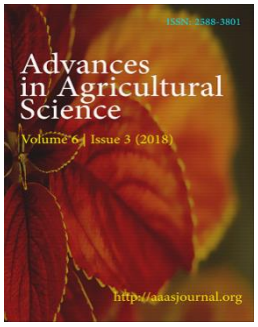
Advances in Agricultural Science

Volume 6 (2018), Issue 03, 17-24

Journal homepage: www.aaasjournal.org

ISSN: 2588-3801



Research Article Open Access

Evaluation of the effect of mouldboard plow and tied-ridger on wheat productivity in Atsibi and Ganta Afeshum districts, Ethiopia

Mulubrehan Kifle [1], Gebremariam Yaebiyo Dimtsu [1*] and Tesfay Gebretsadikan [2]

[1] *Tigray Agricultural Research Institute, P.O.Box 492, Mekelle, Ethiopia.*

[2] *UNESCO-IHE Institute for Water Education, P.O. Box 3015, Delft, Netherlands.*

ARTICLE INFO

Article history:
Received: February 23, 2018
Revised: April 04, 2018
Accepted: April 16, 2018
Available online: September 15, 2018

Keywords:
Mouldboard
Tied-ridger
Economic analysis
Atsibi and G/Afeshum districts

[*] Corresponding Author;
E. Mail: gyaebiyo@gmail.com

ABSTRACT

Ethiopian agriculture is characterized by traditional farming techniques and it is affected by soil moisture deficiency. Hence, an experiment was conducted to evaluate the effect of mould board plow and tied ridge on wheat productivity in G/Afeshum and Atsbi districts. Four test plots for the comparison were laid on a single farmer's land and this was replicated among six farmers. The treatments were plowing with local *maresha* (control), mouldboard, mouldboard plow and tied with tie-ridger, local *maresha* and tied with tie-ridger. Cost and benefit analysis was employed to conduct the economic feasibility of the improved farm implements. The results revealed that the highest yield (2870 $kgha^{-1}$ in Atsibi and 2950 $kgha^{-1}$ in G/Afeshum) and lowest yield (2130 $kgha^{-1}$ in Atsibi and 1972 $kgha^{-1}$ in G/Afeshum) were recorded from mouldboard and tied-ridge plow and local *maresha* plow, respectively. The highest net benefit (14,730 $ETBha^{-1}$ in Atsibi and 17,770 $ETBha^{-1}$ in G/Afeshum) was obtained from using the mouldboard and tie-ridger in both districts. Whereas the lowest net benefit (10,926 $ETBha^{-1}$ in Atsibi and 11,995 $ETBha^{-1}$) was recorded in using local *maresha* in both districts. This indicates that using both the mouldboard and tie-ridger can bring additional benefit to the farming community. Most of the farmers have perceived the tied-ridger to be more effective in moisture conservation than the local *'Dugree'*. They stated that mouldboard plows deeper so that the residuals and weed were buried deep inside and changed into compost. Therefore, there should be institutional services that facilitate an access for the implements.

1. Introduction

Ethiopian agriculture is predominantly of subsistence nature, characterized by the use of traditional farming techniques/implements and practices. The main feature of rainfall in semi-arid regions is very erratic and completely unpredictable (Brooks and Tayaa, 2002). Periodic low soil moisture due to erratic and poorly distributed rainfall, severe soil erosion and runoff loss of water have been the prominent causes for the low agricultural productivity in the Ethiopian highlands (Heluf and Yohannes, 2002). Haregeweyn *et al.*, (2005) also concluded that moisture stress is the limiting factor for the productivity of rainfed agriculture in the semi-arid regions of northern Ethiopia.These problems were mainly attributed to the inadequate efforts and absence of technologies proved to conserve the soil and water resources. In the last two decades a lot of soil and water conservation practices have been done through watershed

approach in Ethiopia, especially in the Tigray region. However, there is still deficiency of soil moisture in the part of the land far away from the soil and water conservation structures. A drought year whose total rain is well below the long-term average may still include periods of excessive rain and flooding, while a high-rainfall season may include periods of drought (Brooks and Tayaa, 2002).

