



Demonstration of Conservation Farming Practices in Improving Sorghum Yield at Tanqua-Abergelle Wereda, Ethiopia

Guesh Assefa^{1*} and Meresa Weleslasie¹

¹*Tigray Agricultural Research Institute, Abergelle Agricultural Research Center, P.O.Box 44, Abi-Adi, Ethiopia.*

Authors' contributions:

This work was carried out in collaboration between both authors. Author GA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author MW managed the analyses of the study and the literature searches. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/ASRJ/2020/v3i3330072

Editor(s):

(1) Dr. Alessandro Buccolieri, University of Salento, Italy.

Reviewers:

(1) B. P. Bhaskar, India.

(2) Qi Cheng, Biotechnology Research Institute, Chinese Academy of Agricultural Sciences, China.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/56649>

Original Research Article

Received 02 March 2020
Accepted 09 May 2020
Published 10 June 2020

ABSTRACT

Conservation agriculture (CA) technologies involve minimum soil disturbance, permanent soil cover through crop residues or cover crops, and crop rotations for achieving higher productivity. Today tillage is seen destroying activity that leads to decline in organic matter and destruction of soil structure. Hence, the objective of this study was then to improve soil moisture and structure through minimizing soil disturbance which can be explained by the obtained yield response of sorghum. The research was undertaken at twenty one (21) interested farmers' piece of land (10 m x 10 m) at Tanqua Abergelle Wereda in specific sites called Sheka Tekli and Agbe tabias', it was successful only at thirteen (13) farmer's land at Sheka Tekli. The conservation farming practices such as basin was prepared two weeks earlier from its sowing date. Grain yield and farmers perception on each practice of conservation agriculture were collected and subjected to simple descriptive statistics. Accordingly, the grain yields obtained from tied-ridger and basin technologies were 1.6 t/ha and 1.31 t/ha, respectively. However, conventional tillage revealed the lowest grain yield of sorghum. Farmers

*Corresponding author: E-mail: guesh1214@yahoo.com;

have shown great interest and promise to adopt tie ridger than basin due to lower yield. Therefore technology promotions and popularization on the study and similar agro ecological areas should be carried out in collaboration with stakeholders.

Keywords: Conservation farming; demonstration; sorghum; productivity; Ethiopia.

1. INTRODUCTION

The Ethiopian economy is mainly dependent on rainfed agriculture and exposed to environmental risk factors of crop production. Tigray, the northern part of the region of the country, suffers from extreme land degradation and put severely eroded steep slopy lands to cultivation for many centuries [1]. Rainfall is seasonal and erratic in northern Ethiopia, particularly in Tigray. Consequently, there is strong seasonal (~8 months) moisture stress limiting the productivity of rainfed agriculture in the region [2].

The problem of food insecurity has become more intensely pronounced in recent years with the threat posed by recent trends, such as climate change, water and rainfall scarcity, as well as ecosystems and biodiversity degradation. In sub-Saharan Africa, most rural communities are suffered by poverty, yet the agricultural system being promoted to unacceptable high environmental, economic, and social costs [3]. Nearly 80% of the population in sub-Saharan countries lives in rural areas with 70% of this rural population being directly dependent on agriculture for their livelihood [4].

Ethiopia's climate is highly variable and is projected to become more variable due to climate change and increased frequency of extreme weather events. The vulnerability to climate related hazards and food insecurity is closely linked to land degradation. About 85% of the land surface of Ethiopia is considered as susceptible to moderate or severe soil degradation and these are reducing the sustainability of agricultural production [5].

Repeated tillage using traditional tillage implement (Maresha), almost complete removal of crop residue at harvest leaving no soil cover, insufficient application of manure and aftermath overgrazing of crop fields is common [6,7,8]. Such practices have been intense in the northern and central part of the country, a region with a long history of human settlement, as well as in our mandate area.

Tillage has long been used by farmers to loosen the soil, make, a seed bed and control weeds. However, Soil erosion due to high tillage frequency and other soil management problems has seriously affected over 25% of the Ethiopian highlands [9]. Such detrimental effect of soil erosion and water stress can be improved to some extent by other management options like conservation tillage. Small farmer holders have introduced the practice, of course, with the technical support by Development Agents, with the aim to improve soil properties, conserve moisture, reduce runoff and soil loss from their farm lands.

