of variance for RCBD as per Gomez and Gomez (1984) using GenStat and MSTAT-C (Michigan State University, 1991) software computer programmes. The least significance difference (LSD) was also worked out for mean separation at 1% and 5 % probability levels. Correlation between yield and important traits were assessed. The qualitative data was also subjected to descriptive analysis of proportions and percentages.

## CHAPTER IV: RESULTS AND DISCUSSION

The results and indications of the garlic participatory varietal evaluation and community based garlic seed production are presented below. The results of garlic participatory variety evaluation trial included variation in Phenology traits, vegetative growth, yield and perception of farmers. The results of community based garlic seed production included skills, approaches, efficiency and sustainability of seed production in Atsbi womberta woreda.

### 4.1 Garlic varieties and seed supply at Tegahne, Atsbi Womberta Woreda

According to the survey results and information from crop and varietal diversity matrix 2008, the formal seed system is unable to provide improved garlic varieties and none of the improved varieties are popular among farmers in the study area. As a result, farmers remain associated with locally produced seed and their local variety. It was also identified that farmers are found to acquire seed from various sources. Seed source of garlic growers in the study area is dominated by the informal seed system. In 2007, 37% of households purchased their garlic planting seed from local market, 20% obtained seed from farm saved seed and 13% obtained seed from exchange with relatives, neighbours or friends. The informal seed flow contributes about 70 % of garlic seed supply in the locality where as 30% of them can not grow because of the shortage of garlic seed in the area. This is because of the recent experience of garlic in the area. Relatively the seed exchange and network of cereals is strong where by farmers can get preferred varieties even in the form of exchange, gift and purchase within a given village where as for garlic the major source is the local market

In 2007 farmers were interested to plant garlic but because of shortage of garlic seed in the locality which was supplied only less than 9 quintals through the channels, they forced to cover their field with other vegetable crops.

According to the focus group discussion, farmers in the study area understood the importance of the availability of seed in time for planting. Therefore, they store seeds to ensure its availability. In general the study showed that there is a problem of availability and access to garlic planting material. In addition to this the seed material supplied through the informal seed system has less quality in terms of varietal mixture. The seed supplied was also small in terms of quantity, farmers tend to use the entire supplied seed as planting material without clove selection, which gives small bulb size and yield produced that has relatively poor market price.

Garlic and some other vegetable crops such as potato, onion, Swiss chard, cabbage and carrot are recently introduced crops with the expansion of irrigation in the study area. An increased farmers' interest to grow these crops and a dedicated support by the administration, OoARD, IPMS/ILRI and other stakeholders to promote high value crops and irrigation development result in an area expansion and based on this we found that, farmers in the study area have little experience in garlic agronomic practices, seed selection and storage in general. Even farmers do not make special arrangement of location, farm isolation or other agronomic practices for seed production, no more differences among crop production and seed production.

## 4.2 Participatory varietal evaluation

### 4.2.1 On-farm performance of the varieties: Researcher assessment

#### 4.2.1.1 Variation in phenological traits

**Emergence success:** Emergence success of all the tested varieties was above 90% (Table-5).

The highest emergence success was recorded with the local garlic variety (96%) and the lowest (90.25%) with the improved variety G-99-2. The local variety has better adaptation in the target area, whereas the improved variety G-99-2 shows less adaptation. In agreement with this study Dickerson and Wall (1993) reported that there was significant difference among 9 cultivars of garlic in emergence success in New Mexico.

**Table 5- Emergence success of different garlic varieties in Tegahne irrigate site, Golgol Naele, Atsbi womberta wereda (2008).**

Treatment	Emergence success (%)
Local	96.00a
G-99-2	90.25c
Bisheftu Netch	93.50ab
G-161-2	94.25ab
Tseday 92	92.25bc
Mean	93.25
SE	1.48
LSD 5%	3.23
CV (%)	2.2

**Days to maturity:** Days to maturity is presented in Table-6. The local variety was found relatively late maturing variety (140 days) as compare to others. G-99-2 was relatively early maturing variety (127 days) which was similar to G-161-2 (129 days) followed by Bisheftu netch (131 days) and Tsedey 92 (137 days). In agreement with this study Kotinska et al. (1990) reported that garlic accessions collected from Russia showed different morphological and agronomic characters such as days to maturity, shape, size and color of bulbs. Panthee et al. (2004) observed high variation with respect to maturity in garlic. In addition to this Mahmood, et al. (2002), from the comparative performance of garlic cultivars, reported that the cultivar ‘Italia’ took significantly longer time (216 days) to reach 50% neck fall than the rest of the cultivars, which ranged from 179-199 days.

**Table 6- Days to maturity of different garlic varieties in Tegahine irrigate site, Golgol naele, Atsbi womberta wereda (2008).**

Treatment	Days to maturity
Local	139.75a
G-99-2	127.00e
Bisheftu Netch	130.75c
G-161-2	129.00d
Tseday 92	137.25b
Mean	132.75
SE	0.401
LSD 5%	1.234
CV (%)	0.6

#### 4.2.1.2 Variation in Vegetative Growth

Analysis of variation in vegetative growth parameters of garlic varieties include plant height, leaf number, leaf length and diameter.

**Plant height:** the variation in plant height among the tested garlic varieties and the local variety is given in Table-7. The results indicated that there was a significant difference ( $p < 0.05$ ) in plant height among the tested varieties (Appendix-1). The highest plant height (55.94 cm) was recorded in variety Tsedey 92 and the lowest (45.22 cm) in the local variety. There was no statistical significance difference ( $p < 0.05$ ) in plant height among the improved varieties. Plant height greater than 50cm was recorded for all the tested varieties, except the local variety.

In line with this study, Getachew and Asfaw (2000) reported that there was significant difference among 17 cultivars of garlic in plant height in 1995 rainy and 1996 dry seasons (under irrigation) at Debre Zeit. Korla et al. (1981) reported highly significance difference in plant height among garlic accessions in India. Similarly Kassahun (2006) also reported that there was a significant difference in plant height among the tested garlic accessions at Chilga, North Gondar. In addition to this Panthee et al. (2004) observed high variation with respect to plant height in garlic.

**Leaf number per plant:** The photosynthetic material synthesized in the leaves primarily flow down to the root zone for bulb formation. Hence, the number of leaves is one of the most important measures of the plant vigor. The number of leaves per plant differed significantly ( $p<0.05$ ) among the tested garlic varieties (Table-7 and Appendix-1). The maximum number of leaves (6.5 leaves/plant) was found in the improved variety Bisheftu Netch. The significantly lowest number of leaves (4.75 leaves/plant) was recorded in the Rie local. There was also significant variation ( $p<0.05$ ) in leaf number among the improved garlic varieties: variety G-161-2 showed the lowest (5.46 leaves/plant) which was similar with G-99-2 (5.48 leaves/plant).

Nehra et al. (1988), and Bhatia and Panday (1991), also reported that leaf number is directly related to varietal characteristics. In agreement with this study, Korla et al. (1981) reported high significance difference in leaf number among garlic accessions in India. Similar to this Kassahun (2006) also reported that a significant leaf number difference among garlic accessions at Chilga, North Gondar.