Hence, introduction and evaluation of in-situ soil moisture conservation practices using improved farm techniques/implements is essential to solve this problem. Among these, tied ridging is an effective practice to conserve soil moisture and increase crop yields (Moldenhauer and Onstand, 1977).The tied-ridge is meant that for reducing runoff by creating a series of micro basins in the field. Farmers did not accept the tie-ridger developed earlier as it was mounted behind the *maresha* (it is a tillage tool that most Ethiopian farmers use for land preparation), which had to be lifted independently and the draft requirement was higher than *maresha*. The tie-ridger was, therefore, modified such a way that it is mounted on the small *maresha*. Its power requirement was thus reduced to 77.8 % of that of *maresha*. Heluf (2003) concluded that in areas with low and erratic rainfall, soil and water conservation is indispensable for increasing crop yields. Kumar and Rana (2007) also reported that adequate soil moisture is the key to successful crop production in dryland areas. Yield and yield components were significantly affected by moisture conservation practices such as tied-ridge (Yoseph and Gebre, 2015).

The local *'Erfi'* and *'mofer'* attached mouldboard plow is a well-designed modified type animal driven tillage implement which is similar to tractor mounted primary tillage implement. Farmers had rejected previously introduced animal driven mouldboard plow because it was complicated and heavy. The weight of newly modified mouldboard plow reduced from 26 kg to 15 kg and its design also made it simple to assemble as well as to operate (Melesse, 2000). The reduction in weight has avoided the problem of soil compaction and hard pan formation. According to Melesse *et al* (2001), the improved *erfi* and *mofer* attached mouldboard plow has advantage over the traditional *maresha* on the yield of maize. Steel mouldboard ploughs introduced by the Italians in the 1930s was unsuccessful at smallholder level due to its heavy weight and the higher power requirements (Solomon 2006).

Even though there are different studies which show the effect of tied-ridging on maize and sorghum productivity, they are site specific and do not represent for the whole agroecology, crop and soil types. Furthermore, the technology is not implemented widely and there is no full information about the combination effect of mouldboard and tied-ridger. There is a need for further study with regard to the effect of these improved farm implements on major crops productivity on flat to gentle slopes and different agroeclogical conditions. Therefore, the objective of this study was to evaluate the effect of the improved *''Erfi'* and *'mofer'* attached mouldboard plow and tie-ridger on wheat productivity and to collect farmers' perceptions on the technologies.

2. Materials and Methods

2.1. Description of the study areas

The study was conducted in G/Afeshum and Atsibi districts (Figure 1). G/Afeshumis located 120 km north of Mekelle and Astbi is located 65 km northeast of Mekelle, the capital city of Tigray region, Ethiopia. The altitude of Atsibi ranges from 918 to 3,069 m and 75 % of the district is in upper highland (*dega*). Lithic Leptosols are the soil types covering nearly 100% in the district, except in some parts where Vertic Cambisols are also observed (IPMS, 2005). Its annual rainfall is between 400 and 972 mm with an average of 600.7 mm and its minimum and maximum temperatures are 9.5 and 20.2°C, respectively (Ethiopia National Meteorological Service Agency, 2015,