In conservation farming, crops are grown using conservation tillage (CT) and legumes are included with other crops. Legumes fix nitrogen, improve fertility of the soil, and increase crop yields. It involves the planting, growing, and harvesting of crops with minimum disturbance of soil surface through the use of minimum tillage, mulch tillage, ridge tillage, or no-till. Conservation agriculture (CA) was introduced as a concept for resource-efficient agricultural crop production based on an integrated management of soil, water and biological resources combined with external inputs [10]. This resource conserving cropping systems may reduce runoff and soil erosion and improve soil quality, thereby increasing crop productivity [11]. Nowadays, to reduce soil erosion, nutrient losses, surface runoff, increased green water availability and grain yield, different farmers and researchers had been implemented conservation tillage systems.

A study was held at Sheka Tekli farmers training center (FTC) to demonstrate the conservation farming practices in 2013/14 and hence, a promising grain yield was obtained from tied ridger and basin compared with the conventional tillage. This type of monitoring is best suited to portraying soil disturbances on-site [12]. On-site improving yield of sorghum monitoring with tie-ridger and basin was found to be a suitable and useful approach as it clearly demonstrates site. Accordingly, the best conservation agriculture practices were selected to further demonstrate and evaluate compared with the conventional tillage.

2. MATERIALS AND METHODS

2.1 Area Description

The study was carried out in Tanqua Abergelle Woreda, central zone of Tigray National Regional State of Ethiopia. Tabia Sheka tekli is a testing site; located 120 km from mekelle town in the western direction (Fig. 1). It is agro ecologically characterized as hot warm sub-moist low land (SM1- 4b) below 1500 meters above sea level. The rainfall pattern is monomodal with a wet season of about two months occurring in July to August. The mean annual rain fall and temperature are 350 -700 mm and 24- 41°C respectively. According to unpublished data of the agricultural office of the Wereda (2008), the coverage of the different soil types varies from sandy loam (63.73%), clay loam (30.47%) to silt loam (5.8%) with low organic matter content.

2.2 Research Design

This research was held at twenty one farmers (21) fields at three different sites called Sheka Tekli (13) and Agbe (8) farmers. However, only the demonstration at Sheka Tekli was successful, while in the remaining two sites were failed, due to many different reasons, such as free grazing (i.e Animals) and delay onset of monsoon. The study was based on primary and

secondary data. Quantitative type of data (grain yield) was taken from 13 farmers using a quadrant (1 m*1 m). Similarly, qualitative type of data (farmers' perception) was collected from primary sources using a semi-structured interview schedule. Secondary data were also reviewed from annual reports, proceedings and journals. The spacing between plots, rows and plants were 50, 75, and 20 cm respectively. The treatments were selected on their previous yield returns were as given below.

- T1: Ripper + Tie- ridger Vs Conventional tillage
- T2: Basin Vs Conventional tillage (i.e Vs = verses)

Basin was constructed two months earlier from its sowing date (i.e May 28, 2013), so as to conserve moisture. Sorghum variety (Chare) was used and its seed rate was 10 kg/ha. Additional packages were used, such as weeding (1 up to 3 times), digging, row planting and herbicides (like, Glyphosate). As its dimension can vary according to its soil stability, for this study it was prepared to be a length of 35 cm, width 15 cm and depth 20 cm. The spacing between basins was 20 cm and the recommended blanket amount of Di -Ammonium Phosphate (DAP) (100 kg/ha) at sowing date and Urea (50 kg/ha) at development growth stage (35 days) was applied in banding method of application. Accordingly, necessary crop parameters and farmers perception were collected for analysis.

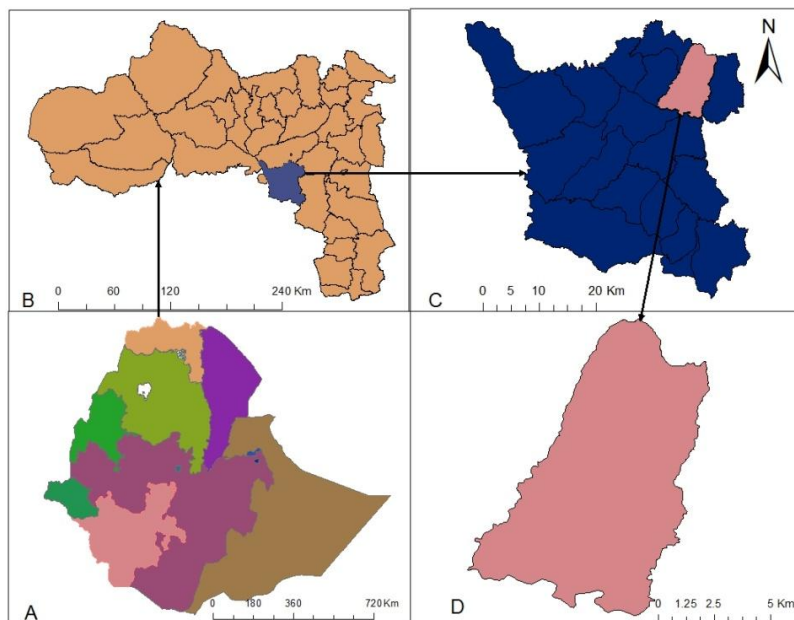


Fig. 1. Map of the study area, A= Ethiopia, B= Tigray region, C= Tanqua Abergelle Wereda and D= Sheka tekli tabia