**Table 7- Plant Height (cm) and leaf number (leaves/ plant) of different garlic varieties in Tegahne irrigate site, Golgol Naele, Atsbi womberta wereda (2008).**

Treatment	Plant height	Leaf number per plant
Local	45.22b	4.75c
G-99-2	50.26ab	5.48bc
Bisheftu Netch	54.58a	6.50a
G-161-2	50.44ab	5.46bc
Tseday 92	55.94 a	5.73ab
Mean	51.29	5.58
SE	2.205	0.30
LSD 5%	6.793	0.924
CV (%)	8.6	10.7

**Leaf length and diameter:** Leaf is a food manufacturing factory. Leaf diameter is directly related with photosynthesis as it provides more area for photosynthetic activity which consequently affects the yield. The tested varieties showed significant variation ( $p < 0.05$ ) with respect to leaf length and diameter (Table-8 and Appendix-2). The highest leaf length (30.74 cm) and diameter (1.525 cm) was recorded in the improved variety Tseday 92 and the lowest leaf length (26.07 cm) and diameter (1.224 cm) was found in the local garlic variety. There was no significant difference ( $p < 0.05$ ) in leaf length among the improved garlic varieties. But, in leaf diameter, G-161-2 showed the lowest leaf diameter (1.295 cm) among the tested improved garlic varieties. In harmony with this study, Baghalian et al. (2005) reported significant difference in leaf width and leaf length in Iranian garlic.

**Table 8- Leaf length (cm) and leaf diameter (cm) of different garlic varieties in Tegahne irrigate site, Golgol Naele, Atsbi womberta wereda (2008).**

Treatment	Leaf length	Leaf diameter
Local	26.07b	1.224b
G-99-2	29.44a	1.363ab
Bisheftu Netch	28.16ab	1.517a
G-161-2	29.75a	1.295b
Tseday 92	30.74a	1.525a
Mean	28.83	1.385
SE	0.895	0.055
LSD 5%	2.757	0.17
CV (%)	6.2	8.0

#### 4.2.1.3 Variation in Yield and Yield Components

Yield and yield components considered in this study were bulb yield, bulb weight (total and average) and clove (number, weight, and diameter).

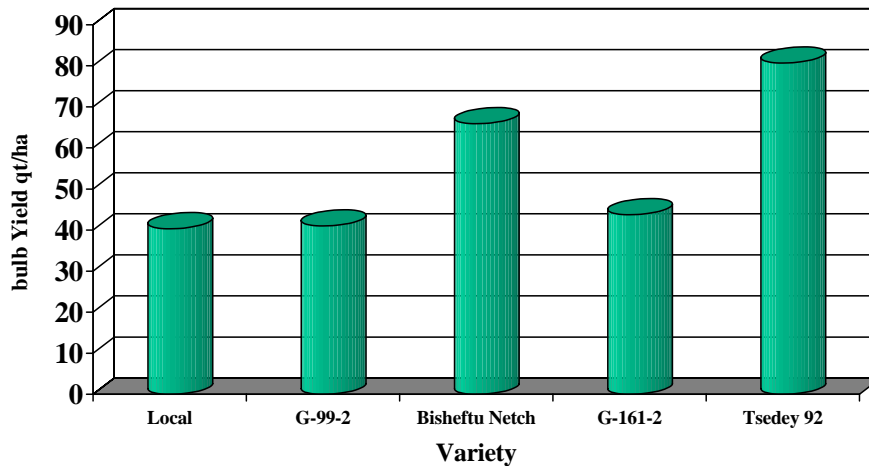
##### **Bulb yield**

A perusal of the average bulb yield per hectare indicated that garlic varieties differed significantly ( $p < 0.05$ ) in producing bulb yield (Table-9 and Figure-10). The highest bulb yield (80.67 qt/ha) was harvested from Tsedey 92 whereas the lowest (40.32 qt/ha) was recorded in the local garlic variety. There was also a significant difference among the improved garlic varieties, G-99-2 variety gave the lowest (41.0 qt/ha) which was similar with G-161-2 variety (43.72 qt/ha). Tsedey 92 gave 100% higher bulb yield as compared to G-99-2 and local variety, indicating that there is a room to improve the garlic bulb yield in the area using the varietal options.

In line with this study, Getachew and Asfaw (2000) reported that there was significant difference among 17 cultivars of garlic in bulb yield per hectare in 1995 rainy and 1996 dry seasons (under irrigation) at Debre Zeit. Korla et al. (1981) reported a highly significance yield difference among garlic accessions in India. Similar to this finding, Kassahun (2006) reported a significant variation among the difference garlic accessions tested at Chilga, North Gondar, Ethiopia. In harmony with this study, Panthee et al. (2004) observed high variation with respect to yield and bulb weight in garlic.

**Table 9 – Cured (sun dried) bulb yield (qt/ha) of different garlic varieties in Tegahne irrigate site, Golgol Naele, Atsbi Womberta wereda (2008).**

Treatment	Yield (q/ha)
Local	40.32b
G-99-2	41.0b
Bisheftu Netch	65.90a
G-161-2	43.72b
Tsedey 92	80.67a
Mean	54.30
SE	5.9
LSD 5%	18.1
CV(%)	21.6



**Figure 8- Variation in Cured (sun dried) bulb yield (qt/ha) of tested garlic varieties**

### **Bulb weight**

There was a significant variation ( $p < 0.05$ ) in total bulb weight and mean bulb weight among the tested varieties (Table-10 and Appendix-3). Tsedey 92 gave the highest total bulb weight (312.78 g) followed by Bisheftu Netch. Similar trend also recorded for mean bulb weight. Local variety showed the lowest total bulb weight (147.95 g) and mean bulb weight (12.33 g). Varieties G-99-2 and G-161-2 were not significantly different from the local variety both in

their total bulb weight or mean bulb weight. In harmony with this study, Panthee et al. (2004) observed high variation with respect to bulb weight, bulb diameter, yield, in garlic.

**Table 10 - Total bulb weight (g) and mean bulb weight (g) of different garlic varieties in Tegahne irrigate site, Golgol Naele, Atsbi womberta wereda (2008)**

Treatment	Total bulb weight	Mean bulb weight
Local	147.95c	12.33c
G-99-2	156.37c	13.03c
Bisheftu Netch	249.00b	20.75b
G-161-2	168.99c	14.08c
Tseday 92	312.78a	26.07a
Mean	207.20	17.25
SE	11.47	0.96
LSD 5%	35.35	2.95
CV(%)	11.08	11.08

### **Clove weight, number and diameter**

**Mean clove weight:** There was a significant variation ( $p < 0.05$ ) in mean clove weight among the tested varieties (Table-11 and Appendix-4). The highest mean clove weight (2.73 g) was recorded Tseday 92 whereas the lowest (1.11 g) was recorded in G-99-2.

**Clove number:** Variation in clove number per bulb was not significant among the tested garlic varieties (Table-11). However, the highest clove number (12.25 cloves/bulb) was observed in G-99-2 and the lowest (9.5 cloves/bulb) was recorded in Tseday 92. In contrast to this result, Figliuolo et al. (2001) and Panthee et al. (2004) reported highly significant difference with respect to cloves per bulb.

**Clove diameter:** There was a significant variation ( $p < 0.05$ ) in clove diameter among the tested varieties (Table-11). The highest mean clove weight (1.54 cm) was recorded in the improved variety Tsedey 92 and the lowest (1.17 cm) was recorded in the improved variety G-99-2. In line with this study, Figliuolo et al. (2001) and Panthee et al. (2004) reported highly significant difference with respect to clove diameter and weight of cloves.

**Table 11 - Mean clove weight (g), clove number (cloves/ bulb), and clove diameter (cm) of different garlic varieties in Tegahne irrigate site, Golgol Naele, Atsbi womberta wereda (2008)**

Treatment	Mean clove weight	Clove number	Clove diameter
Local	1.18d	10.50ab	1.21b
G-99-2	1.11d	12.25a	1.17b
Bisheftu Netch	2.19b	9.75b	1.49a
G-161-2	1.40c	10.25b	1.25b
Tseday 92	2.73a	9.50b	1.54a
Mean	1.71	10.45	1.33
SE	0.06	0.641	0.06
LSD 5%	0.19	1.974	0.17
CV(%)	7.7	14.13	8.31

#### 4.2.1.4 Variation in marketable and unmarketable yield of cloves

**Clove Size Category:** Weight based clove grades were used to assess the market quality of cloves for tested garlic varieties. There are no grade standards for garlic crop in Ethiopia. Nevertheless, from experience it can be argued that size grade category is more of specific attribute for a cultivar. In this study, the clove size category based on marketable and

unmarketable were explained as follows: Very large clove (> 2.5 g), large clove (2.0 – 2.5 g), medium clove (1.5 – 1.99 g), small clove (1.0 – 1.49 g) and very small clove (< 1.0 g).