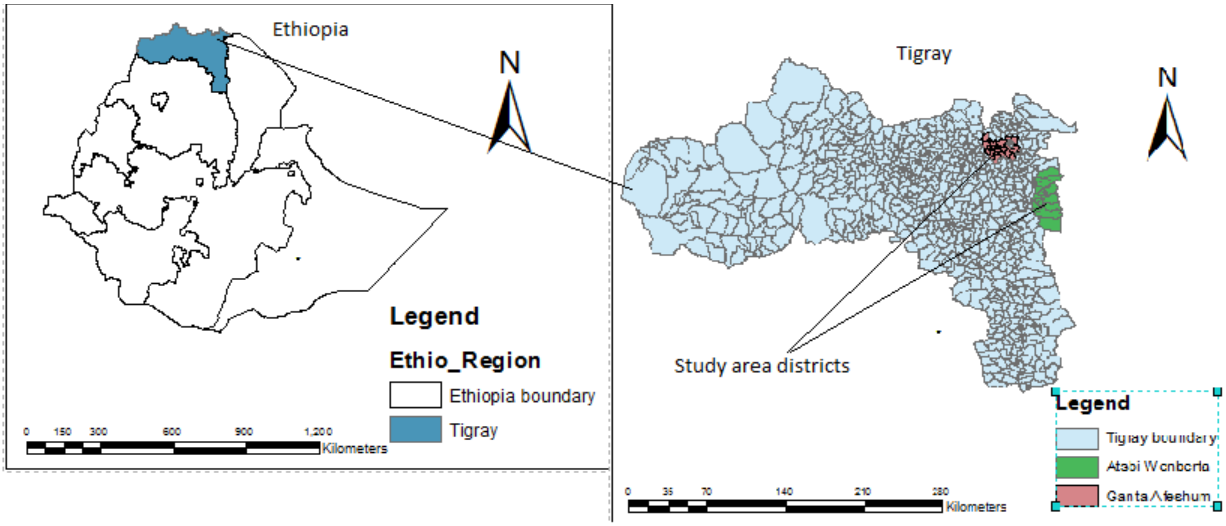


Figure 1: Study areas location.

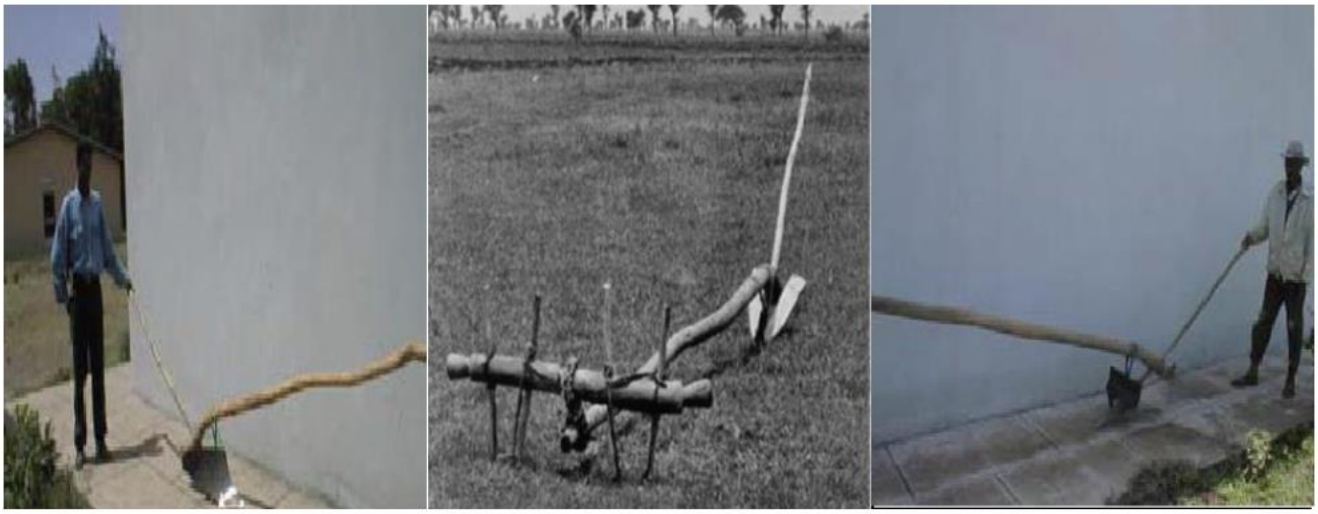


Figure 2: (a) Mouldboard (Temesgen, 2000); (b) Ethiopian local maresha (Astatke and Jabbar, 1999); (c) Tied-ridger (Temesgen, 2000).

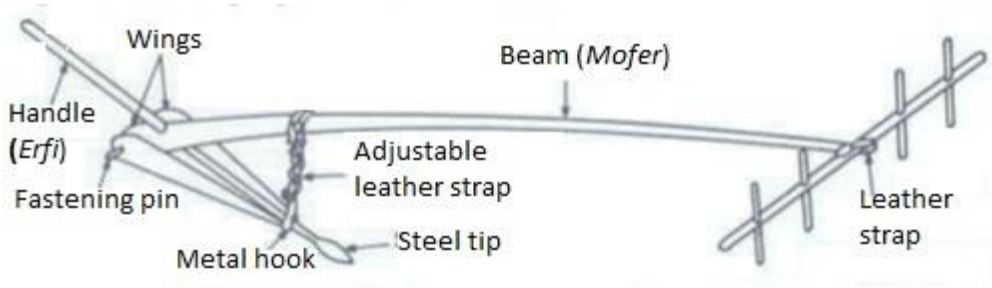


Figure 3. Components of the traditional plough (*maresha*) (Jutzi *et al.*, 1986).

