Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.6, No.3, 2016

Demonstration and Popularization of Mould Board Plow with Their Production Packages in Tigray Region

Taddesse Tesfamariam
1. Mekelle Agricultural Mechanization and Rural Energy Research Center, P.O box 81, Mekelle, Tigray, Ethiopia
2. Department of Rural Development and Agricultural Extension, Haramaya University, Ethiopia.

Tadele Adisu
1. Mekelle Agricultural Mechanization and Rural Energy Research Center, P.O box 81, Mekelle, Tigray, Ethiopia
2. Department of Natural Economics, Mekelle University, Ethiopia

Abstract
Tigray is one of the national regional states of Ethiopia which is located in the North part of the country. Agriculture is the mainstay of Tigray's economy. Agriculture in Tigray is predominantly of subsistence nature, characterized by the use of traditional farming implements and practices. Improved farm implements i.e. MBP with their production package were verified and demonstrated using the local farm implements as a local check. The overall objective of the project is to help increase agricultural production and productivity through the promotion of improved agricultural mechanization technologies (Melkassa mould board plough). Representative site and farmers were selected in collaboration with staff of MoARD. Then on-farm trainings were given to farmers and DAs. The Pre-extension popularization of Melkassa mould board plough was conducted on 215 host farmers respectively, across 6 woredas of the study areas from 2012-2015. Yield, economic data and farmers' perception were collected. Descriptive statistics was used for analyzing quantitative data. The simple statistical analysis across all the demonstration sites indicated that the improved farm implements exhibited higher yield advantage and percent yield increase over the Traditional (Mahiresha). the improved MBP has 21-50% increment in productivity, 40% efficient in weed control,40 % decrease work frequency or time saving and 19% more power efficient than the traditional Maresha. The demonstration of mould board plow on farmers field for different crops such as wheat, barely, sorghum, and teff was done since 2012. and the result of the trials shows that an average yield increment of 30.5%.and the specific result based on crop type also shows that use of improved Mould Board plow had 34.8%,45.25 %26.72% and 25.2% yield increment of teff, sorghum, barely, and wheat respectively over the use of the tradition maresha. Different parameters were used to assess farmers' perception on the improved farm implement MBP. Most of the farmers interviewed perceived that MBP was technical suitable to their farm, time saving, effectiveness in weed control, and higher productivity. It was, thus, recommended that further popularizing and scale out of this improved farm implements are quite pertinent.
Keywords: Demonstration, Popularization, Melkassa Mould Board plow

1. INTRODUCTION

1.1. Back ground and justification

Agriculture is the mainstay of Ethiopia's economy. The majority of farmers operate mainly on small farms, in rain-fed cropping systems and livestock production. Small-scale farming predominately produces limited food to support the small-holder farmers and their family for consumption, leaving little to sell. Consequently, improving agricultural productivity is a national priority in Ethiopia.

Developing countries often have to rely on a variety of imported farm machines, which are seldom appropriate for small farms. Farm machines are likewise beyond the reach of most farmers owing to high acquisition and maintenance costs. Poor rural infrastructures such as roads, bridges, canals, and power network also pose as a major obstacle to farm mechanization. Also, in developing countries, farm labor is abundant; hence, the need for machinery is seldom recognized. However, the income of farmers has remained very low and the value of working day very cheap.

Ethiopian agriculture is predominantly of subsistence nature, characterized by the use of traditional farming implements and practices. According to the Central Statistical Agency of Ethiopia (CSA, 2010), the low level of crop productivity in the country is attributed to inefficient farming methods that utilize outdated crop production and protection technologies, and fragmented pieces of land holdings . To bridge the gap between the demand and supply for food, and also to enhance the desired change in the livelihood of majority of the population, MARC developed *'Erfi'* and *'Newit'* attached mould board plow. Mould board plow is a well designed modific type animal driven tillage implement which is similar to tractor mounted primary tillage implement.

Hence, this study was made in order to demonstrate improved mould board plow with their production

package and to create awareness about improved technologies of **MBP** to the farming community and assess farmers' feedback.