**Very large clove:** The data revealed that the varieties were variable in their expression for the trait very large clove (Table-12, Figure-11 and Appendix-6). The highest record for very large clove (168.1 g/plot) was from Tsedey 92 and the lowest (9.93 g/plot) was from local variety. There was also significant variation ( $p < 0.05$ ) in very large clove among the improved garlic varieties. Variety G-99-2 showed the lowest (10.75 g/plot). Very large clove is directly related with yield potential and market advantage, when the clove size increase bulb yield also increase and it has better market preference. In harmony with this study Dickerson and Wall (1993) reported that there was significant difference among 9 cultivars of garlic in clove weight in New Mexico.

**Large clove:** There was a significant variation ( $p < 0.05$ ) in large clove category among the tested varieties (Table-12, Figure-11 and Appendix-6). The highest record for large clove, 108.17 g/plot was from Tsedey 92 and the lowest, 20.12 g/plot was from the improved variety G-99-2. Similar to very large clove this has also direct relation with yield potential and market advantage, when the clove size increase bulb yield also increase and it has better market preference. In harmony with this study Dickerson and Wall (1993) reported that there was significant difference among 9 cultivars of garlic in clove weight in New Mexico.

**Medium clove:** The tested varieties showed significant variation ( $p < 0.05$ ) with respect to medium clove category (Table-12, Figure-11 and Appendix-6). The highest record for medium clove, 65.54 g/plot was from Bisheftu Netch and the lowest, 25.52 g/plot was recorded in the improved variety Tsedey 92. In harmony with this study Dickerson and Wall (1993) reported that there was significant difference among 9 cultivars of garlic in clove weight in New Mexico.

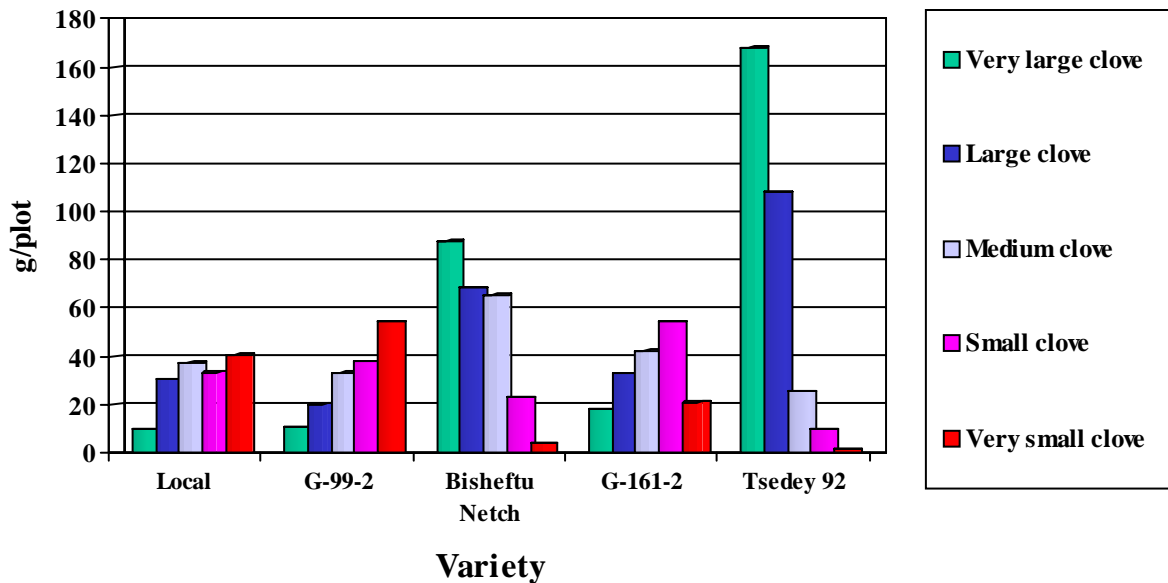
**Small clove:** There was a significant variation ( $p < 0.05$ ) in small clove category among the tested varieties (Table-12, Figure-11 and Appendix-6). The highest record for small clove (54.52 g/plot) was from G-161-2 and the lowest, 9.68 g/plot was in Tsedey 92. Small clove has negative relation with yield and market preference, when the clove size increase bulb yield decrease and it has less market preference. In harmony with this study Dickerson and Wall (1993) reported that there was significant difference among 9 cultivars of garlic in clove weight in New Mexico.

**Very small clove:** The tested varieties showed significant variation ( $p < 0.05$ ) with respect to very small clove category (Table-12, Figure-11 and Appendix-6). The highest record for very small clove (54.51 g/plot) was found in the improved variety G-99-2 and the lowest (1.31 g/plot) was recorded in the improved variety Tsedey 92. Similar to small clove this has also indirect relation with yield potential and market advantage, when the clove size increase bulb yield decrease and it has less market preference. In harmony with this study Dickerson and Wall (1993)

reported that there was significant difference among 9 cultivars of garlic in clove weight in New Mexico.

**Table 12 - Clove size categories (g/plot) of different garlic varieties in Tegahne irrigate site, Golgol Naele, Atsbi womberta wereda (2008)**

Treatment	Very large clove	Large clove	Medium clove	Small clove	Very small clove
Local	9.93c	26.55cd	37.4bc	33.39ab	40.69b
G-99-2	10.75c	20.12d	33.20bc	37.8ab	54.51a
Bisheftu Netch	87.9b	68.48b	65.54a	23.21bc	3.88d
G-161-2	18.21c	32.92c	42.33b	54.52a	21.01c
Tsedey 92	168.1a	108.17a	25.51c	9.68c	1.31d
Mean	59.00	51.20	40.80	31.70	24.30
SE	6.97	3.69	3.95	7.27	2.71
LSD 5%	21.47	11.38	12.17	22.39	8.35
CV(%)	23.63	14.4	19.40	45.8	22.30

