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Comparative studies on the effects of conventional and conservation Agriculture practices on Tef yield insouth-western Shewa Zone of Oromia Region-

Ethiopia

A Thesis

submitted to Indira Gandhi National Open University School of Continuing Education in partial fulfillment of requirements for the degree of Masters of Arts in Rural Development

By

BeleteDemissie

Enrolment No: ID1403967

May, 2016

Addis Ababa, Ethiopia

DECLARATION

I declare that this MSc thesis, entitled, **"Comparative studies on the effects of conventional and conservation agriculture practices on Tef yield in South-Western Shewa Zone of Oromia Region in Ethiopia",**submitted by me for the partial fulfillment of the M.A.in Rural Development to Indira Gandhi National Open University, (IGNOU) New Delhiis my own original work and has not been submitted earlier to IGNOU or to any other institution for the fulfillment of the requirement for any course of study. I also declare that no chapter of this manuscript in whole or in part is lifted and incorporated in this report from any earlier work done by me or others.

Place: Addis Ababa Signature: _____

Date: May, 2016 Enrolment No. ID 1403967

Name: BeleteDemissie

Address: Addis Ababa, Ethiopia

CERTIFICATE

This is to certify that Mr. **BELETE DEMISSIE T/HAIMANOT,**a student of M.A. (RD) from Indira Gandhi National Open University, New Delhi was working under my supervision and guidance for his Project Work for the course MRDP-001. His Project Work entitled **Comparative studies on the effects of Conventional and Conservation agriculture practices on Tef yield in south-western Shewa zone of Oromia region in Ethiopia** which he is submitting, is his genuine and original work.

Place: _____

Date: _____

Signature _____

Name_____

Address of the Supervisor_____

_____

Acknowledgement

I thank Dr. MengistuHuluka and Mr. MossisaKejela (St. Mary's University) for their technical assistance and for providing important suggestions.

I would like to acknowledge participant farmers and their families for immeasurable and whole hearted efforts in managing the field and the harvested crop.

My special thanks go to Yemesrach Asmare and Assaita Belete for their enthusiastic efforts made in collecting the data.

The technical and financial support by Anglo Gulf Limited, Dubai, has become the driving force in the whole process.

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Acronyms

CT……Conservation Tillage

Non-CT…Conventional Tillage

FG…… FeyessaGemeda (Name of participating farmer)

DB……. DadiBonssa “ “ “ “

AF……. AletayeFeyessa “ “ “ “

MM…… Mustefa Mohammed “ “ “ “

MG…… MegerssaGutema “ “ “ “

JM…… Jemal Mohammed “ “ “ “

Abstract

Historically, crop production systems have relied on the cultivation and inversion of the top soil layer to prepare a seed-bed and to control weeds. This concept of bare soil technology by manual and mechanical means has resulted in a gradual deterioration of soil structure resulting in a pulverized soil which is prone to erosion and with low levels of nutrient. Continuous use of ploughs at the same depth and during periods of moisture content creates compact subsurface layers known as plough pan. Such a phenomenon will have damaging effects on the development of plant root system, oxygen availability and soil water movement.

In our farming community, there is often a pronounced shortage of animal traction and many hours of hand labour are spent in clearing, land preparing for planting crops, which are grown primarily for subsistence. Traditionally, tillage forms an important part of crop production. The principal motive to prepare the soil is to facilitate planting and accelerate seedling growth. Besides that, land preparation is considered necessary to obtain uniform crop without the interference of weeds

The concept of conservation agriculture (CA) is based on building up the organic matter layer on the soil surface with crop and other organic residues to form mulch as well as to keep the crop root and stalks intact in the soil. There is absolutely no soil inversion, which can destroy the soil structure.

The present experiment was carried out to seek for sustainable and harmless alternatives to our resource poor farmers. The study was carried out at kuraluku village 80 km distance from Addis Ababa .The result showed that yield per hectare varies from farm to farm in both CA and Non-CA ranging from 9_ quintals/ha to 21_ quintals/ha. The difference could be site factors, such as differences in moisture regime. However, the difference in yield between CA and Non-CA had not been that significant for all farmers. Thus, CA's advantage was not shown to be on increment of yield of Tef, but mainly in reduction of cost of production, and may also be on improvement of soil structure due to less tillage, better weed control and conservation of soil moisture.

Chapter One---Introduction

Tef (*Eragrostistef*) is the most important cereal highland crop grown in Ethiopia, occupying about 2,246,017 hectares of land (Meher season, CSA, 2005/2006, Statistical Bulletin 361). Adaa and Becho plains from Oromia and Eastern Gojjam highlands of the Amhara Regions are predominantly native areas of Tef production in Ethiopia.

Tef, among other crops, has been grown in Ethiopia from antiquity**.** It is considered cultural staple food for almost all Ethiopians, regardless of ethnic group, as all prefer Tef*injera* (thin pancake like bread) provided that it is accessible and affordable. Even those scattered Ethiopians living abroad as diaspora prefer injera more than anything else.