1.2. Overall objective

The overall objective of the project is to help increase agricultural production and productivity through the promotion of improved agricultural mechanization technology: Melkassa mould board plough end users.

2. RESEARCH METHODOLOGY

2.1. Description of the Study Area

2.1.1. Location

The study was conducted in the Tigray Regional State which is located in the northern escarpment of Ethiopia between 360-400E longitude and 12.50-150N latitude. It borders with Eretria in the north, Sudan in the west, Amhara Regional State in the southwest and Afar Regional State in the east. The landform is complex composed of highlands (in the range of 2300-3200 m.a.s.l) and lowland plains (with an altitude range of 500-1500 m.a.s.l). It has diversified agro-ecological zones and niches each with distinct soil, geology, vegetation cover and other natural resources.

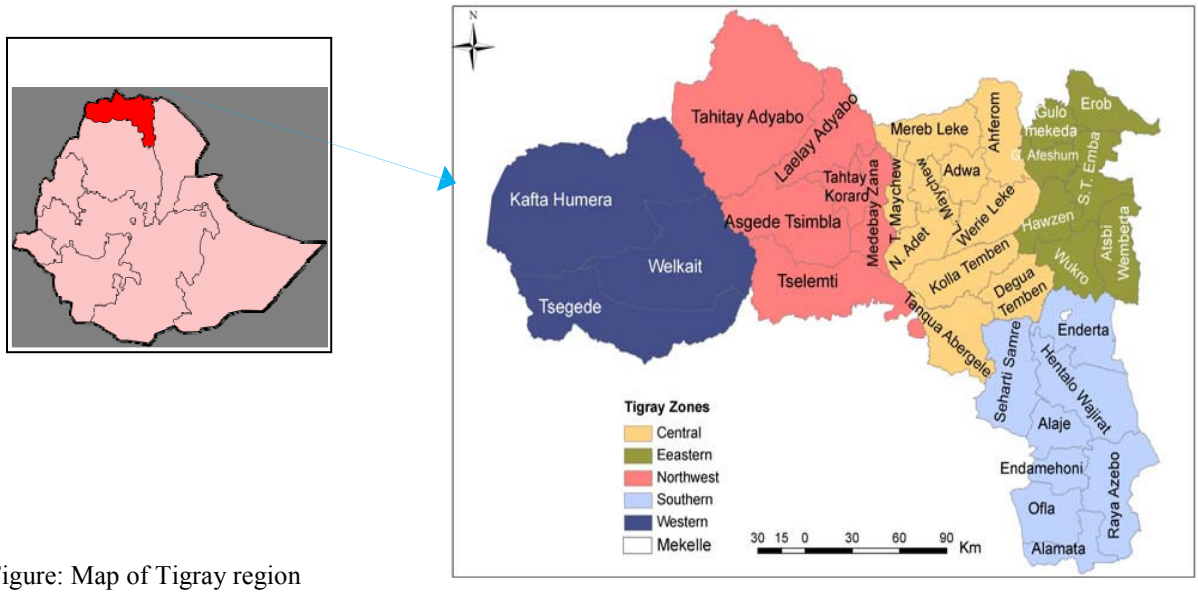

Figure: Map of Tigray region

2.1.2. Demography

According to the report of the 2007 housing and population census, the number of population of Tigray was 4,314,456. The sex composition of the population, 49.2 % of the populations is males and the remaining 50.8% are females. On the other hand, in terms of settlement, 19.5 % of the population is living in urban areas where as 80.5% is living in the rural areas of the region. The population growth in Tigray region has decreased from 2.67 % before the 2006 census to 2.5 % in the 2007 census. In general, even though the population of our Tigray has been growing from time to time, this growth is believed to create a regional workforce. (Tigray Region Plan and Finance Bureau)

2.1.3. Climate and agro-ecology

The climate of Tigray is highly unpredictable characterized specially by unreliable rainfall. The region is a semi-arid area characterized by a long dry season. The main rainy season (locally called *kiremt*) lasts for 3 to 4 months, between June and mid-September (Araya et al., 2010; Gebrehiwot and van der Veen, 2013). Moreover, some part of the region also gets a small rain shower (locally known as *Belg*) from February to May. Tigray Region belongs to the African dry land zones often called the Sudano-Sahalian region. Rainfall distribution in the region is characterized by high temporal and spatial variability with annual precipitation ranging from 500 to 1000 mm. Average annual rainfall varies from 200 mm in the eastern lowlands to over 1800 mm in the western highlands.