2.3 Data Analysis

As the experiment was evaluated for two consecutive years, only grain yield and farmer's perception were collected. The collected data was then subjected to simple descriptive statistics for detecting the difference between the conservation agriculture practices and the conventional farming system at $p=0.05$ probability level. As the experiment was held at the Sheka tekli (i.e FTC) testing site, it was assumed that the source of variation between treatments and external factors was kept minimum. Hence, deviation was used to evaluate if there is a difference in yield and other parameters between treatments.

3. RESULTS AND DISCUSSION

3.1 Conservation Technologies over Conventional

From the field trial, the results showed a significant sorghum yield, between conservation farming technologies under study and conventional practices. The highest grain yield of sorghum obtained from tie-ridger (1.6 ton/ha) and the next successive one, basin (1.31 ton/ha), respectively. Comparatively the lowest yield obtained from conventional practices. The result indicated that there was a highly deviation among application of tie ridger and basin technologies, as well as with the conventional practices for sorghum grain yield. This implies that sorghum production, using conservation farming practices (tie ridger and basin), provides better yield than using conventional practices (Table 1). So, I concluded that the application of conservation tillage brought significant effect of agricultural productivity compared to the conventional tillage.

Percent of deviation (d in %) from the control (C) was calculated using (Eq.(1)). Y and C represent the measured data (grain or above ground biomass or soil water data) obtained in the conservation farming practices and its corresponding value in the control treatments, respectively. This type of equations was used in maize and lentil yield assessment by Odendo et al. [13], respectively.

$$d = \frac{Y-C}{Y} * 100 \quad (1)$$

Conventional tillage revealed the lowest grain yield of sorghum in the most of the farmers' field. The yield obtained from conservation agriculture

was higher in most of the farmers land as can also be observed (Fig. 2).

The results were in line with the findings of Brhane [14], that demonstrated sorghum yield increment by 7 to 48% due to the effect of conservation tillage integrated with fertilizers compared to the traditional tillage, in the semi-arid areas of northern Ethiopia. The increment of yield due to the tied-ridging and fertilizer interaction effects were higher for Chibalas compared to Woitozira. The mean sorghum crop yield for Chibal was 1.45 ton/ha and that of Woitozira was 1.31 ton/ha. The investigation indicated tied-ridging increased sorghum grain yield by more than 40%, as compared to the traditional tillage practice (shilshalo) [14]. Similarly, [8] compared conservation tillage practices in the Adigudom area of Tigray region. The average barley yield was 1650 kg/ha above the bund, which was 43% higher than below the bund.

3.2 Constraints in the Adoption of Conservation Tillage

A mental change of farmers, extensionists, researchers and other stakeholders away from soil degrading tillage operations towards sustainable production systems like no tillage is necessary to obtain changes in attitudes of farmers [15]. The adoption of conservation tillage (CT) is constrained by a number of factors that are both environmental and socio-economic [16]. While all facts prove the superiority of CT compared to conventional tillage adoption by smallholder farmers are still low. The semi-arid region of Ethiopia is characterized by low and erratic rainfall coupled with high evaporation rates, which makes it difficult to produce sufficient biomass for soil cover [17]. Moreover, lack of grazing during dry seasons and the system of communal grazing restricts the possibility of leaving crop residue on the field after harvest [18]. Zero tillage without mulch can produce significant losses. The semi-arid region of Ethiopia is characterized by low organic matter content [19] which makes them prone to compaction. In addition if some of the crop residue left, burning of crop residues has become also a common feature in our region. This also creates environmental problem.

The other factor is also technical and socio-economic factors such as the need for dry season animal feed and high costs of herbicide are among others [20]. The possible challenges for the future adoption of CF in Ethiopia include

Table 1. Yield deviations between conservation agriculture and conventional tillage

| Treatments | Conservation Agriculture (CA) | |
|-----------------------|-------------------------------|-------|
| | Tied ridger | Basin |
| CA (ton/ha) | 1.6 | 1.31 |
| Conventional (ton/ha) | 1.2 | 1.1 |
| Deviation (%) | 26.7 | 19.1 |



Fig. 2. Some representative photos of the conventional tillage and conservation agriculture practices at tabia sheka tekli

how to improve farmer awareness of CF benefits and how efficiently incorporate green manure and cover crops.