The demand of Tef*injera* by Ethiopians is next to none as staple food. Simulated *injera* of rice, when that of Tef is unavailable, is considered as *'injera'***,** as the shape, structure and taste is made similar. Hence, as more and more Ethiopians go out of the country to work and live there, Tef is also becoming more and more export product. Tef macaroni is under production in Ethiopia, thus, rendering Tef an industrial product or commodity. National Estimated yield of Tef is 9.69 quintals/ha (CSA,2005/2006, Statistical Bulletin 361).

The global empirical evidence shows that farmer-led transformation of agricultural production systems based on Conservation Agriculture (CA) principles is already occurring and gathering momentum worldwide as a new paradigm for the 21st century.

CA systems, comprising minimum mechanical soil disturbance, organic mulch cover, and crop species diversification, in conjunction with other good practices of crop and production management, are now practiced globally on about 125 M ha in all continents and all agricultural ecologies, including in the various temperate environments.

Table 1. Area under CA by continent

Continent	Area (ha)	Percent of total
South America	55,464,100	44
North America	39,981,000	32
Australia and new Zealand	17,162,000	14
Asia	4,723,000	4
Russia and Ukraine	5,100,000	4
Europe	1,351,900	1
Africa	1,012,840	1
World Total	**124,794,840**	**100**

SOURCE: Field action science report, November 2012

Farmers' current practice of frequent tillage until the soil is very much pulverized exposes the fertile top most soil to be lost through surface run-off. The situation becomes serious when sloppy lands are used for farming.

The adoption of CA minimizes, to a greater extent, the loss of our fertile soil through various means. It is true that farmers usually attach more emphasis on the financial gain a certain technology would entail than giving values to its hidden virtues.

It should, therefore, be the task of all of us involved in this sector and other stakeholders to raise their awareness on the importance of maintaining their farmlands, at least by improving on their soil fertility and conservation as little as can be achieved. Needless to say, inappropriate land use, poor management and lack of inputs lead to decline in agricultural productivity, soil erosion, salinization and loss of vegetation.

In a country like Ethiopia, where land configuration is not uniform (up and down), farmers have no interest to avoid plowing on the sides and top of hills. The conservation Agriculture (with no plowing) using round-up herbicide to control weed has tremendous potential towards saving our soils from erosion. This could also partly help to avoid improper land management practices that contribute to land degradation in Ethiopia.

Generally, Conservation Tillage saves 2-3 plowings which are usually done before planting crops and provides farmers with additional time to engage themselves to other activities (Findlay, 1998).

1.1 Back ground and justification

Historical barriers to adoption of conservation agriculture (CA) – achieving suitable weed control, planting into heavy crop residue, getting a good stand – are falling like dominoes. The tradition of turning the soil over and over again is being questioned on a grand scale.in many areas of the world, annual rate of top soil loss are in excess of 10 or more tons per acre. Sediment from plowed fields clogs waterways, which also carry away soil nutrients and pesticides, causing further contamination. Conservation agriculture (no-till)has the potent entail to keep up to two thirds of a ton per acre per year of carbon dioxide out of the atmosphere. Leaving crop residue intact over the soil surface greatly reduces wind and water erosion, as well as airborne dust. The agronomic benefits of conservation agriculture are also significant. Moisture retention and water infiltration are improved dramatically as plowing decreases. Soil structure and organic matter levels improve overtime, slowly at first but substantially over five to ten years. And then there are the time and labor savings to the farmer (WOW 2000 Global)

In Ethiopia, the agriculture sector is the backbone of the nation's economy. This sector continues to be extremely important, contributing about 55%to the national GDP, 60% to merchandise exports and 80%to the population's employment (World Bank, 1995).

Besides its contribution as the main income generating sector for the majority of the rural population, it also serves as the main source for household consumption.

Crop production by this sector largely depends on oxen power for tillage. Significant numbers of farmers do not own oxen for tilling their piece of land. They have to rent from those who could spare them on different payment arrangements. Under such circumstances delay in operation is common occurrence , as they have to wait until the owner cover his plots.in conservation farming system , provided the plot in question has been in use the preceding years ,the need for oxen is not there or minimal(SG-2000).

1.2 Statement of the problem

Even though there is no plowing in the natural forest areas, one can easily observe plants germinating, flowering and setting seeds. With the advent of modern technology and an intention to produce more, however, man has been and is still striving to create conducive conditions for crops to grow and also control weeds through frequent plowing thereby importing consequential damage to the soil.

As we all know, without soil, there would be no life on earth at all. Yet our soils are being eroded and depleted at an alarming rate. Our farmers usually plough their farms on an average 4-6 times to grow Tef (Hailu*et al*., 1991).

Even though there is no plowing in the natural forest areas, one can easily observe plants germinating, flowering and setting seeds. With the advent of modern technology and an intention to produce more, however, man has been and is still striving to create conducive conditions for crops to grow and also control weeds through frequent plowing thereby importing consequential damage to the soil. As we all know, without soil, there would be no life on earth at all. Yet our soils are being eroded and depleted at an alarming rate. Our farmers usually plough their farms on an average 4-6 times to grow Tef (Hailu*et al*., 1991).