Unpublished). G/Afeshum lies between latitude 14° 20′ north and longitude 39° 15′ east with a total area of 1,636.36 km^2. Its annual rain fall ranges from 372.4 – 716.5 mm with an average of 540.9 mm; and its minimum and maximum temperatures are 8 and 24.1°C, respectively (Ethiopia National Meteorological Service Agency, 2015, Unpublished). Its agroecological condition is mostly *weina-dega*. Population density in G/Afeshum is 54.17 persons km^{-2}, with an average of 4.59 persons to a household (CSA, 2008). The main food crops cultivated in both districts are mostly wheat and barley. Traction power is provided by oxen. The major hazards to crop production are: rust which affects the cereals, and drought.

2.2. Treatments and procedures

For the evaluation of the improved farm implements, three farmers from each district of G/Afeshum and Atsbi were selected. Informal and formal discussion with the farmers carried out to have better knowledge on the improved tied-ridger and *'Erfi'* and *'Newit'* attached mouldboard plow effectiveness starting from planting time up to harvesting time. Four test plots for the comparison were laid on a single farmer's land and this was replicated among six farmers. The size of the test plot was 6 m by 12 m and sown by wheat. The yield was compared among the four treatments. The treatments were plowing with local *maresha* (control), plowing with mouldboard plow, plowing with mouldboard plow and tied with tied-ridger, and plowing with local *maresha* and tied with tied-ridger. The animal-drawn implements used for this experiment are shown in figure 2. Cost and benefit analysis was carried out among the treatments. The costs that vary across the treatments and the benefits obtained from the respective treatments were computed.

Most components of the traditional plough (*maresha*) (Figure 3) are produced from local timber except leather strap, steel tip and metal hook. Blacksmiths make the metal part of the *maresha* by forging to the required shape and size.

The plots were ploughed by tied-ridger during the planting time of the crop after ploughing by the mouldboard at the appropriate time. The sketch map of the furrows and ridges constructed by the tied-ridger are shown in figure 4 below. The furrows were tied in a staggered position and closed at the end (Figure 4).

3. Results and Discussions

As indicated in Table 1, the highest wheat productivity was recorded from using mouldboard and tie-ridger which was by 34.7 % higher than using the local *maresha*. Moreover, the net benefit obtained from using the mouldboard and tie-ridger out smarts the net benefits from the rest three combinations in Atsbi (Table 1).

The difference in net benefits between local *maresha* and the other three treatments are 3804, 2874, and 1416 $ETBha^{-1}$ for mouldboard with tied-ridger, mouldboard, and local *maresha* with tied-ridger, respectively. This indicates that local *maresha* is dominated by the other three treatments. Hence, using both the mouldboard and tie-ridger can bring additional benefit to the farming community in Atsibi. More weeds were observed in using local *maresha* with tied-ridger and only local *marehsa* than using mouldboard. This could be related to the fact that if weed seeds cannot be exposed to the surface or not destroyed by effective ploughing, they can be regrown when they get moisture. Similarly, the result in G/Afeshum showed that the highest wheat yield was recorded from using both the mouldboard and tied-ridger and the lowest was recorded from using of local *maresha* (Table 2). Moreover, using of mouldboard with tied-ridger can add a benefit of 5775 $ETBha^{-1}$ compared to using the local *maresha* alone. The computation from the cost and benefit analysis generally indicated that using the "mouldboard and tied-ridger", "mouldboard alone" and "local *maresha* and tied-ridger" has

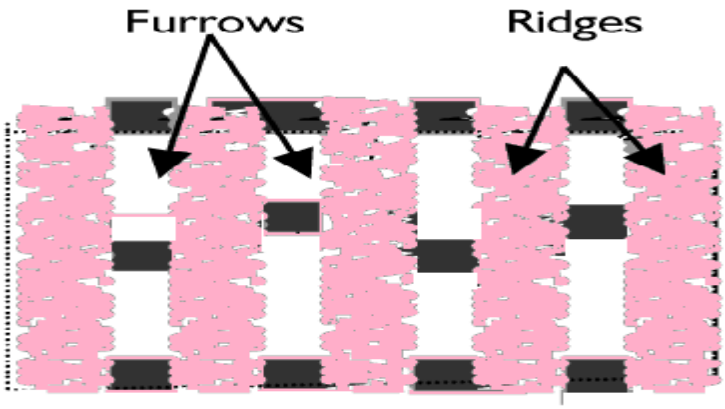


Figure 4. Ridges and furrows in tied-ridger plowed plot

Table 1. Wheat productivity and partial budget analysis under different farm implements in Atsibi.