2.1.4. Socio-economic condition

Livelihoods in Tigray region are significantly dependent on agricultural income options supported by off-farm income generation such as labor trading and petty trade. However, agricultural production and diversification remain low. Agriculture of **Tigray** is characterized by overwhelmingly small holdings due to higher population density and nearly 85 per cent of its population residing in the rural areas coupled with unabated land fragmentation. In this region the average size of land available to a four persons is about 0.5 hectare, too small to support the family on agricultural production alone. The average production of cereals (the major agricultural output) is less than 7 quintals per household in the drought prone areas and this level of staple cereal production

can only feed a family only for 5-8 months a year at best (Kidane, 2006).

The region, thus, is highly vulnerable to recurrent droughts and with reducing trend of natural resources. The regional government, currently, together with other development partners is working to reverse this situation. Multifaceted efforts are being undertaken to improve the living conditions of the people in the region and the nation as a whole with the assistance of donor agencies and international communities.

2.2. Site selection and Group formation

Rapid assessment, community meeting and group discussion was conducted for the selection of the specific target groups. Representative site and farmers were selected in collaboration with staff of MoARD. The centre was prepared familiarity workshop and make understanding about the intended activities with each woreda officials and experts. Based on this, interested farmers in each woreda were selected by the DAs and woreda experts together with us. The participants had their own land and volunteer to cultivate with his/her own labour by getting support from the research centre and the woreda office. The site selection, group formation, training implementation and related activities was made in different months of the year according the proposed plan. Frequent supervision was made by researchers and extension group of MoARD for evaluation and technical backstopping.

Demonstration of improved farm implements of MBP with their production packages was conducted. At the same time before intervention, baseline information about the target group was collected using structured questionnaires which were utilized for future impact assessment. 215 farmers from six woredas of Tigray were participated. It was conducted for three consecutive years from 2004/05 to 2006/07. The target *woredas*, *Tabiyas* and host farmers were selected purposively. In order to create awareness on advantage of improved technologies over the local farm implements, two treatments were demonstrated i.e. improved farm implements with and local farm implements with farmers' traditional practices. 2500 m2 area each was used for the demonstration.

Factors such as time, method and frequency of land preparation, time and method of sowing and harvesting were applied as per the farmers' practices. A detailed labor and yield component perception data were collected during each year cropping cycle. Field days and individual observations were employed to gather feedback from farmers and development agents.

2.3. Method of Data collection

Data collection involved desk studies, expert consultations, discussion with key informants and household surveys**.** Interviews were held at the farmer's fields and agriculture practices were observed and discussed. Structured and semi structured interview schedules were used to collect data of perceptions of the household on MBP from 60 sample farmers. During the study, the inherent characteristics of the improved farm implement were selected.

2.4. Method of Data analysis

Descriptive statistics (frequency, percentage, mean, SD) for quantitative data and narration for qualitative data was used for analyzing the data gathered.

3. RESULT AND DISCUSSION

3.1. Verification and Demonstration of Mould Board Plow in Tigray

'Erfi' and *'Newit'* attached mould board plow is a well designed modific type animal driven tillage implements which is similar to tractor mounted primary tillage implement. Farmers had rejected previously introduced animal driven mould board plow because of it was complicated and heavy. The weight of newly modified mold board plow reduced from 26 kg to 5 kg and its design also made it simple to assemble as well as to operate.