Environmental degradation is one of the most severe problems affecting food security in Ethiopia. Cultivation of steep lands in the absence of conservation practices, poor farming practices and continuous cropping without nutrient recycling, overgrazing and improper land use practices are among the causes for accelerated soil erosion (amounting to over 2.5 million tons/yr.). In addition, crop residue and dung are increasingly being used to meet rural household energy needs, rather than being used for ameliorating soil fertility and hence increased agricultural productivity (Nedessa, 1998).

Ethiopia is experiencing severe degradation to its farmlands. Much of this degradation can be attributed to exploitative farming practices that include ploughing, removing crop residues, mono-cropping which have significant contributions to the destruction of soil structure and degradation of organic matter. To this end, promoting conservation agricultural practices is a step forward in the right direction.

According to FAO, Conservation Agriculture (CA) is an approach to managing agro-ecosystems for improved and sustained productivity, increased profits and food security, while preserving and enhancing the resource base and the environment (FAO, 2008).

1.3 Research Questions

1. Does Conservation Tillage have an advantage in improving Tef yield as compared to Conventional Tillage?
2. Is there any difference among farmers in adopting the practice of conservation tillage?

1.4 Research Objectives

1.4.1 General objectives

The whole objective of this research was to carry out comparative study between Conventional Tillage and Conservation Agriculture in the production of Tef crop and to evaluate the differences in yield of Tef.

1.4.2 Specific objectives

- To compare agronomic and economic advantages of conventional and conservation agriculture; and
- To evaluate and compare the performance of conventional and conservation agriculture in Tef production technology.
- Reduce tillage operation

CA and conventional plots

1.5Significance of the study

This study will be the first kind of a demonstration at field condition that practically reached the farming community. As a result it will give the agricultural as well as the industrial sectors well-organized information available for them to use it properly. It will also help the policy makers to give much emphasis to such type of new technologies which give more benefit to our resource poor farmers.

1.6 Scope and Limitations

The focus of this research paper is to examine the effect of conservation and conventional agriculture practices on Tef and to look at the different types of the advantages gained. This study faced challenges from the fact that a spontaneous change of the mindset of the people. Therefore, the biggest problem of this work is shortage in availability of local research data. Additionally, there is also shortage of previous works in this subject matter.Capacity is one of the major limiting factors for bringing change in the transformation of agriculture. Whatever good practices we have in conservation agriculture, they do not bear fruits unless they are translated into action that can bring the desired changes. The implementation of such programme can be guaranteed, first and foremost, through an integrated and active involvement of all forces at all stages of development interventions.

The most important problem of all, according to farmers, is open/astray grazing before and after spraying the herbicide (Roundup). When livestock are left to graze astray, it is very difficult to control the weeds even if herbicides are sprayed mainly because of stamping. In the practice of open grazing, it is also difficult to exercise proper residue management since whatever is left on the field will be taken up by livestock.

1.7Chapterizaion of the paper

This thesis comprises five chapters. Chapter one consists introduction, back ground and justification, statement of the problem, research questions/hypothesis, research objectives, significance of the study, limitations and chapterization of the paper.

The second chapter presents literature review that will provides theoretical and empirical frame work to the research, definition of conservation agriculture, the goal of conservation agriculture, advantages of conservation agriculture.

The third chapter encompasses the research design and methodology that includes research methods, research design, data collection tools, universe of the study and sampling techniques.

The fourth chapter is the main body of the research that comprises data analysis interpretation, findings of the study and their relationship to the relevant literatures.

Finally the fifth presents conclusion and recommendation. Based on the results obtained from the study the theoretical and practical implications are presented.

Chapter Two --- Review of Literatures

The primary purposes of soil tillage are to provide suitable seedbed conditions and adequate weed control (Triplett and van Doren, 1977; Lal, 1989). However, tillage systems can affect various soil physical and chemical properties including soil moisture, mechanical resistance, organic matter (OM), nitrate (NO_3), and ammonium (NH_4). As tillage disturbance increases, soil structural deterioration and erosion are exacerbated especially on erosion-prone soils. However, stubble and crop residue maintenance, reduced tillage systems and crop rotations are among the crop management practices that can play a significant role in maintaining favorable soil chemical and physical properties (Aulakh and Gill, 1988; Stobbe, 1990; Sweeney and Moyer, 1995).

Conservation tillage may be defined as any soil management system that leaves the soil surface resistant to erosion and conserve soil moisture (Stobbe, 1990). Some conservation methods are: zero tillage /no tillage/, minimum tillage /reduced tillage/, and mulch tillage. With minimum tillage disturbance of the soil is reduced by minimizing the degree of tillage, including only those operations that are essential; appropriate herbicides are substituted for tillage, in order to create suitable conditions for seed germination, plant growth and weed control (Hamblin *et al.*, 1982; Triplett and van Doren, 1977). In conservation tillage, dead plant material that remains on the ground after the crop is harvested is left on or near the surface of the soil, rather than being plowed deeply into the ground as in traditional tillage. The dead plant material at the surface of the soil helps to keep moisture within the ground, and protects the soil from erosion.