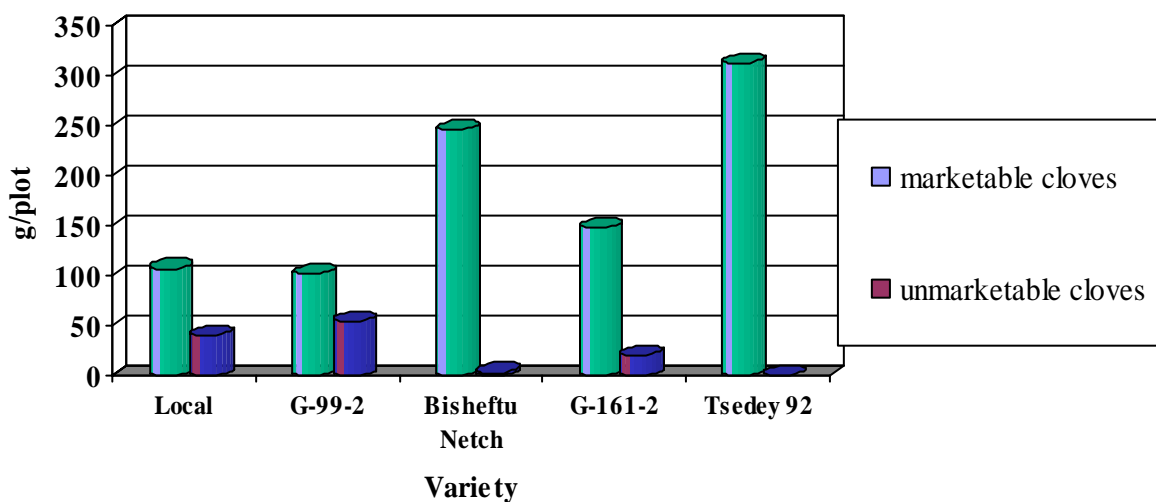


**Figure 9-Clove size categories (g/plot) of tested garlic varieties**

**Marketable and unmarketable cloves-** The varieties expressed significant difference in their both marketable and unmarketable clove (Table-13 and Figure-12). Tseyey 92 was the best variety yielding the highest marketable clove (311.5 g/plot) and the lowest unmarketable clove (1.3 g/plot) in the trial. The local variety and G-99-2 were inferior in their marketable clove yield and the highest unmarketable clove yield recorded by these two varieties, in general Tseyey 92 and Bisheftu Netch were fantastic in their marketable clove yield. This is the summary of the clove size category and marketable clove has direct relation with yield potential and market advantage, when the marketable clove increase bulb yield also increase and it has better market preference whereas the unmarketable clove, it has negative relation with yield and market preference, when the unmarketable clove increase bulb yield decrease and it has less market preference. In harmony with this study Dickerson and Wall (1993) reported that there was significant difference among 9 cultivars of garlic in clove weight in New Mexico.

**Table 13 - marketable (g) and unmarketable (g) cloves of tested varieties in Tegahine irrigate site, Golgol naele, Atsbi womberta wereda (2008)**

<i>Treatment</i>	<i>Marketable</i>	<i>Unmarketable</i>
Local	107.3	40.7
G-99-2	101.9	54.5
Bisheftu Netch	245.1	3.9
G-161-2	148.0	21.0
Tseyey 92	311.5	1.3
Mean	182.70	24.30
SE	11.79	2.71
LSD 5%	36.33	8.35
CV (%)	12.9	22.3



**Figure 10- marketable (g) and unmarketable (g) cloves of tested varieties in Tegahine irrigate site, Golgol naele, Atsbi womberta wereda (2008)**

#### 4.2.1.5 Relationships between vegetative and yield parameters

Correlations among yield and yield components and other growth parameters help in understanding the interdependence of the parameters. The data (Table-14) indicated that there was a significant correlation among the vegetative growth and yield parameters of garlic.

**Table 14 - Simple correlation coefficient(r) for vegetative and yield parameters of garlic**

	PH	NLPP	LL	LD	TBW	MCW	CD	LC	MC	SC	MarCW
NLPP	0.483*										
LL	0.775**	0.428									
LD	0.792**	0.554*	0.568**								
TBW	0.611**	0.475*	0.404	0.728**							
MCW	0.566**	0.364	0.310	0.663**	0.948**						
CD	0.674**	0.585**	0.505*	0.724**	0.827**	0.822**					
LC	0.550**	0.402	0.373	0.677**	0.968**	0.978**	0.832**				
MC	0.050	0.309	-0.198	0.098	0.046	0.049	0.109	-0.092			
SC	-0.467*	-0.340	-0.177	-0.530*	-0.799**	-0.931**	-0.781**	-0.893**	-0.084		
MarCW	0.599**	0.463*	0.373	0.705**	0.988**	0.972**	0.834**	0.966**	0.111	-0.846**	
Y/ha	0.708**	0.569**	0.506*	0.784**	0.917**	0.838**	0.880**	0.880**	0.044	-0.711**	0.899**

❖ Correlation is significant at  $p < 0.05$ .

❖ PH: Plant height, NLPP: Number of leaf per plant, LL: Leaf length, LD: Leaf diameter, TBW: Total bulb weight, MCW: Mean clove weight, CD: Clove diameter, LC: Large clove, MC: Medium clove, SC: small clove, MarCW: Marketable clove weight and Y/ha: Yield per hectare.

Bulb yield per hectare showed positive and significant correlation with plant height, number of leaves per plant, leaf length, leaf diameter, total bulb weight, weight of clove, clove diameter, large clove category and marketable clove weight except with medium clove category, and negative and significant correlation with small clove category (Table-16). The increment in bulb yield was a result of increase in plant height, number of leaves per plant, leaf length and leaf diameter, which led to relatively giant plant morphology.

Plant height showed a positive and significant correlation with number of leaves per plant, leaf length, leaf diameter, total bulb weight, bulb yield per hectare, weight of clove, clove

diameter, large clove category and marketable clove weight except with medium clove category, and negative and significant correlation with small clove category. In harmony with this study, Korla et al. (1981) reported that plant height was positively and significantly correlated with weight of bulb and bulb diameter. Plant height also showed a positive and significant genotypic relationship with number of leaves per plant and it was positively and significantly correlated with leaf length that obviously led to increment in photosynthetic area that might have partly contributed to increment in yield of bulb per plant.

Number of leaves per plant indicated positive and significant correlation with leaf diameter, total bulb weight, bulb yield per hectare, clove diameter and marketable clove weight. The positive and significant correlation of number of leaves per plant with such parameters indicated the paramount contribution for bulb yield in garlic. This is in agreement with the work of Badshah and Umar (1999), who have reported positive correlation between leaf number and yield in garlic.

Leaf diameter was positively and significantly correlated with plant height, number of leaves per plant, total bulb weight, bulb yield per hectare, weight of clove, clove diameter, large clove category and marketable clove weight except with leaf length, and negative and significant correlation with small clove category. Leaf diameter is directly related with photosynthesis as it provides more area for photosynthetic activity which consequently affects the yield. Leaf length was positively and significantly correlated with leaf diameter, bulb yield per hectare and clove diameter, but it was none correlated with number of leaves per plant,

total bulb weight, weight of clove and marketable clove weight. In this study, it seems leaf length showed less effect in garlic yield compare to the other morphological parameters.

#### 4.2.2 On-farm performance of the varieties: Farmers' assessment

Farmers' participatory varietal evaluation has indicated preferred plant characteristics (Table-15) and preferred varieties (Table-16 and 17). Farmers were most interested in some of the parameters such as bulb yield, earliness, and overall appearance (vigorousness of the varieties, bulb size and bulb colour). Among the criteria mentioned by farmers, bulb yield and bulb size scored the highest responses. Bulb yield was the overriding selection criterion mentioned by farmers. During the focus group discussion, farmers confirmed that all other selection criteria are considered only after their choice of bulb yield is fulfilled followed by bulb size.

During the evaluation, farmers indicated that their preference coincide with researchers selection criteria for bulb yield. However, in most cases farmers have expressed their relevant traits like culinary properties, aesthetic features and colour.

We found women and men farmers had different preferences. Women farmers select for yield, culinary properties and aesthetic features such as colour and brightness while men inclined for bulb yield and size.

**Table 15 - Pair- wise ranking of farmers selection traits in Tegahine irrigate site, Golgol naele, Atsbi womberta wereda (2008)**

(n=14)\*

<b>Criterion</b>	<b>Maturity</b>	<b>Plant height</b>	<b>Bulb size</b>	<b>Bulb colour</b>	<b>Germination</b>	<b>Total</b>	<b>Rank</b>
<b>Maturity</b>						3	3
<b>Plant height</b>	Maturity					2	4
<b>Bulb size</b>	Bulb Size	Bulb Size				4	2
<b>Bulb colour</b>	Maturity	Plant Height	Bulb Size			0	6
<b>Germination</b>	Maturity	Plant Height	Bulb Size	Germination		1	5
<b>Bulb yield</b>	Bulb Yield	Bulb Yield	Bulb Yield	Bulb Yield	Bulb Yield	5	1

- Number of participants -14

Farmers are very eager to test new varieties and are extremely critical about unproductive introduction of varieties. Generally farmers responded positively to the new varieties Tsedey 92 and Bisheftu Netch they have evaluated and the local variety showed poor performance (Table-16 and Table-17).