According to Melesse *et al* (2001), the improved *erf* and *mofer* attached mold board plow has advantage over the traditional *maresha* on the yield of maize. Both plow type and tillage frequency showed a significant effect on grain yield of the maize. The yield increment due to the mould board plows was 75%, 43% and 25% for plowing once, twice and three times respectively in comparison to the local *maresha*. Besides the yield increment, the tillage operation time also reduced by half for the second and third plows when compared to the local *maresha*.

As Mahari woldu 2000 studies in Tigray, he observed that MBP had many advantages over the tradition local farm implement'' maresha. During his verification trial, He found that the improved MBP had 21-50% increment in productivity, 40% efficient in weed control,40 % decrease work frequency or time saving and 19% more efficient draft power than the traditional Maresha.

Table : A partial budget analysis for wheat production under different plowing technologies in Atsbi /Felegewoini/

	Treatment		
	Mould board & Tie-ridger	Mould board	Local 'maresha'
Gross farm gate benefits (Birr/ha)			
1. Average yield (Q/ha)	28.70	26.90	21.30
2. Farm gate price(Birr/Q)	600	600	600
3. Gross farm gate benefits (Birr/ha) (1x2)	17,220	16,140	12,780
4. Weed control/labor/ (Birr/ha)	480	480	552
5. Harvesting/Labor/ (Birr/ha)	390	390	300
6. Total Variable input costs (Birr/ha) (4+5)	870	870	852
7. Net benefit (Birr/ha) (3-6)	16,350	15,270	11,928
8. Change in net benefits from trt 3 to trt 1 and 2 (Birr/ha)	4422	3342	

Source Marc RCBP Report,2012

Moreover, MARC had made detail study on the improved farm impalement of Mould Board Plow. In their report to RCBP, 2002; they confirm that MBP has yield advantages over the traditional on in terms of in productivity and net benefit. Their partial budget analysis report 2010 for wheat production shows that use of MBP had 3342 birr/ha net benefit over the use of traditional maresha (Abrhaley et.al,2002).(see table below) MAMRERC also made another detail separate study on the advantage of this improved farm implements. The Project was conducted at Raya Azebo from southern zone, Tanqua Abergelle from south eastern zone and Atsibi Wenberta from eastern zone of Tigray regional state. The result is discussed below in detail.

3.2. Demonstration of MBP in Crop Field

The Different verification trials shows that the improved Mould Board plow has many advantages than the tradition maresh (Meles 2008, Mahar ,2008 and Abrahaley et.al 2010). Therefore, introduction of improved farm implements with full package is expected to increasing production and productivity of crop. Towards this end the demonstration of mould board plow on farmers field for different crops such as wheat, barley, sorghum, teff and ground nut was done since 2012. The result was measured with respect to the amount of production obtained from each demonstration.

3.2.1. Demonstration of MBP in wheat crop field of Atsibi wonberta wereda

MBP was distributed to 20 farmers who have involved in wheat production and demonstration of mould board plow on farmer's field was done. Factors such as time, method and frequency of land preparation, time and method of sowing and harvesting were applied as per the farmers' practices. The result showed that the average wheat yield gained from plot of land which was ploughed with MBP was 34.04ql per ha, where as the average wheat yield obtained from plot of land which was ploughed with TP was 27.41 ql per ha. This result showed that the MBP has yield advantages than the traditional one.

Table : Comparison in (Productivity) b/n a land plowed by MBP and TP in Wheat crop field

Wheat Crop	Farm implements	Min	Max	Mean	Mean dif	Min Dif	Max Dif	mim % increment	% max increment	% of Avg increment
Atsibi Wonberta	MBP	24	40	34.04	6.9	2	13	9.09	63.27	25.2
	TP	14.7	36	27.41						

Source: Own survey result, 2014

Thus, the mean difference between the land ploughed with MBP and the land ploughed with TP was 6.9 ql/ha. As shown in the table the minimum and maximum yield increment was 9.09% and 63.27% respectively. This result indicate that the plot of land which was ploughed with MBP had 25.2% yield advantage over the tradition one 'Maresha' in Wheat crop field

3.2.2. Demonstration of MBP in Barely crop field of Atsibi wonberta wereda

MBP was distributed to 20 farmers who have involved in barely production and demonstration of mould board plow on farmer's field was done. Factors such as time, method and frequency of land preparation, time and method of sowing and harvesting were applied as per the farmers' practices. And the result showed that the average yield obtained from plot of land which was ploughed with MBP was 18.54 ql of barely per ha, where as the average yield obtained from plot of land which was ploughed with TP was 14.63 ql of barely per hectare.