The primary function of conservation tillage is to reduce soil erosion due to wind and water. The impact of soil lose on crop production may not be observed by the farmer on the short term (Stobbe, 1990). Traditional tillage may harm the soil if used continuously over many years, especially if the fertile topsoil layer is thin. Nowadays, in developed countries many farmers use minimum or reduced tillage to conserve the soil.

2.1 Definition of Conservation Agriculture

CA is a concept for resource-saving agricultural crop production that strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving the environment. CA is based on enhancing natural biological processes above and below the ground. Interventions such as mechanical soil tillage are reduced to an absolute minimum, and the use of external inputs such as agrochemicals and nutrients of mineral or organic origin are applied at an optimum level and in a way and quantity that does not interfere with, or disrupt, the biological processes (FAO, 2007).

Reduced tillage has an advantage in decreasing soil erosion and run-off and maintaining soil structure and long-term productivity (Hargrove and Hardcastle, 1984; Lal, 1989; Philips *et al.*, 1980). Reduced tillage can increase soil moisture, OM in the surface layer of the soil, and increase water infiltration (Kamwaga, 1990). All these facts contribute to enhanced soil productivity that would result in higher crop yield. Moreover, conservation tillage involves lower labor requirement, less costly machinery and traditional land preparation operations that sounds more sustainable

2.2 The goal of Conservation Agriculture

Conservation Agriculture (CA) aims to conserve, improve and make more efficient use of natural resources through integrated management of available soil, water and biological resources combined with external inputs. It contributes to environmental conservation as well as to enhanced and sustained agricultural production. It can also be referred to as resource-efficient and resource-effective agriculture (FAO, Agriculture and consumer protection department, 1998).

2.3 Advantages of Conservation Tillage:

- Reduction in labor, time and equipment costs;
- Increase net income, in some cases from the beginning

  in all cases after a few years;
- Satisfy human food, feed and fiber needs and contribute to bio-fuel or strengthened food security;
- Carbon sequestration (greenhouse effect), in some places

  no-till farmers start to receive carbon-grant payments; the

  global potential of conservation agriculture in carbon sequestration could equal the human made increase in CO^2 in the atmosphere.

Sustainable agriculture is defined as “the successful management of resources for agriculture tsatisfy changing human needs while maintaining or enhancing the quality of the environment and conserving natural resources” (TAC, 1988).

Hence, conservation tillage is a component of sustainable cropping system. Sustainable cropping system involves the efficient use of nutrients through recycling of nutrients in crop residues; minimum leaching loses of nutrients, maximizing BNF (biological N_2 fixation) and low level of fertilizer inputs sufficient to compensate for nutrients removed by the harvested product.

Currently, however, sustainability is threatened by declining nutrient supply, build-up of toxic levels of mineral elements through acidification, salinization; deterioration of soil physical properties through surface sealing, erosion, compaction; and build-up of weed, pest and disease infestation.

One of the second-generation problems of the system was that bare soil without cover was exposed to the impact of direct rainfall drops because of recurrent plowing ahead of the commencement of rainfall, and consequently, to detachment and vigorous erosion. Literatures attest this fact.

The long term effects of population pressure, the indiscriminate removal of natural vegetation, escorted by backward traditional agricultural practices have left

Ethiopia with an estimated loss of about 1-2 billion tons of fertile soil annually and an interruption of the normal hydrological cycle and environmental equilibrium, causing the recurrent droughts and famines (Nedessa, 1998).

According to Nedessa, if the current land degradation is to continue, 7.6 million ha of agricultural land is to be out of production by the year 2010. Where there is overgrazing and *exposed soil surface*, wind erosion also takes its toll. It is obvious much of this toll is from the recurrently tilled and exposed farmland, particularly meant for Tef.

On the other hand, cultivation/plowing for producing Tef is of vital importance as it required **four to eight** subsequent plowings to curb the negative influence of weeds on crop productivity.

This triggered the feeling that the technology might resolve some of the technical, financial and labour problems of the Ethiopian small-scale farmers and would deserve some attention and testing in areas of the country where soil erosion and moisture stress have been prevalent (Nedessa, 1998).

Chapter Three ---Research Design andMethodology

In a country like Ethiopia where land configuration is not uniform (up and down), farmers have no option in order to avoid plowing on the sides and top of hills. Conservation tillage (with no plowing) using glyphosate (Roundup) for weed control has tremendous potential towards saving the soil from erosion.