The other major challenge for the adoption of conservation tillage is weed infestations associated with reduced tillage [20]. Even though one of the primary purposes of tillage is weed control, with reduced tillage or zero tillage weeds become the serious challenge. So, manual labours are employed to apply herbicides and are too costly for the poor farmers. Moreover, the high costs of conservation tillage implements have also affected the wider adoption of the technology [21]. It will be better if cost effective tillage technologies that take into account all smallholder farmers in the light of costly living conditions will make easy to adopt and increase yields from a drop of water.

The establishment of furrows and ridges increases soil moisture and grain yield and reduces soil loss. However, dissemination of the modified tools remains limited. Recent tendencies are towards testing relatively simple conservation agriculture tools. Major challenges remain, however; the need for capacity building and problems in marketing the tools [22].

3.3 Farmers' Perception

Farmers' perception was collected on the attributes of tie ridger and basin, and response of the technologies on grain yield. Most of the respondents believed that conservation farming technologies were best in grain yield than conventional practices. They also stated that basin is very important for efficient and effective use of the applied fertilizer as this couldn't be affected by sheet or splash erosion. However, farmers complain for labor intensiveness of the technology, particularly for large areas, its applicability of this technology could be tedious. Instead, farmers were believed that for further use and popularize tied ridger for moisture and soil fertility managements. Farmers were also complaining on the use of crop residue (particularly sorghum residue) is susceptible to weed infestations.

4. CONCLUSION AND RECOMMENDATION

Conservation tillage is an important strategy for improving soil fertility, which in turn increased agricultural productivity under moisture deficit

and high rainfall areas. Even though conservation tillage changes soil properties, improved grain yields and reduced soil loss, the adoptions by smallholder farmers are usually inconsistent and are still low. The mean sorghum grain yield obtained from conservation tillage by far exceeded than conventional practices. Sorghum production using tie ridging and basin, provided a yield advantage of 26.7% and 19.1% over conventional practices, respectively. So, application of conservation tillage brought significant effect of agricultural productivity compared to the conventional practices. This would be due to the complexity of changes in soil properties caused by tillage. Environmental and socio-economic factors especially weed infestations and unaffordable costs of the conservation tillage technologies are among the major challenges for its adoption in Tigray region, as well as in Ethiopia. Hence, investment in these conservation farming systems is expected to increase agricultural production.

In moisture stressed areas high evaporation, low infiltration, reduced soil fertility and low water productivity are the major problems, hence, conservation tillage technologies are more appropriate. Locally adaptable improved and appropriate conservation tillage would be needed to achieve a more sustained agricultural production. Thus, further popularization and scaling out of conservation farming technologies to locations prone to moisture stress areas should be implemented by the research centers and stakeholders.

CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the author(s).

ACKNOWLEDGEMENT

The authors would gratefully need to acknowledge the project dry land coordination group (DCG) for financial funds of this research activity. Moreover, all staff members of Abergelle agricultural research center who directly or indirectly helped in data collection and other research activities are highly acknowledged.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Wolde M, Veldkamp E, Mitiku H, Nyssen J, Muys B, Kindeya G. Effectiveness of exclosures to restore degraded soils as a result of overgrazing in Tigray, Ethiopia. *J. Arid Environ.* 2007;69:270–284.
2. Haregeweyn N, Poesen J, Verstraeten G, De Vent J, Govers G, Deckers S, Moeyersons J. Specific sediment yield in Tigray-Northern Ethiopia: Assessment and semi-quantitative modelling. *Geomorphology.* 2005;69:315-331.
3. Gibbon P, Bolwig S. The economics of certified organic farming in tropical Africa: A Preliminary Assessment', DIIS Working Paper 2007:3. Copenhagen: Danish Institute for International Studies; 2007.
4. Carney D. (ed.). Sustainable rural livelihoods: What contribution can we make? London: Department for International Development; 1998.
5. Sustainable Land Management (SLM). Tigray-Planning Workshop proceedings, June 19-20, Mekelle, Tigray, Ethiopia; 2008.
6. Oicha T, Cornelisc WM, Verplancke H, Nyssen J, Govaerts B, Behailu M, Haile M, Deckers J. Short-term effects of conservation agriculture on Vertisols under tef (*Eragrostis tef* (Zucc.) Trotter) in the northern Ethiopian highlands. *Soil & Tillage Research.* 2010;106:294-302.
7. Araya T, Cornelis WM, Nyssen J, Govaerts B, Gebregziabher T, Oicha T, Getnet F, Raes D, Haile M, Saire KD, Deckers J. Effects of conservation agriculture on runoff, soil loss and crop yield under rainfed conditions in Tigray, Northern Ethiopia. *Soil Use and Manage.* 2011;27: 404–414.
8. Araya T, Cornelis WM, Nyssen J, Govaerts B, Raes D, Sair KD, Deckers J. Building resilience against drought and soil erosion: impact of field water conservation in the drought prone Vertisol areas of northern Ethiopia. *Agro. Environ. Wageningen;* 2012.
9. Kruger H, Berhanu F, Yohannes G, Kefeni K. Creating an inventory of indigenous soil and water conservation measures in Ethiopia. In: Sustaining the soil: indigenous soil and water conservation in Africa, eds C., Reij I., Scoones C, Toulmin D, International Institute for Environment and Development Earthscan UK; 1996.