Table: Comparison in (Productivity) b/n a land plowed by MBP and TP in barely crop field

Barely Crop	Farm implements	Min	Max	Mean	Mean dif	Min Dif	Max Dif	mim % increment	% max increment	% of Avg increment
Atsibi Wonberta	MBP	12	20	18.54	3.91	2	5.52	10	50	26.72
	TP	8	22	14.63						

Source: MAMRERC survey result, 2014

This result showed that the MBP has yield advantages than the traditional one. Thus, the mean difference between the land ploughed with MBP and the land ploughed with TP was 3.91 ql/ha. As shown in the table the minimum and maximum yield increment was 10 % and 50 % respectively. This result indicate that the plot of land which was ploughed with MBP had 26.72% yield advantage over the tradition one 'Maresha' in barely crop field

3.2.3. Demonstration of MBP in Teff crop field of Raya and Tanqu abergelle Wereda

MBP was distributed to 20 farmers who have involved in teff production. This improved farm implement was expected to perform well in the area. As it was verified by different researchers, MBP has many advantages over the local *meresha in increasing productivity*. Factors such as time, method and frequency of land preparation, time and method of sowing and harvesting were applied as per the farmers' practices.

The result obtained from the teff crop field is presented in the table below and it shows that the average yield obtained from plot of land which was ploughed in Raya with MBP was 11.73 ql of teff per ha, where as the average yield obtained from plot of land which was ploughed with TP was 8.7 ql/ha of teff. Thus, the mean difference between the land ploughed with MBP and the land ploughed with TP was 3.03 ql/ha. As shown in the table the minimum and maximum yield increment was 22.2% and 51.5% respectively. This result indicates that the plot of land which was ploughed with MBP had 34.8% yield advantage over the tradition one 'Maresha' in Teff crop field.

Table: Comparison of Productivity b/n a land plowed by MBP and TP in teff crop field in Raya Azebo and Abergelle

Teff Crop	Farm implements	Min	Max	Mean	Mean dif	Min Dif	Max Dif	mim % increment	% max increment	% of Avg increment
Raya	MBP	7.4	16.5	11.73	3.03	1.9	4.53	22.2	51.5	34.8
	TP	5.5	13.5	8.7						
Abergelle	MBP	4	6.5	5.57	0.66	0	1.18	0	22.18	13.44
	TP	4	5.4	4.91						

Source: MAMRERC survey result, 2013

The same trial also conducted in **Tanqu abergelle wereda** and the result obtained from the teff crop field and the result shows that the average yield obtained from plot of land which was ploughed with MBP was 5.57 ql of teff per ha. where as the average yield obtained from plot of land which was ploughed with TP was 4.91 ql/ha of teff. (It was a year of moisture stress).The result from both woreds showed that the MBP has yield advantages than the traditional one.

3.2.4. Demonstration of MBP in Sorghum Crop Field of Raya and Tanqu abergelle Wereda

Factors such as time, method and frequency of land preparation, time and method of sowing and harvesting were applied as per the farmers' practices and the result obtained from the Sorghum crop field is presented in the table below.