3.1 Material and Method of the study

Farmers participating in the study

1) AtoFeyessaGemeda (FG)
2) AtoDadiBonssa (DB)
3) AtoAletayeFeyessa (AF)
4) AtoMustefa Mohammed (MM)
5) AtoMegerssaGutema (MG)
6) AtoJemal Mohammed (JM)

FIVE OF THE PARTICIPATING FARMERS IN THE STUDY

Initially, farmers were advised to divide their plots into two equal parts, 0.125 ha each. In one plot Tef crop was sown according to recommendations of the extension package program set for the area. The other plot was left to the farmer to practice Conservation Agriculture (CA). Conventionally, Tef fields are plowed on an average 4-5 times before planting, while in the case of CA they are plowed only once and even this one is done very lightly for the mere purpose of covering the applied fertilizer.

Plots allotted for CA are left untouched, with a reasonable amount of crop residues left on the surface, until quite close to the season for sowing. The ensuing rain would then trigger weeds to flush out. Instead of removing them by plowing which is the normal traditional practice in the area, the weeds are killed by spraying Roundup, a non-selective herbicide, with a very good safety record. The weeds are then left to die there by giving a good ground cover. Plots under CA are then planted with very minimal disturbance of the soil. Then the recommended rate of seed is evenly broadcasted over the plot. It is worth mentioning that, with the exception of tillage operations and weed control methods, all other practices (i.e., crop variety, fertilizer type and rate, planting date, etc...) on both CA and conventionally tilled plots are identical.

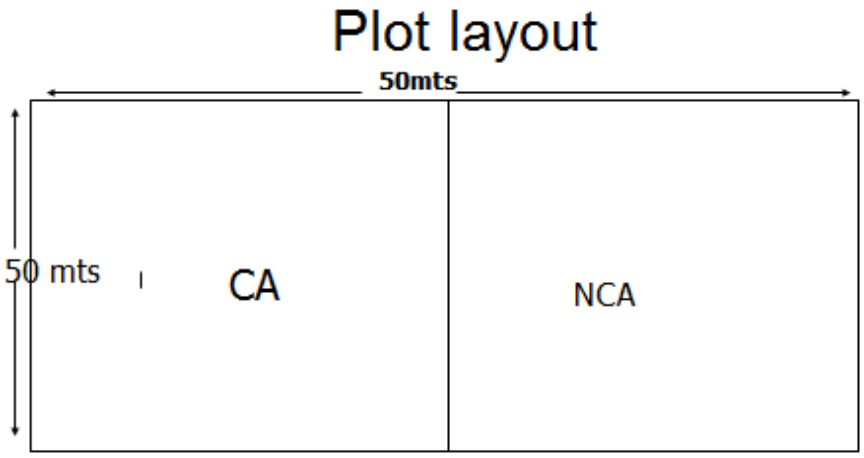
Crop management practices: conventional tillage consisted of three to five plowings prior to sowing (i.e., farmers' practice); for CA, one pass with the ox-plow was used to incorporate broadcast seed and fertilizer. For the CA treatment, chemical spray was practiced during the ''short rains'': pre-plant spray with glyphosate (Roundup) was applied at 1440 ga.i. ha^{-1} during the fallow period (i.e., as required to prevent weeds from attaining a height of 10 cm).

All fields were sown with recommended seed rates (32 kgs/ha) and fertilizer levels (100kgs of DAP and 100kgs of UREA). Due to the risk of damage by spray drift, supplementary hand weeding was used to control weeds. After 34 days of the plant age 2-4-D herbicide was sprayed on both fields at the rate of 1lt/ha.

3.2 Research Design

The study used the descriptive research method to describe what exists with respect to variable or conditions in a situation. Relevant data were collected through the data collection tools developed. The collected data were tallied, tabulated and analyzed using both qualitative and qualitative data analysis method.

The data are discussed and interpreted base on the theoretical framework devised and at the end, the findings of the study are summarized and conclusion and recommendation forwarded accordingly.



3.3 DataCollection Tools

Survey method was the strategy of the research to achieve a maximum outreach, using secondary and primary data sources. The secondary data is from books, articles or journals from the library and from websites. The primary data source was experimental observation of the researcher. The research has taken two variables 1) conservation agriculture 2) conventional tillage. Focus group discussion, personal observation and key informal interview were also used in the data collection

3.4 Universe of the study

The study was conducted in one of the **best Tef** growing villages of the south-western Shewa zone, ToleaWereda, KuralukuKebele, of Oromia regional state. The plot of land size each farmer owns varies between 0.10 to 5.00 hectares. Tef yields on peasant farms were rather low being about 1.0 t/ha. Such low yield is attributable to both agronomic and socio-economic constraints (Hailu*et al*., 1991).

3.5Sampling techniques

At ToleaWoreda ,KurakukuKebele observation research was carried out on 50m by 50m plot area of Tef. The sites were selected randomly based on the past cropping history (2 sites –Tef after Tef, 2sites- wheat after Tef, 2sites- pulses after Tef).