10. FAO. Conservation Agriculture, Food and Agricultural organization; 2008. Available:<http://www.fao.org/ag/ca/index.html> (last access: 8 July 2014).
11. Araya T, Nyssen J, Govaerts B, Lanckriet S, Baudron F, Deckers J, Cornelis W. Eight years of conservation agriculture-based cropping systems research in Eastern Africa to conserve soil and water and mitigate effects of climate change. *Geophysical Res.*2014;16:86-1.
12. Corner RA, Bassman JH, Moore BC. Monitoring timber harvest impacts on stream sedimentation: Instream vs. upslope methods. *Western J. Appl. For.* 1996;11(1):25–32.
13. Odendo M, Ouma J, Wachira S, Wanyama J. Economic assessment of maize yield loss due to stem borer in major maize agro-ecological zones of Kenya. *In: African Crop Science Conference Proceedings.* 2006;6:683–687.
14. Brhane G. Effect of Tillage and Fertilizer Practices on Sorghum Production in Abergelle Area, Northern Ethiopia. *MEJS.* 2011;4(2):52-69.
15. Derpsch R. Keynote: Frontiers in conservation tillage and advances in conservation practice. In Stott D. E., Mohtar R. H. and Steinhart G. C. (Eds.), *Sustaining the global farm. Selected papers from the 10th International Soil Conservation Organisation Meeting held May 24-29, 1999 at Purdue University and the USSA-ARS National Soil Erosion Research Laboratory;* 2001.
16. Castrgnano A, Maiorano M, prudenzano Fornaro, Cafarelli B. Assessment of the effect of tillage and crop residue management on soil impedance taking into account spatial heterogeneity. *In: World Congress on Conservation Agriculture, Madrid, and 1-5 October, 2001. XUL Avda. Medina Azahara 49, pasaje, 14005 Cordoba, Spain.* 2001;133-147.
17. Tenalem A. Water management problem in Ethiopian rift. Challenges for development. *J. Afr. Earth Sci.*2007;48: 222-236.
18. Kossila V. The availability of crop residues in developing countries in relation to livestock populations. In: Reed J.D., Capper B.S, and Neato P.J., (eds.). *Plant Breeding and the Nutritive Value of Crop Residues. Proc. Workshop held at ILCA, Addis Ababa, Ethiopia, 7-10 December 1987, ILCA, Addis Ababa, Ethiopia;* 1998.
19. Mulatu T, Regassa T. Nazriet mixed farming systems zone survey report. Research report No, 2/87. Department of Agricultural Economics and Farming Systems Research, Institutes of Agricultural Research, Addis Ababa, Ethiopia; 1986.
20. Temesgen M. Conservation tillage systems and water productivity implications for smallholder farmers in semi-arid Ethiopia, PhD Thesis, Taylor & Francis/Balkema, Leiden, the Netherlands; 2007.
21. Steiner KG. Conserving natural resources and enhancing food security by adopting no-tillage. An assessment of the potential for soil conserving production systems in various agro-ecological zones of Africa. Published by GTZ. Postfach 5180. D-65726 Eschborn. 1998;47.
22. Nyssen J, Govaerts B, Araya T, Cornelis WM, Hans B, Haile M, Sayre K, Deckers J. The use of the *marasha* ard plough for conservation agriculture in Northern Ethiopia. *Agronomy Sustain. Devel.* 2011; 31:287-297.

© 2020 Assefa and Weleslasie; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:
The peer review history for this paper can be accessed here:
<http://www.sdiarticle4.com/review-history/56649>