Farmers' overall evaluation indicated that Tsedey 92 scored higher responses followed by Bisheftu Netch, while the local variety showed poor performance. Because of time limitation, the post harvest aspects of the varieties have not been documented. However, there was an inclination of preference for local varieties for its pungent character and its active flavouring.

**Table 16- Matrix ranking garlic varieties by group of farmers in Tegahine irrigate site, Golgol naele, Atsbi womberta wereda (2008)**

(n=14)\*

Selection Criterion	Relative weighed criteria	Rie local	G-99-2	Bisheftu	G-161-2	Tseday
Bulb Yield	3	2	2	4	3	5
Bulb Size	3	2	2	4	2	5
Maturity	2	2	5	4	5	4
Bulb Colour	1	5	4	5	4	3
Plant Height	2	2	3	5	3	5
Germination	2	4	4	5	4	5

- \* Number of participants -14

- Rating of the performance of a variety for a criteria: 5= very good, 4= good, 3= average, 2= poor and 1 = very poor.

- Rating of the importance of a criteria 3= very important, 2 = important, 1 = somewhat important.

As it has been demonstrated by farmers a new and promising varieties were identified using the participatory varietal evaluation methodology and this method contributed a lot to facilitate variety selection based on farmers' preference and created access for the communities to improved garlic varieties.

**Table 17 - Pair wise ranking garlic varieties by group of Farmers in Tegahine irrigate site, Golgol naele, Atsbi womberta woreda (2008).**

(n=14)\*

Variety	Rie local	G-99-2	Bisheftu Netch	G-161-2	Total	Rank
<b>Rie local</b>					0	5
<b>G-99-2</b>	G-99-2				1	4
<b>Bisheftu Netch</b>	Bisheftu	Bisheftu			3	2
<b>G-161-2</b>	G-161-2	G-161-2	Bisheftu		2	3
<b>Tseday 92</b>	Tseday	Tseday	Tseday	Tseday	4	1

\* Number of participants -14

## 4.3 Farmer-based seed production

### 4.3.1 Farmers Reflection

Seed producer and other farmers in the study area expressed their impression how the farmer-based seed production scheme is efficient in improving garlic seed availability and access of farmers in a short period of time. Seed producer farmers also expressed that they have secured garlic seed material for the next season from the seed production intervention and they developed knowledge and skill about garlic seed production.

Based on the outcome of the field day discussion on the demand side farmers showed a strong demand for garlic and on the supply side farmers showed clearly the presence of gap in garlic seed supply which is no formal seed system for garlic and the informal seed system is dominant but responsible only for the maintenance of existing varieties.

The existing garlic varieties in the locality have lower yield, small bulb size and poor quality; as a result they have lower return. Farmers have also lack of knowledge in garlic seed production; the existing experience in seed production is similar to the crop production.

Although, seed producer farmers have such benefit and perception in the first year seed production intervention, to scale up with in the study area as a whole in a sustainable way some measures should be taken to solve the major constraints. So to succeed farmer-based seed production and to solve the major constraints in garlic seed production suggested protocols are given below.

### 4.3.2 Suggested Protocol for Effective On-Farm Garlic Seed Production

Farmer-based garlic seed production has a wide range of objectives including improved dissemination of modern garlic varieties, preserving genetic diversity and quality, improving seed availability (time, place, and quantity), and reducing the cost of seed and dependence on external sources. Promoting these activities is challenging and no single approach or model exists for success. Key elements needed to ensure the successful development of farmers-based garlic seed production includes:

#### 4.3.2.1 Search for Garlic Varieties

Selection of well-adapted and farmer-preferred varieties is the first step in the production of garlic seed and such range of superior varieties (from farmers' perspective characteristics like bulb yield, bulb size and marketability) should be regularly available. Apart from its adaptation, the variety should have high yield potential, tolerance to biotic and abiotic stresses and have good marketability and consumer preferences. Unless the variety meets the requirements of farmers and consumers, it is less likely to be widely adopted and, therefore, the demand for seed can be addressed.

#### 4.3.2.2 Creating strong institutional support to develop farmers' capacity for seed production

To improve crop management, seed producers may also require close and regular field supervision by technical support staff for an initial period. Supporting seed production efforts by farmers requires technical and business-related expertise and Collaborative linkages need to be fostered among farmers, researchers, agro-enterprise specialists, NGOs, and the formal seed industry. Seed policy reforms need implementing more client-oriented research systems, this gives a chance to farmer seed producers to involved in participatory varietal selection with plant breeders or offer feedback on newly released varieties.

Farmer based seed production and marketing schemes need access to credit for purchasing field equipment, inputs (e.g. source seed, fertilizers and pesticides) and seed-handling equipment (e.g. for cleaning, treatment, and packaging). Encouraging them to work towards an annual business plan based on demand-led production is critical to the development of sustainable, financially profitable seed production and marketing scheme.

Farmers require step-by-step training in technical skills (for planting, harvesting, cleaning, treatment, testing and storage), financial and enterprise management skills (for the day-to-day operation of seed enterprises, record keeping, developing business plans). Farmers are assisted in establishing a network to link up with input providers, and facilitate information exchange and sharing of experiences. Linkages between

grain producers and local agro-processing industries stimulate the use of better technology, creating demand for the use of quality seed.

#### 4.3.2.3 A Flexible Quality Control System

Farmer-based seed production and marketing schemes are operating at local level to ensure availability and access to varieties and seeds by farmers in less favourable environments and remote areas. The quality of the seed produced meets relevant quality standards, which are those appropriate to farmer requirements, and does not necessarily meet formal standards of garlic seed (purity > 97%, sprout > 90% and isolation 20-30 meters minimum). Appropriate low-cost cleaning and treatment technology is used for production, processing and storage, resulting in improved seed quality.

#### 4.4 Process Impact of Participatory Varietal Evaluation and Farmer Based Seed Production

It is difficult to assess the impact of the research and development components with one year. However the appreciation of the farmers and their decision to grow garlic is considered part of the demand for it. So here below the process impact of the interventions is presented.

The process impact of garlic participatory varietal evaluation and farmer based seed production ranges from knowledge and skills enhancement to improved availability and access to garlic seed varieties.

Farmers have selected two promising garlic varieties through the PVE approach. Agroclimatic, edaphic and economic conditions in garlic production systems are highly variable and potentially promising new garlic varieties brought directly to farmers without going through multi-year, multi-locational trials. Such small research and extension system speed up the flow of improved garlic varieties to farmers because of farmers evaluated under their production conditions what researchers have developed elsewhere.

The seed production had also a positive impact on the producers in the areas of financial improvement and empowerment. With in the same season, during the introduction of farmer based seed production scheme, participant seed producers expressed their satisfaction with the intervention, and they harvested cured bulb yield ranged from 18 kg to 53 kg per 100 m<sup>2</sup> plot area (Table- 18). The harvested produce was not as much as a higher yield but participant seed growers were secured their garlic seed material for the limited irrigated land they have in the next season.

In the next season all participant seed producers were covered their irrigated land using the garlic seed material that was harvested under the farmer based seed production scheme. The area covered ranges from 56 m<sup>2</sup> to 138 m<sup>2</sup>. Ato Fitsum Atsbiha, one of the

ten farmers, has harvested 82 kg fresh garlic bulb yield per 86.2 m<sup>2</sup> plot area. As garlic loss 20% moisture during curing, this fresh garlic bulb yield gives 65.6 kg cured garlic bulb yield which is 76.1 qt/ha cured garlic bulb yield.