Treatment: - 1- Conventional tillage

2- Conservation agriculture

Replications: - 6x2=12

Plot size: - 50m x25m

Site selections

3.5 Nature of the herbicide used in the study

ROUNDUP

- Roundup is a water based solution containing 360 g/l. glyphosate per litter.
- Being a non-selective herbicide it kills all actively growing green vegetation provided that optimum rates are used for the intended target weeds.
- It has no residual activity both in soil and plants.
- It moves within the treated plant and adversely affects roots, rhizomes, stolons, tubers, etc. The ultimate result of this is death of the plant. The time for this to happen, however, depends on growing stage of the specific weed, prevailing weather condition of the area, etc.
- As its mode of action is exclusive to plants it will impart no harm on wild life, human beings and livestock.
- It degrades rapidly into naturally occurring nitrates, phosphates, carbon dioxide and water (Monsanto, 1996).

Pic- 7. Herbicide Application

3.6 Operational sequences to be followed when Implementing CA on Tef

A. Grazing plots destined for Conservation Agriculture should be kept to a minimum immediately after harvest;
B. Weeds that germinate should not be grazed at all. If they happen to be grazed somehow by stray animals, one has to wait for a while until there is a good leaf area on the target weeds;
C. Identification of the type of weeds should receive utmost attention, as the rate of application of Roundup will be governed by the type of target weeds to be controlled;
D. Application of Roundup should not be carried out on weeds which are either moisture stressed or growing under water logged condition. Active growth of weeds will facilitate the action of Roundup;
E. Use clean water for spray purposes;
F. Spray equipment should be calibrated properly before use;
G. Use the right dose of Roundup and spray;
H. Depending on the soil workability, one has to apply the recommended rate of fertilizer and cover it by using lighter implements & then broadcast Tef seeds;
I. Post-emergence application of herbicides should be carried out using **2-4 D** fluid at the recommended growth stages of the crop;
J. Remove those weeds, if there are any, which escape or withstand herbicide treatment by hand.

Chapter Four ---Results and Discussion

4.1 Methods of Data analysis and Interpretation

After administering the subjects were tallied, tabulated and organized. Descriptive statistical method was employed to analyze the data. This is because, the method involves gathering data that describe events and then organizes, tabulates, depicts and describe the data.

4.2 Cost-Benefit Analysis of Conservation vs Conventional Agriculture

Data were collected from each farm and analyzed on both Conventional and Conservation Agriculture separately (Appendix 1). Farm operations, such as, pre-plantingpractices, including herbicide application, and date of planting were performed at about the same week for both CA and Non-CA by all participating farmers (Tables 2 & 3).

With regard to cost of production for Tef plots under Conservation Agriculture, all six farmers incurred the same amount, i.e., Birr 5280.00/ha (Table 2). However, the cost incurred has risen to Birr 5780.00/ha for each of the five farmers under Conventional system, while in the case of one farmer, the production cost was Birr 6580.00 (Table 3).

Yield per hectare varies from farm to farm in both CA and Non-CA, ranging from 9 quintals/ha to 21 quintals/ha (Tables 2 & 3). The differences could be due to site factors, such as differences in moisture regime. However, the differences in yield between CA and Non-CA had not been that significant for all farmers (Table 2 & 3).

Thus, CA's advantage was not shown to be on increment of yield of Tef, but mainly in reduction of cost of production, and may also be on improvement of soil structure due to lessbetter weed control and conservation of soil moisture.

Table 2. Cost- Benefit Analysis of Conservation Agriculture system

Region: OROMIA, **Zone:** SOUTHWEST SHOA, **Woreda:** TOLEA, **Crop:** TEF

№.	**Name of Farmer**	**Pre-planting operation/ (Date)**	**Planting Date**	**Total cost of production/ha (Birr)**	**Yield/plot**	**Yield/ha (Quintal)**	**Total sales /ha (Birr)**	**Net income/ ha (Birr)**
1	FeyesaGemeda	15/07/15	01/08/15	5280	1.125	9.00	10,800 birr	5,520 birr
2	AltayeFeyessa	18/07/15	03/08/15	5280	2.250	21.00	25,200 birr	19,920 birr
3	DadiBonsa	20/07/15	05/08/15	5280	1.125	9.00	10,800 birr	5,520 birr
4	Mustefa Mohammed	12/07/15	29/07/15	5280	2.625	21.00	25,200 birr	19,920 birr
5	Jemal Mohammed	15/07/15	01/08/15	5280	2.250	18.00	21,600 birr	16,320 birr
6	MegeressaGutema	18/07/15	03/08/15	5280	2.625	21.00	25,200 birr	19,920 birr

REMARK:Price/QT=1200 BIRR; Plot Size = 1250 $m^{2;}$; Tef Variety: Cross-37

Table 3. Cost- Benefit Analysis of Conventional Agriculture system

Region: OROMIA, **Zone:** SOUTHWEST SHOA, **Woreda:** TOLEA, **Crop:** TEF

No.	Name of Farmer	Pre-planting operation/ (Date)	Planting Date	Total cost of production/ha (Birr)	Yield/plot	Yield/ha (Quintal)	Total sales /ha (Birr)	Net income /ha (Birr)
1	FeyesaGemeda	15/07/15	01/08/15	6580	1.125	9.00	10,800	4,220 birr
2	AltayeFeyessa	18/07/15	03/08/15	5780	2.250	18.00	21,600	15,820 birr
3	DadiBonsa	20/07/15	05/08/15	5780	1.125	9.00	10,800	5,020 birr
4	Mustefa Mohammed	12/07/15	29/07/15	5780	2.625	21.00	25,200	19,420 birr
5	Jemal Mohammed	15/07/15	01/08/15	5780	2.250	18.00	21,600	15,820 birr
6	MegeressaGutema	18/07/15	03/08/15	5780	2.250	18.00	21,600	15,820 birr