Table : Comparison in (Productivity) b/n a land plowed by MBP and TP in sorghum crop field

Sorghum Crop	Farm implements	Min	Max	Mean	Mean dif	Min Dif	Max Dif	mim % increment	% max increment	% of Avg increment
Raya	MBP	7.5	46.47	15.89	4.95	1.17	18.67	15	66.6	45.25
	TP	5	28	10.94						
Abergelle	MBP	14.32	40	21.76	5.96	4	8	25	62.5	37.72
	TP	9.5	32	15.8						

Source: MAMRERC survey result, 2014

The result shows that the average yield obtained from plot of land which was ploughed with MBP in Raya was 15.89 ql/ha of Sorghum, where as the average yield obtained from plot of land which was ploughed with TP was 10.94 ql/ha of teff). This result showed that the MBP has yield advantages than the traditional one. Thus, the mean difference between the land ploughed with MBP and the land ploughed with TP was 4.95 ql/ha. As shown in the table the minimum and maximum yield increment was 15% and 66.6% respectively. This result indicates that the plot of land which was ploughed with MBP had 45.25% yield advantage over the tradition one 'Maresha' in Teff crop field.

The same trial also conducted in **Tanqu abergelle wereda** and the result obtained from the Sorghum crop field in this site is presented in the table above and it shows that the average yield obtained from plot of land which was ploughed with MBP was 21.76ql of Sorghum per ha, where as the average yield obtained from plot of land which was ploughed with TP was 15.8ql/ha of Sorghum. The result from both woreds,Raya and Tanqua Abergelle showed that the MBP has yield advantages 45.25 and 37.72 respectively than the traditional one

3.3. Popularization of Mould Board Plow

Pre extension Popularization of improved farm implements of MBP with their production packages was conducted. MBP was distributed to 215 farmers in nine *Tabias* of six woredas of Tigray. These include Adwa, Tselemiti, Raya Azebo, T/mai chew,T/ koraro, Enderta kiltie Awila.elo and Wejerat. It was conducted for three consecutive years from 2012 to 2015. In order to create awareness on advantage of improved technologies over the local farm implements, the target woredas, tabiyas and host farmers with a representative field were selected purposively.

B. Result of perception of farmers

Percent of 60 households		yes	Remain the same	No
MBP	**Time saving**	75	5	20
	power saving	45	10	55
	Decrease frequency of plow	82	15	3
	weed control	95.4	4.6	0.0
	suitability	85.4	14.6	0.0
	yield	82	18	0
	biomass	90	10	0

Source: MAMRERC survey result, 2014

3.3.1. Farmers' Perceptions to Mould Board Plow

In order to get essential information and insight into farmers' perception of improved farm implements looking at their perception on each parameter/indicators are quite important. Hence, knowledge of farmers' evaluative perception on improved farm implements attributes in the study area is an appropriate issue to be discussed. This section aimed at examining farmers' perception of improved farm implements attributes. For this purpose, five verified/ known advantages of MBP, suitability to small farm, time and power saving, depth of plow weed control and productivity were used to assess farmers' perception on the improved farm implement MBP.

Based on the data collected from 60 farmers during 2013/2014 production season 86.2% of them have observed change in effectiveness of MBP in the last two years. They able to recognize that yield has increased and there has been reduction drudgery work i.e, of power and time. All farmers (50) who perceive change on yield are responding they will to continue using MBP and MBP is appropriate to their area. Different factors that farmers consider appropriate to adapt improved farm implements was mentioned.

A. Perception of suitability of MBP to small scale farms

Most of the farmers interviewed perceived that MBP was suitable to their small farm. About 85.4 percent of them perceive the MBP has no problem in application; it is almost as of the traditional Maresha. However 95 percent of those who agree in its suitability have also noticed that the MBP is more effective only in plane land with no stones (Table 3). And this was also known by researcher. The statistical record of MBP data from the different researchers also revealed that it was more effective in place where no more stony and level. Thus, farmers' perceptions appear to be in accordance with the statistical record of MBP.

B. Perception of farmers on time and power saving of MBP

With regards to the time, farmers observe that MBP reduce both plow time and frequency of plowing per plot. 65.4% of the respondents perceive that MBP have decrease time of plowing and 82% also have the perception of decrease frequency of plowing per plot, while about 14.6% of the respondents have the perception that MBP has in more change in saving of time, and 20% of the respondents have the perception that MBP has increased time of plowing or consume more time than the traditional one. This is may be due bin proper application and lack of skill to operate the improved farm implement MBP. With regards to the power, 40% of the respondents have the perception that MBP need more power than the traditional on where as 45% have the perception on the contrary and only 15% of the respondents have the perception that it is as the same as the traditional one in terms of use of power.