	Treatments			
	Mouldboard and Tied-ridger	Mouldboard	Local '*maresha*' and Tied-ridger	Local '*maresha*'
Gross farm gate benefits				
1.Average yield (kgha^{-1})	2870	2690	2403	2130
2.Farm gate priceduring the study (ETBkg^{-1})	6	6	6	6
3.Gross farm gate benefits (ETB/ha) (1x2)	17,220	16,140	14,418	12,780
Costs (ETBha^{-1})				
4.Weed control/labor/ (ETBha^{-1})	480	480	528	552
5.Harvesting/Labor/ (ETBha^{-1})	390	390	360	300
6. Cost of implements (ETB)	750	600	300	150
7.Total Variable input costs (ETBha^{-1}) (4+5+6)	1620	1470	1188	1002
8.Net benefit (ETBha^{-1}) (3-6)	14,730	13,800	12,342	10,926

ETB – Ethiopian birr, ha - hectare

economic advantage compared to the "local *maresha*" in that order (Table 2). More weeds were observed in using local *maresha* with tied-ridger and only local *marehsa*. Whereas, in using mouldboard, more weed seeds were brought to the surface or buried deep inside and could be destroyed during the next ploughing season, thereby producing a weed-free field after planting.

The differences in crop yields could be attributed to the differences in soil moisture conservation among the treatments. Other studies such as McHugh et al. (2007) reported that ridges significantly increased soil moisture and grain yield and reduced soil loss in north Wollo, Ethiopia.Tied-ridger is the best practice of moisture conservation practices that will increase crop productivity through enhanced soil moisture retention during the crop growing period (Yoseph and Gebre, 2015). Heluf and Yohannes (2002) observed maize yield increments of 15 to 50 % due to tied-ridges and 15 to 38 % for sorghum on different soil types of eastern Ethiopia. Temesgen et al (2001) also revealed that the use of the tied-ridger increased grain yield of maize by 22.3 % compared to the farmers' practice of flat planting. Similarly, Solomon (2015) reported that the grain yield of early maturing maize varieties was significantly affected by moisture conservation practices. On the other hand; Tekle (2014), reported that grain yield of

Table 2. Wheat productivity and partial budget analysis for wheat production under different farm implements in G/Afeshum

	Treatment			
	Mouldboard and Tied-ridger	Mouldboard	Local '*maresha*' and Tied-ridger	Local '*maresha*'
Gross farm gate benefits				
1. Average yield ($kgha^{-1}$)	2950	2800	2424	1972
2. Farm gate price ($ETBkg^{-1}$)	6.6	6.6	6.6	6.6
3. Gross farm gate benefits ($ETBha^{-1}$) (1x2)	19,470	18,480	15,998	13,015
Costs ($ETBha^{-1}$)				
4. Weed control/labor/ ($ETBha^{-1}$)	500	500	550	550
5. Harvesting/Labor/ ($ETBha^{-1}$)	450	420	350	320
6. Cost of implements (ETB)	750	600	300	150
7. Total Variable input costs ($ETBha^{-1}$) (4+5+6)	1700	1520	1200	1020
8. Net benefit ($ETBha^{-1}$) (3-6)	17,770	16,960	14,798	11,995

ETB – Ethiopian birr,ha– hectare

cowpea was not affected significantly due to moisture conservation practices. This indicates that considering the type of crop instead of using farmers' practices in moisture stress areas; therefore, it is essential to use tied-ridger for maximum crop production.