REMARK:Price/QT=1200 BIRR; Plot Size = 1250 $m^{2;}$; Tef Variety: Cross-37

TEF CROP BEFORE HARVEST

When cost-benefit analysis was worked out, the income advantages for CA was not that much glaring at ongoing price of Tef at the time, i.e., Birr 1200.00. The advantage for CA was only Birr 500.00 each in the case of 3 farmers, Birr 1300.00 in the case of one farmer. However, in the case of two participants, the difference in income between CA and Non-CA farmers was Birr 4100.00, showing that the potential of CA could be high if every condition is properly facilitated (Appendix II).

CA seems to be a very beneficial technology to Tef farmers.

Harvested crop

4.3 Effect of CA on Plant Height

The growth rate of Tef plant was checked by measuring its height at least 3 times during the growing season. At first, when measured at the end of one month growth stage, on average, faster growth rate was recorded on Non-CA plots than CA plots. However, at the end of the second month, the height of Tef plants on CA plots was greater than Non-CA plots. At harvest time, Tef on CA plots finished by being taller than Non-CA grown plants which may attribute to the yield differences of the two practices (Table 4).

Table 4.Average plant height of Tef under Conservation and Conventional Agricultural systems on farmers' field in Toleawereda

Farm practices	Number of plots	FIRST MONTH (cm)	SECOND MONTH (cm)	AT HARVESTING (cm)
CA (Conservation Agriculture)	6	25.50	60.17	81.84
Non-CA (Conventional Agriculyure)	6	29.33	50.83	76.50

Source: Own survey

Data collection – Height Measurement

Chapter Five --- Conclusion and Recommendation

5.1 Conclusion

Conservation Agriculture is one of the recent technologies which are being promoted to keep the soil alive, healthy and productive. This technology has become more and more popular particularly in big commercial farms since it saves time, fuel, depreciation of machineries and reduces soil erosion and loss of applied fertilizers**.** Generally, conservation agriculture has an advantage over the traditional tillage because it gives farmers more flexibility, reduction in soil erosion and better soil moisture retention.

It is also true that our peasant farmers are pragmatic and want to take some time before committing themselves to adopting any new technology. When this project was initiated on selected farmers' plots, most farmers were very skeptical about the practical significance of this technology. Some even dared to out rightly ridicule the approach. However, after closely observing the development of their plants and crop growth on CA plots in their respective areas, they didn't take time to express their change of heart about the usefulness of the technology. Farmers were very much impressed with the performance of this technology.

On CA plots, weed seeds were no longer spread and the system allows the integration of different practices, which makes it more sustainable.

The drudgery and time consumption in seed-bed preparation for Tef crop is quite obvious for all those involved in this venture.

With the advent of CA, the constraints have been successfully avoided without any compromise on all beneficial aspects of the crop husbandry, not to mention the other extra benefits (which include, among many others, soil organic matter build up, arresting soil erosion problem to a great extent, enhancing water holding capacity of the soil, etc) that will accrue with proper application of the technology.

Because of the opportunities for increased outputs, reduction in production costs and higher income levels which a technological change to CA can offer, it is useful to take into consideration the process of adoption of technical innovations. The economic potential of Conservation Agriculture, in terms of costs of production, profit, yield, soil conservation, etc. is very important. However, unfamiliarity with Conservation Agriculture practices might make the initial impact on yield and input usage uncertain. In general, Conservation Agriculture can produce higher yields compared to conventional tillage systems if properly applied.

5.2 Recommendations

- Under Ethiopian context, Conservation Agriculture would alleviate the problem of traditional land preparation that requires a pair of oxen which most farmers cannot afford economically, and also reduces the constraints of land for grazing traction animals as it is shrinking from time to time due to high population growth in the rural areas.

- The practice of rotation of Tef with legumes are vital in Tef based Conservation Agriculture and should be adopted.
- Conservation agriculture should not always be seen only from yield advantage point of view, i.e., its long-term positive effects on soil and the environment should be given due emphasis.
- Conservation agriculture is a component of sustainable agriculture. Conservation agriculture could be one major component of crop management practices in Tef based cropping systems in Ethiopia to minimize soil degradation due to erosion, from runoff and wind as it encompasses retention of crop residues to cover the soil. Retention of crop residues on the soil surface improves the moisture retention, water infiltration, build up the soil OM and subsequently resulting in soil productivity.
- For conservation agriculture to be more effective and reliable under Ethiopian condition, the total weed killer required to keep the field weed free before sowing must be available on time at affordable prices
- In conservation agriculture practices the N requirement of Tef crop may be more than the recommended rate at the early stage of the tillage system. This should be fulfilled through N_2 fixation by legume crops that should be included in rotation with chickpea and by applying additional chemical N fertilizer based on the study result that should be given due attention.