C. Perception of farmers on depth of plow of MBP

It is also apparent from Table below that from the total sampled farmers about 96% of them perceive or observe that plot of land plowed with MBP has more depth than Tradition Maresh. They also observe that the land plowed with MBP had more moisture and gives better performance of crop especially at its early stage.

D. Perception of farmers on weed control of MBP

With regards to the weed control, farmers observe that MBP reduce weed infestation in their plot. 95.4% of the respondents perceive or observe that using MBP have decreased amount and type of weed per plot, while only about 4.6% of the respondents have the perception that MBP had no more change weed control.

E. Perception of farmers on yield advantage/productivity increment of MBP

Ninety percent of the respondents observed changes in crop performance especially in the early stage of land development over the past 3 years, and 82 percent noticed an increase in the amount of yield. Almost 18 percent of the respondents noticed a change not in the total amount of yield, but in the crop performance in the early

stage. High variability in the timing of rains was mentioned by all farmers in the study area. Besides, they noticed that the summer is coming late and is also shorter. With regards to amount of biomass, of the total sampled farmers about 90 % of them perceived increase in amount of biomass due to MBP use in the last 2 years; whereas, 10% of them have the perception that there is no change in amount of biomass in the last 2 years because of MBP use. None of the sampled respondents had the contrary that is use of MBP has decrease amount of biomass.

4. CONCLUSIONS AND RECOMMENDATIONS

Verification and demonstration trial shows the over advantage of MBP over the tradition farm implement Maresha. The descriptive statistics, including mean and %, showed an increase in yield and biomass due to use of MBP. Moreover, the results of this study shows that majority of the farmers are well aware of the advantage of the improved farm implements, their perception on the technology, MBP, is already high. Still, however, considerable number of farmers has wrong perception of the technology that has already changed over the course of their working lives, which indicates that, further effort is required by agricultural development actors to raise farmers' awareness about the improved farm implement: The perception of local people which confirms the different advantages of MBP, on the other hand, events such as weight of the MBP and its effectiveness only in level land have observed as drawback of the technology as per farmers perception.

In Tigray most wordas are experiencing a moisture deficit and drought conditions in the last decade. If the same trend continues in the future, more chances of moisture stress are expected. Therefore, use of this improved farm implement MBP is appropriate technology in this region. And high demand is created in *tabias* where the MBP was demonstrated. Hence, there is a need to popularize the reality throughout the community by strengthening farmers' awareness on the technology.

References

Abrhaley Gebrelibanos, Mulubrehan Kifle and Tesfay Gebretsadikan. (2010). A partial budget analysis for wheat production under different plowing technologies in Atsbi /Felegewoini.un published doc.

Araya A, Keesstra SD, Stroosnijder L. (2010). A new agro-climatic classification for crop suitability zoning in northern semi-arid Ethiopia. Agric. Forest Meteorol. 151:1047–1064.Gebrehiwot and van der Veen, 2013

CSA (Central Statistical Agency), (2010). Summary and statistical report of the 2010 population and housing census. CSA: Addis Ababa.

Gebrehiwot T, van der Veen A. (2013). Assessing the evidence of climate variability in the northern part of Ethiopia. J. Dev. Agric. Eco. 5(3):104-

Kidane Chekol. (2006). Responding to food security challenges through an integrated watershed approach: The Tigray experience. The international famine center: Cork.

Mahari woldu (2008) Evaluation of Mekassa mould board plough in Tigray. Un published doc.

Melesse, T., Rockstrom, J., Savenije, H.H.G., Hoogmoed, W.B., Dawit, A. (2008). Determinants of tillage frequency among smallholder farmers in two semiarid areas in Ethiopia. Phys. Chem. Earth 33, 183–191.

Tigray Region Plan and Finance Bureau (2010) http://www.tigraybopf.gov.et/plan.html

http://www.wageningenur.nl/en/Publication-details.htm?publicationId=publication-way-333733313737