In other peasant associations (PAs), 72 farmers who visited the farmer based seed production plots at the filed day, a total of 13 farmers (from Hadnet 7 farmers, Felege Weini 3 farmers, Gebre kidan 2 farmers, and Ruba Feleg 1 farmer ) planted their irrigated land using garlic seed. Others they were very interested to plant garlic, but there was garlic seed shortage.

**Table 18– Cured garlic bulb yield (kg per hectare) at Tegahine irrigate site, Golgol naele, Atsbi womberta wereda (2008).**

SEED GROWERS	BULB YIELD (KG/ 100 M <sup>2</sup> )	REMARK
Ato Halefom Abrha	33	
Ato Hailemariam Hibom	53	
Ato G/micael W/hawariat	21	post emergence management problems
Ato Kiros W/hawariat	29	
Ato Fitsum Atsbiha	25	
Ato Niguse Berihu	26	
Ato Birhane Mezgebo	53	
W/ro Tsehaytu Nireyo	28	
Priest Abrha G/jiworgies	26	
Ato Mehari Kidane	18	Germination failure and post emergence management problems

#### 4.5. Lessons learnt

Farmer-based seed production and participatory variety evaluation are two research and extension methodologies. Participatory variety evaluation preceded the farmer based garlic seed production; this process gave farmers a chance to increase the availability of seeds of the varieties of their choice, which were often site specific.

Farmer-based seed production system is a learning by doing approach, shows farmers how to produce better seeds for their own use and to exchange or to sell excess to other farmers, it shortens the time for seed to reach to farmers. Farmer based seed production could bring a number of economic benefits, both to seed producers and to seed purchasers.

Engaging partner organizations in the decentralized seed production reduced the costs of dissemination and the work load of researchers. The time lag between variety release and farmers having access to its seeds was reduced considerably.

# CHAPTER V. CONCLUSIONS AND RECOMMENDATIONS

## 5.1 Conclusions

Considering the results of PVE of garlic and farmers overall preference Tseday 92 followed by Bisheftu Netch were found the most promising varieties for yield and bulb size of garlic. The local variety was poor performing variety for various agronomic traits, how ever it was found to be preferred for its pungency and flavour and further breeding works.

Significant differences ( $p < 0.05$ ) among varieties were recorded for plant height, number of leaves per plant, leaf length, leaf diameter, total bulb weight, bulb yield per hectare, clove diameter, weight of clove, clove categories, marketable and unmarketable clove, emergence success and days to maturity.

Garlic varieties differed significantly ( $p < 0.05$ ) in producing bulb yield, the highest bulb yield (80.67 qt/ha) was obtained from Tsedey 92. This variety performed 100% better than G-99-2 and the local variety, indicating that there is a room to improve the garlic bulb yield in Atsbi Womberta using the varietal options. Weight based grade to assess the market quality of cloves showed that Tsedey 92 recorded the highest very large marketable clove (168.1 g/plot) and large clove (108.17 g/plot) which indicates preferable market value. G-99-2 was found early maturing variety (127 days) as compare to rest of varieties. The local garlic variety was a late maturing variety requiring 140 days to reach physiological maturity. G-99-2 might be suitable for rainfed areas.

Bulb yield per hectare showed positive and significant correlation with all parameters except with medium and small clove categories. This suggested that the increment in bulb yield was a result of increase in leaf diameter, plant height, number of leaves per plant and leaf length, which led to relatively giant plant morphology.

Leaf diameter was positively and significantly correlated with total bulb weight, bulb yield per hectare, clove diameter, large clove size category and marketable cloves. On the other hand leaf diameter negatively and significantly correlate with small clove category. Indicating that leaf diameter had a significant influence on clove category. Leaf diameter is directly related with photosynthesis as it provides more area for photosynthetic activity which consequently affects the yield. In this study, it seems leaf length showed less effect in garlic yield compare to the other morphological parameters (Leaf diameter, plant height, number of leaves per plant).

The results of farmers' preference showed that women and men farmers have different preferences. Women farmers select for yield, culinary properties and aesthetic features such as colour and brightness, while men indicated a preference for bulb yield and size. Among the criteria mentioned by farmers during the interview, bulb yield and bulb size scored the highest responses and bulb yield was the overriding selection criterion mentioned by farmers. Promising varieties were identified using the participatory variety selection and this method contributed a lot to facilitate variety selection based on farmer's preference. Farmers' overall evaluation indicated that Tseday 92 followed by Bisheftu Netch was found the most promising varieties for yield and bulb size of garlic. The local variety was poor performing variety for

various agronomic traits, however it was found to be preferred for its pungency and flavour and further breeding works.

According to the survey results and information from focus group discussion the formal seed system is unable to provide improved garlic varieties and none of the improved varieties are popular among farmers in the study area, as a result farmers remain associated with locally produced seed and their local variety. Garlic seed supply at the study area is dominated by the informal seed system. In 2007, 37% of households purchased their garlic planting seed from local market, 20% obtained seed from farm saved seed and 13% obtained seed from exchange with relatives, neighbours or friends. These channels contribute only about 70 % of garlic seed supply in the locality.

Several important lessons have been learned through the community based seed production. Seed producers have understood and applied the principles and procedures for growing garlic for seed. They also demonstrated how garlic seed production monitored strictly throughout the entire crop growth period, from planting through to harvesting, and storage.

Based on the result reported here, it can be concluded that, the experiments have shown that participatory variety selection is a viable method for identifying growers' preferences, limitation and the potential of varieties. Community based garlic seed production is also viable and hold potential for improving the availability and accessibility of improved garlic varieties.

## 5.2 Recommendations

- ◆ Tsedey 92 and Bisheftu Netch garlic varieties can be recommended to the target area.
- ◆ Participatory variety evaluation is an entry point to farmer based seed production. Linking this participatory approach with informal distribution methods to enhance the availability of and access to seed of varieties that farmers want is crucial.
- ◆ Since farmers know some of the unique situations on their farms better than researchers and farmers usually judge a variety according to their own criteria, in line with their policy of risk avoidance, the potential of making research partnership with farmers to achieve quicker development and adoption of appropriate technologies should be given utmost importance.

## REFERENCE

- Assefa, A. 2005. Farm management in mixed crop-livestock systems in the north highlands of Ethiopia. Tropical resource management paper, ISSN 0926-9495. Wageningen University and Research Center. Wageningen , The Netherlands
- ATTRA, 2001. Organic Garlic production, <http://attar.Org/attar-pub/.htm>
- Badshah, N., and K. Umar, 1999. Evaluation of garlic (*Allium sativum*) cultivars grown under the agro climatic conditions of Peshawar valley, Pakistan. *Sarhad J. of Agric. (Pakistan)*. 15(15):431-436.
- Baghalian, K., M.R. Naghari, S.A. Ziai, and H.M. Badi. 2005. Post planting evaluation of morphological characters and allicin content in Iranian garlic (*Allium sativum* L.) ecotypes. *Scientia Horticulture* 107 (4): 405-410.
- Belay Simane. 2002. The national seed industry policy and strategy: current status of sorghum and millets. Paper presented at the 1st sorghum and millet national workshop held at Melkassa Agricultural Research Center. October 12 -14, 2002.
- Bellon, M.R., and J. Reeves (eds.). 2002. Quantitative Analysis of Data from Participatory Methods in Plant Breeding. Mexico, DF: CIMMYT.
- Bhatia, A. K. and Pandey, U. C. 1991. Effect of planting methods, fertility levels and spacing on seed production of Kharif onion. *Res. and development Rep.*, 8: 10-16.
- Bishaw, Z., and A.J.T. van Gastel. 2008. ICARDA's approach to seed delivery in less favorable areas through village-based seed enterprises: conceptual and organizational issues. *Journal of New Seed*, in press.
- Bishaw, Z., Yonas, S. and Belay S., 2008. The status of the Ethiopian seed industry. In:

- Thijssen, M.H., Z. Bishaw, A. Beshir and W.S. de Boef, 2008 (Eds.). Farmers, seeds and varieties: supporting informal seed supply in Ethiopia. Wageningen, Wageningen International. 348 p.
- Bishaw, Z., Van Gastel, A., Niane, A. and Amegbeto, K. 2008. Village-based seed enterprises in Afghanistan. In: Thijssen, M.H., Z. Bishaw, A. Beshir and W.S. de Boef, 2008 (Eds.). Farmers, seeds and varieties: supporting informal seed supply in Ethiopia. Wageningen, Wageningen International. 348 p.
- BoARD (Bureau of Agriculture and Rural Development). 2004. Annual report for 2003/2004. Mekelle.
- BoARD (Bureau of Agriculture and Rural Development). 2007. Annual report for 2003/2004. Mekelle.
- Brewster, J.L. 1994. Onions and Other Vegetable Alliums. CABI publishing, Wellesbourne, UK. 236p.
- Brewster, J.L 1997. Onions and Garlic. The physiology of vegetable crops CAB international, Wallingford, UK. pp. 581-619.
- Dawit, A. and David. J. S. 2006. The Ethiopian Seed System: Regulations, Institutions and Stakeholders Paper submitted for ESSP Policy Conference 2006 “Bridging, Balancing, and Scaling up: Advancing the Rural Growth Agenda in Ethiopia”, Addis Ababa, Ethiopia.
- De Boef, W.S., and M.H. Thijssen. 2006. Participatory tools working with crops, varieties and seeds. A guide for professionals applying participatory approaches in agro biodiversity management, plant breeding and seed sector development. Wageningen, Wageningen International, 29 pp.

- Dickerson, G.W. and Wall M. 1993. Varietal Evaluation of Garlic in New Mexico: Agricultural Experiment Station Research Report 717. College of Agriculture and Home Economics
- Dickerson, G.W. 1999. Garlic production in New Mexico. College of agriculture and home economics. New Mexico State University.
- Engeland, R.L. 1991. Growing great Garlic: the definitive Guide for Organic Gardners and small farmers. Filaree farms, Okanogan, WA. ISBN# 0-9630850-1-8. 226p.
- ESE (Ethiopian Seed Enterprise). 2000. Annual report. Ethiopian Seed Enterprise. Addis Ababa.
- Etoh, T. and P.W. Simon, 2002. Diversity, Fertility and Seed Production in Garlic. pp.101-118 In: Rabinowitch, H.D. and L.Currah (eds) Allium Crop Science: Recent Advances. CABI Publishing, Wallingford, UK.
- FAO (Food and Agriculture Organization). 1994. FAO Seed Review, 1989-90. FAO, Rome, Italy.
- FAO (Food and Agriculture Organization). 2007. Area and production of crops by countries [www.faostat.fao.org](http://www.faostat.fao.org).
- Fetien, A., and A. Bjørnstad. 2008. Participatory varietal selection of barley in the highlands of Tigray in Northern Ethiopia. In: Thijssen, M.H., Z. Bishaw, A. Beshir and W.S. de Boef, 2008 (Eds.). Farmers, seeds and varieties: supporting informal seed supply in Ethiopia. Wageningen, Wageningen International. 348 p.
- Figliuolo, G., V. Candido, G. Logozzo, and P.L.S. Zeuli. 2001. Genetic Evaluation of Cultivated garlic Germplasm. Euphytica. 121(3):325-334.
- Getachew, T., and Z. Asfaw. 2000. Research Achievements in Garlic and Shallot.

- Research Report. No. 36. Ethiopian Agricultural Research Organization, Addis Ababa. Ethiopia..
- Gomez, A.K., and A.A. Gomez. 1984. Statistical Procedures for Agricultural Research. John Willey and Sons Inc., New York. 657p.
- Janet, B. 2008. Garlic: Organic Production, [www.attra.ncat.org](http://www.attra.ncat.org).
- Jones, H.A., and Mann, L.K. 1963. Onions and their allies. Botany, cultivation, and utilization. Leonard Hill (books) limited. London, UK. 286p.
- Joshi, A., and Witcombe, J. R. 2002. Participatory varietal selection in rice in Nepal in favourable agricultural environments – A comparison of two methods assessed by varietal adoption. *Euphytica* 127:445–458.
- Kamenetsky, R., and Rabinowitch, H.D. 2001. Floral development in bolting garlic Sexual Reproduction 4: 235-241.
- Kassahun, T. 2006. Variability and Association among Bulb Yield And Yield Related Traits in Garlic (*Allium Sativum* L.). M.Sc. Thesis. Alemaya University
- Keusgen, M. 2002. Health and Alliums. pp. 357-378. In: Rabinowitch, H.D. and L. Currah (Eds.). Allium crop science: Recent advances. CAB International, Wallingford, UK.
- Kotinska, T., P. Havranek, M. Navratil, L. Girasimova, A. Pimakhov and S. Neikov, 1990. collecting onion, garlic and wild species of Allium in Central Asia, USSR. Plant Genetic Resource Newsletter. International Board for Plant Genetic Resources, Rome, No. 83/84, pp. 31-32.
- Korla, B.N., Singh, A.K., and Kalia, P. 1981. Genetic Variability in Garlic. Haryana J. Horti. Sc. 0:77-80.
- Lanteri, S., and Quagliotti, L. 1997. Problems related to seed production in the African

- region. *Euphytica* 96: 173-183.
- Larinde, M. 1996. Improving seed supply to small islands countries. Lessors from the CARICOM countries. Paper presented at the Workshop on Improved Seed Supply Strategies for Pacific Islands Countries held in Nadi Fiji.
- Lelo, F., Ayieko, J., Makenzi, P., Muhia, D., Muiriri, H., Omello, J., and Ocholo, W. 1995. Field Handbook for Participatory Rural Appraisal Practioners. The PRA Programme, Egerton University, Njoro, Kenya.
- Libner, N., 1989. vegetable production van nostrand rein hold, New York, USA, 657p.
- Linda, J.H. 1997. Garlic: safe methods to store prevent and enjoy. Department of food science and technology university of California.
- Louise, S., and H.D. Cooper. 2002. [Towards effective and sustainable seed relief activities...](#) Understanding Seed Systems and Strengthening Seed Security: A Background Paper
- Marschner, H. 1995. Mineral Nutrition of higher plants. 2<sup>nd</sup> Ed. Academic Press, London.
- McGuire, S. 2005. Getting genes: Rethinking seed system analysis and reform for sorghum in Ethiopia. PhD thesis. Wageningen, Wageningen University.
- MoARD (Ministry of Agriculture and Rural Development). 2007. Crop Variety Register. Ministry of Agriculture and Rural Development. Addis Ababa.
- Monty, J., Timoty, D., Nila, L., and Amadou. B. 2000. Participatory Varietal Selection. West Africa Rice Development Association (WARDA), 01 BP 2551, Bouake, Cote d\_Ivoire.
- Nehra, B. K., Pandita, M.L., kirti, S., and Sing, K. 1988. Cultural and nutritional studies in relation to seed production in onion. *Haryana J. Horti. Sci.*, 17: 106-110.
- Nonnecke, I.L. 1989. Vegetable Production, New York. 657p.