- One of the major purposes of conservation agriculture is to retain crop residues on the field to minimize soil erosion and moisture loss due to runoff and evaporation. But, under the present conditions in our country, *in situ* residue retention is impractical since animals are left to **freely graze** in the field after the crops have been removed. This practice, unless checked step by step, is exposing farmland to more and more erosion, compaction, and finally will result in more serious land degradation.
- To instill conservation agriculture practices in the Ethiopian peasant farming systems, specialists in different sectors (soils and water, agronomy, crop improvement, forestry, livestock and socio-economics) should work hand in hand with farmers.
- Farmers should be given training about conservation agriculture repeatedly andfollow-up action be exercised for its proper implementation (conservation tillage is more than reducing cost of production or enhancing yield).

GROUP HAND WEEDING of TEF PLOT

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APPENDIX I

Summary of Collected Data

Operational Details

	CT	Non - CT	No. of FARMERS (name code)
Plot size ha.:	0.125 ha	0.125	6
Ploughing frequency:	1 time	6 times	6
Weed control (pre-planting):			
Herbicide:	**ROUNDUP;**	oxen tillage	6
Dosage: 4 lt/ha			
Application Date: 15/07/2015			
Target weeds (dominant):	1. Digetaria spp. 2. Cyprus esculunthus,		6
	3. Phalariscanariensis, 4. Galinsogaparviflora, 5.Avenafatua,		
	6. Amaranthus spp., 7. Malvaparviflora		
Planting Date:	01/08/2015	05/08/2015	6
Crop type & variety:	Tef (cross-37)	Tef (cross-37)	6
Seeding rate :	34 kg/ha	34 kg/ha	6
Fertilizer type & rate at planting:	DAP/100kg/ha	DAP/100kg/ha	6
Top/side dressing	UREA/100 kg/ha	UREA/100 kg/ha	6
Weed control post-planting:			
Manual weeding	1st _____4 man days	1st _____4 man days	6
Pre-emergence/post-planting:	2-4 D (herbicide)	2-4 D (herbicide)	6
Dosage rate :	1 lt/ha1 lt/ha		
Date of application:	12/09/2015		
Type of sprayer used:	**manual knapsack sprayer**		6
Tank capacity	16 lt		
Nozzle size & number	AN-1		
Spray width/swath	1.50 mts		
Spray Volume	100 lt/ha		

DIRECT AND INDIRECT COSTS

	CT	NON – CT	No. of FARMERS (name code)
Operation	**Cost in Birr**	**Cost in Birr**	
Ploughing 1st	400	400	6
2nd	None	400	6
3rd	None	400	6
4th	None	400	1 (FG)
5th	None	400	1 (FG)
Planting & Covering	600	600	6
Seed purchase	720	720	6
Fertilizer & application	1400	1400	6
Top/side dressing	1130	1130	6
Pre-planting Herbicide Application	700	None	6
Post emergence App.	100	100	6
Hand weeding	280	280	6
Harvesting & threshing	140	140	6
Transporting	210	210	6
Total cost of production	**5280**	**6580**	**1 (FG)**
	5280	**5780**	**5**
Achievements			
Yield (qt/plot)	1.125	1.125	2 (FG, DB)
	2.625	2.625	1 (MM)
	2.625	2.250	2 (AF, MG)
	2.250	2.250	1 (JM)
Yield (qt/ha)	9. 00	9.00	2 (FG, DB)
	21.00	21.00	1 (MM)
	21.00	18.00	2 (AF, MG)
	18.00	18.00	1 (JM))

Appendix II

Cost – Benefit Analysis:

Farmer No. 1: FeyessaGemeda

Total income =	10,800 Birr	10,800 Birr
Net income =	5,520 Birr	4,220 Birr

Difference = **1300 Birr**

Farmer No. 2: DadiBonsa

Total income =	10,800 Birr	10,800 Birr
Net income =	5,520 Birr	5,020 Birr

Difference = **500 Birr**

Farmer No. 3: AltayeFeyessa

Total income =	25,200 Birr	21,600 Birr
Net income =	19,920 Birr	15,820 Birr

Difference = **4100 Birr**

Farmer No. 4: Jemal Mohammed

Total income =	21,600 Birr	21,600 Birr
Net income =	16,320 Birr	15,820 Birr

Difference = **500 Birr**

Farmer No. 5: Mustefa Mohammed

Total income =	25,200 Birr	25,200 Birr
Net income =	19,920 Birr	19,420 Birr

Difference = **500 Birr**

Farmer No. 6: MegersaGutema

Total income =	25,200 Birr	21,600 Birr
Net income =	19,920 Birr	15,820 Birr

Difference = **4100Birr**