Using of mouldboard and tied-ridger reduces surface area thus minimizing loss of moisture through evaporation. They could be laid along the contour and be used to check run-off, thus conserving soil and water. The draft force required by the mouldboard plough for a given area of cross section is smaller than that of the *Maresha*. Hence, the draft force can be reduced to a level less than that of the *Maresha* (Temesgen, 2000). *Maresha* modified subsoilers have been found to effectively disrupt the plow pan resulting in increased infiltration (Temesgen *et al.,* 2009; McHugh *et al.,* 2007). Plow pan formation under *Maresha* cultivation has been found elsewhere in Ethiopia with its peak located at a depth of 18–20 cm (Biazin *et al.,* 2011; Temesgen *et al.,* 2008).

The second method of data collection /qualitative data collection/ using participatory research appraisal (PRA) method with particular attention to Focus Group Discussion was also used to look into the merits and/or demerits of the improved farm techniques beyond economic feasibility. Discussion with key informants and groups in both communities resulted in similar feedbacks. Farmers were able to compare the new plough with that of the traditional (*maresha*). The farmers' views on the use of the improved farm techniques are as follows: all farmers in the groups agreed that moisture stress is a priority problem in the area. They reported a 34.7 to 49.6 % increase in yield resulting from the new plough, the highest advantages having been obtained in season of severe moisture stress. They

had known the implements/particularly the tied-ridger/ before and that they refused them for being awkward for the oxen. The farmers in the study area use an indigenous ridging practices such as using the woody furrowing part of the plough /locally called '*Dugree'/.*Now, they have perceived the techniques/implements to be well designed in such a way that they are easy for operation. In comparison, most of the farmers have perceived the tied-ridger to be more effective in moisture conservation than the local *'Dugree'.* According to the local farmers, the mouldboard plows deeper so that the residuals and weed were buried deep inside and changed into compost /contributing for soil fertility/; and more water could be retained. The roots could grow deeper in search of moisture and nutrients. Using of mouldboard achieved complete ploughing in one pass thereby reducing tillage passes by 50 %, hence farmers could get free time to do other activities. Draught oxen could get rest and use the extra time available for grazing which helped them maintain their body weight and remain powerful during planting time when draught power shortage was particularly critical (Temesgen, 2000). The implements are particularly important for furrowing in vegetable production such as potato, onion, garlic and tomato. Regarding the technical knowledge, they are experienced enough and can manage to operate them well. Finally, they confirmed that there is no reason for the technology to be against the values and beliefs in the community society.

4. Conclusions and recommendation

The highest wheat productivity per hectare was recorded from using mouldboard and tied-ridger in both districts. Whereas, the lowest wheat productivity was obtained from using local *maresha* in both districts. Moreover, the highest and lowest net benefits were recorded in using of mouldboard with tied-ridger and local *maresha*, respectively in both districts. The differences in crop yields could be attributed to the differences in soil moisture conservation among the treatments. More weeds were observed in using local *maresha* with tied ridger and only local *marehsa*. Hence, using both the mouldboard and tie-ridger can bring additional benefit to the farming community. From the qualitative data analysis it is concluded that all farmers in the groups agreed that moisture stress is a priority problem in the area. Farmers have perceived the techniques/implements to be well designed in such a way that they are easy for operation. Most of the farmers have perceived the tied-ridger to be more effective in moisture conservation than the local *'Dugree'*. The mouldboard plows deeper so that the residuals and weed were buried deep inside and changed into compost /contributing for soil fertility/. Therefore, there should be an opportunity for use of the implements by farmers in similar large areas of the region. Moreover, there should be institutional services that facilitate an access for the implements. Further study is needed for soil properties analysis.

Acknowledgements

We are grateful to Tigray Agricultural Research Institute for financially and transport supporting for the fieldwork part. We consider it a profound pleasure to express our deep sense of profound thanks to farmers and development agents of the study areas for their cooperation in collection of data.

References

Astatke, A. and Jabbar, M., 1999. Animal drawn implement for vertisols management and strategies for land use intensification. IBSRAM Vertisol Workshop, 8–14 May, Harare, Zimbabwe.

Biazin, B., Stroosnijder, L., Temesgen, M., Abdulkadir, A. and Sterk, G., 2011. The effect of Long-term *maresha* ploughing on soil physical properties in the central rift valley of Ethiopia, *Soil Till. Res*., 111: 115–122.

Brooks, K.N. and Tayaa, M., 2002. Planning and managing soil and water resources in drylands: Role of

watershed management. Arid Lands Newsletter No. 52, International Arid Lands Consortium.