- Panthee, D.R., P.P. Subedi, S. Bhattarai and J. Dhakal, 2004. Diversity Analysis of Garlic (*Allium sativum*) Germplasm Available in Nepal Based Morphological Characters. *Genetic Resource and Crop Evolution J.* 53 (1):205-212.
- Pereira, J.S., and Chaves, M.M. 1993. Plant water deficits in Mediterranean ecosystems. In: water deficits: plant response from cell to communities (eds: smith, J.A.C. and Griffiths, H.). BIOS publishers. Oxford.
- Rice, R.P., Rice L.W., and Tindall, H.D. 1990. Fruits and vegetables production in warm climates. Macmillan education Ltd. Hong Kong. 486p.
- Rubatzky, V.E., and Yamaguchi, M. 1997. World vegetable. Principles, production and nutritive values. Second edition. Chapman and hall. International Thomson publishing New York. USA. 843p.
- Salomon, R. 2002. Virus diseases in garlic and the propagation of virus free planting. pp. 311-327. In: Rabinwitch, H.D. and L. Currah (Eds.). *Allium crop sciences: Recent advances*. CAB International, Wallingford, UK.
- Scowcroft, W.R. 1997. Seed security strategies for developing countries: Role in restoring food security after disaster. Position paper for FAO, Rome 43 pages.
- Setimela, P.S., E. Monyo, and M. Bänziger (eds). 2004. *Successful Community-Based Seed Production Strategies*. Mexico, D.F.: CIMMYT.
- Shawn, M. 2005. *Getting Genes: Rethinking seed system analysis and reform for sorghum in Ethiopia*. Wageningen University Thesis ISBN 90 8504 179 1
- Siegel, G., A.Walter, S.Engel, A.Walper and F. Michel, 2000. Pleiotropic Effects of Garlic. pp. 163. In: Cousins, D.T, and C.D, Aldridge (Eds.). *Review of aromatic and*

- medicinal plants. CAB Abstracts. Vol. 6:3. CAB International, Wallingford, UK.
- Sims, W. L., Davis, T. M. Little and R.E. Voss. 1976. Growing Garlic in California. UC Davis, Vegetable Research and Information Center
- Soniia, D., 2008. Farmer seed enterprises in Uganda. In Thijssen, M.H., Z. Bishaw, A. Beshir and W.S. de Boef, 2008 (Eds.). Farmers, seeds and varieties: supporting informal seed supply in Ethiopia. Wageningen, Wageningen International. 348 p.
- Thijssen, M.H., Z. Bishaw, A. Beshir and W.S. de Boef, 2008 (Eds.). Farmers, seeds and varieties: supporting informal seed supply in Ethiopia. Wageningen, Wageningen International. 348 p.
- Tindal, H.D. 1983. Vegetables in the tropics. The Macmillan press Ltd, Hong Kong. 533p.
- Tripp, R., Louwaars, N., van der Burg, W.J., Virk, D.S., and Witcombe, J.R. 1997. Alternatives for seed regulatory reform: An analysis of variety testing, variety regulation and seed quality control. AgREN Network Paper No. 69. Overseas Development Institute, London, UK
- Virk, D.S., D.N. Singh, S.C. Prasad, J.S. Gangwar, and J.R. Witcombe, 2003. Collaborative and consultative participatory plant breeding of rice for the rainfed uplands of eastern India. Euphytica 132(1): 95-10.
- Witcombe, J.R., A. Joshi, K.D. Joshi & B.R. Sthapit. 1996. Farmer participatory crop improvement. I. Varietal selection and breeding methods and their impact on biodiversity. Expl Agric 32: 445-460.
- [www.com.,2005.Gourmet](http://www.com.,2005.Gourmet). Garlic Gardens. The growing of garlic.
- [www.garlic.com](http://www.garlic.com). 2006. Dr Duke's Essential Herbs.

[www.healthnotes.com.2002](http://www.healthnotes.com.2002). inc

Yonas, S. Belay S. and Zewdie B. 2008. The farmer-based seed production and marketing scheme: lessons learnt In: Thijssen, M.H., Z. Bishaw, A. Beshir and W.S. de Boef, 2008 (Eds.). Farmers, seeds and varieties: supporting informal seed supply in Ethiopia. Wageningen, Wageningen International. 348 p.

# APPENDIX

## Appendix - 1

**Analysis of variance for plant height and leaf number traits in Tegahine irrigate site, Golgol naele, Atsbi womberta wereda (2008).**

Source	Plant height			Leaf number		
	Mean square	F	P	Mean square	F	P
Replication	54.143	2.785	0.086	3.372	9.37	0.002
Variety	71.112	3.658	0.036	1.581	4.40	0.020
Error	19.441			0.360		
$r^2$		0.66				0.79

## Appendix - 2

**Analysis of variance for leaf length and leaf diameter traits in Tegahine irrigate site, Golgol naele, Atsbi womberta wereda (2008).**

Source	Leaf length			Leaf diameter		
	Mean square	F	P	Mean square	F	P
Replication	9.783	3.06	0.07	0.007	0.58	0.64
Variety	12.92	4.04	0.027	0.072	5.89	0.007
Error	3.202			0.012		
$r^2$		0.69				0.69

### Appendix - 3

**Analysis of variance for total bulb weight and mean bulb weight traits in Tegahine irrigate site, Golgol naele, Atsbi womberta wereda (2008).**

Source	Total bulb weight			Mean bulb weight		
	Mean square	F	P	Mean square	F	P
Replication	970.86	1.844	0.193	6.742	1.844	0.193
Variety	20448.03	38.843	0.001	142.000	38.843	0.001
Error	526.43			3.656		
r <sup>2</sup>			0.93			0.93

### Appendix - 4

**Analysis of variance for mean clove weight, clove number and clove diameter traits in Tegahine irrigate site, Golgol naele, Atsbi womberta wereda (2008).**

Source	Mean clove weight			Clove number			Clove diameter		
	Mean sq.	F	P	Mean sq.	F	P	Mean sq.	F	P
Replication	0.028	1.86	0.190	2.183	1.33	0.331	0.041	3.36	0.055
Variety	2.048	135.52	0.001	4.675	2.85	0.071	0.117	9.52	0.001
Error	0.015			1.642			0.012		
r <sup>2</sup>			0.98			0.56			0.80

## Appendix - 5

**Analysis of variance for Cured (sun dried) bulb yield (qt/ha) in Tegahine irrigate site, Golgol naele, Atsbi womberta wereda (2008).**

Source	Yield (q/ha)		
	Mean square	F	P
Replication	235.2	1.70	0.219
Variety	1314.5	9.52	0.001
Error	138.0		
$r^2$			0.78

## Appendix - 6

**Analysis of variance for clove categories (g/plot) in Tegahine irrigate site, Golgol naele, Atsbi womberta wereda (2008).**

Source	Very large clove			Large clove			Medium clove			Small clove			Very small clove		
	Mean sq.	F	P	Mean sq.	F	P	Mean sq.	F	P	Mean sq.	F	P	Mean sq.	F	P
Replication	623.4	3.21	0.062	214.86	3.94	0.036	10.55	0.17	0.915	176.2	0.83	0.501	31.87	1.09	0.392
Variety	19138.8	98.55	0.000	5451.83	99.98	0.000	917.45	14.69	0.000	1117.8	5.29	0.011	2137.43	72.79	0.000
Error	194.2			54.53			62.45			211.1			29.36		
$r^2$			0.97			0.97			0.83			0.66			
	0.96														

## Appendix - 7

**Analysis of variance (Msquare values) for marketable and unmarketable traits in Tegahine irrigate site, Golgol naele, Atsbi womberta wereda (2008).**

Source	Marketable cloves			Unmarketable cloves		
	Mean square	F	P	Mean square	F	P
Replication	798.8	1.44	0.086	31.87	1.09	0.392
Variety	33908.6	60.99	0.036	2137.43	72.79	0.000
Error	556.0			29.36		
$r^2$			0.95			0.96