CSA (Central Statistical Authority), 2008. Federal Democratic Republic of Ethiopia. Statistical Abstracts. Addis Ababa.

Haregeweyn, N., Poesen, J., Verstraeten, G., DeVent, J., Govers, G., Deckers, S. and Moeyersons, J., 2005. Specific sediment yield in Tigray-Northern Ethiopia: Assessment and semi-quantitative modelling. *Geomorphology*, 69: 315-331.

Heluf, G. and Yohannes, U., 2002. Soil and water conservation (tied-ridges and planting methods) on cultivated lands: The case of eastern Ethiopian; Soil and Water Management Research Program, Alemaya University (AU); 154p.

Heluf, G., 2003. Grain Yield Response of Sorghum (*Sorghum bicolor*) to Tied-Ridges and Planting Methods on Entisols and Vertisols of Alemaya Area, Eastern Ethiopia Highlands. *J. Agric. Dev. Trop. Sub-Trop.* 104(2): 113-128.

IPMS, 2005. Atsbi Wemberta district Pilot Learning Site Diagnosis and Program Design.

Jutzi, S., Anderson, F.M. and Astatke, A., 1986. Low-cost modifications of the traditional Ethiopian tine plough for land shaping and surface drainage of heavy clay soils: Preliminary results from on-farm verification trials. This is a modified version of a paper presented at the Second West African Integrated Livestock Systems Net workshop held 19 to 25, September in Freetown, Sierra Leone.

Kumar, A. and Rana, K.S., 2007. Performance of pigeon pea + green gram intercropping system as influenced by moisture conservation practices and fertility level under rain fed conditions. *Indian J. Agron*., 52: 31-35.

McHugh, O., Tammo, S., Berihun, A. and Erick, C. M. F., 2007. Performance of in-situ rain water conservation tillage techniques on dry spell mitigation and erosion control in the drought-prone North Wello Zone of the Ethiopian highlands, *Soil Till. Res.*, 97: 19–36.

Moldenhauer, W. and Onstand, C., 1977. Engineering practices to control erosion; in: Soil Conservation and Management in the Humid Tropics, edited by Greenland, D. and R. Lal, R.; pages 87–92; John Wiley and Sons, Chichester, New York.

Solomon, G., Mouazen A.M., Van Brussel, H., Ramon, H., Nyssen, J., Verplancke, H., Mintesinot, B., Deckers J. and De Baerdemaeker, J., 2006. Animal drawn tillage, the Ethiopian ard plough, *maresha*: a review, *Soil Till. Res.* 89: 129–143.

Solomon, T., 2015. On-Farm Verification of the Effects of Selected Soil Moisture Conservation Techniques on Yield and Yield Components of Early Maturing Maize Varieties at Bako, Western Ethiopia. *Int. J. Adv. Earth Sci. Engg.,* 4(1): 254-264.

Tekle, Y. 2014. Performance evaluation of cowpea (*Vigna unguiculata* L.) varieties under moisture conservation practices for yield and yield components at Alduba, Southern Ethiopia. *Int. J. Res. Agric. Sci.*1(3): 2348 – 3997.

Temesgen, M., 2000. Animal-drawn implements for improved cultivation in Ethiopia: participatory development and testing. Proceedings of the workshop of the Animal Traction Network for Eastern and Southern Africa (ATNESA) held 20-24 September 1999, Mpumalanga, South Africa. 344p.

Temesgen, M., Georgis, K., Goda, S. and Abebe, H., 2001. Development and evaluation of tillage implements for maize production in dryland areas of Ethiopia, Seventh eastern and southern Africa regional maize conference. Pp. 308-312.

Temesgen, M., Rockstr¨om, J., Savenije, H. H. G., Hoogmoed, W. B. and Alemu, D., 2008. Determinants of tillage frequency among smallholder farmers in two semi-arid areas in Ethiopia, in: Physics and Chemistry of the Earth, University Press, Cambridge, 183–191.

Yoseph, T. and Gebre, W., 2015. Evaluation of different moisture conservation practices on growth, yield and yield components of sorghum at Alduba, southern Ethiopia. *Research Journal of Agriculture and Environmental Management.* Vol. 4(3): 169-173.