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Evaluation of tillage and planting method under conservation farming for soil and crop productivity in the dry-land areas of Tigray, Ethiopia

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Study on conservation farming (CF) was conducted in moisture deficit area of Tigray, Ethiopia from 2013-2014. The experiment was conducted both on station and on farmers' field. The treatments were: conventional tillage with fertilizer, conventional tillage without fertilizer, sub soiling with fertilizer, sub soiling + tie ridging with fertilizer, sub soiling + tie ridging + intercropping with fertilizer, sub soiling + tie-ridging + intercropping without fertilizer, sub soiling + tie ridging + transplanting with fertilizer, direct plating on basin with fertilizer and transplanting on basin with fertilizer. Significantly, higher mean sorghum grain yields of 2.40 and 2.50 t/ha were recorded from transplanted sorghum seedlings and directly planted sorghum seeds in basin respectively in the on station trial using early maturing 'Hormat' variety. Similarly, 2.40 and 2.38 t ha^{-1} grain yields were obtained from tie ridging and transplanting at basin respectively, while the lowest mean grain yield of 0.94 t/ha was obtained from the conventional tillage without fertilizer treatment in the farmers managed plots. Mean grain yield of 3.90 and 5.60 t/ha were also obtained from 'Kodem' and 'Abaere' Sorghum land races, respectively planted in planting basin at farmers field. Some soil chemical properties (like total nitrogen, available phosphorus and organic carbon) on the conservation treatments show increment. Planting basin (either direct planted or transplanted) and tie ridging tillage method with micro-dossing of fertilizers combined with conservation farming package components enhance crop, water and soil productivity and help mitigate the effects of prolonged dry spells in the moisture deficit of Tigray.

Key words: Conservation farming, conventional tillage, basin, tie-ridge, mulching, moisture deficit, sorghum.

INTRODUCTION

The problem of food insecurity has become more intensely pronounced in recent years with the threat posed by climate change, water and rainfall scarcity as well as ecosystems and biodiversity degradation. In Sub-Saharan Africa (SSA), most rural communities are languishing in poverty yet, the agricultural practice being promoted there has unacceptably high environmental, economic and social costs (Bolwig et al., 2007).

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Table 1. Geographical location of research districts.

Woreda	Districts (PA)	Altitude (m.a.s.l)	Longitude (E)	Latitude (N)
Raya Azobo	Genetie	1567-1595	39° 37' 31"	12° 46' 36"
	Tsigea	1578-1600	39° 38' 38"	12° 47'59" N
Raya Alamata	Garjalle	1520-1559	39° 34' 01"	12° 23' 03"
	Tao	1560-1569	39° 33' 01"	12° 22' 05

Nearly 80% of the population in SSA countries lives in rural areas with 90% of population being directly dependent on rainfed agriculture (Wiggins, 2009; Wiggins and Sharada, 2013; Rockström, 2003). However, rainfall is poorly distributed (Ngigi, 2005) and high losses occur due to high surface runoff, poor crop rooting conditions, past and present soil erosion and evaporation losses from soil and crop canopy (Rockström, 2003).

The impact of climate change on agricultural productivity is severe in SSA due to low adoption of key agricultural production technologies that enhance adaptation to climatic change, enhance soil, water, and crop productivity.

Ethiopia's economy and ecological system are very vulnerable to impact of climate change (César and Ekbom, 2013). Food security is highly sensitive to climate risks and rainfall is one of the climatic determinants of food production in Ethiopia. However, rainfall is highly erratic and unreliable (Stroosnijder and Van Rheenen, 2001; Mesfin et al., 2009) in respect to mainly delay in the onset and early cessation. This intermittent long dry spells throughout the growing season has a tremendous influence crop production (Rockstrom, 2000; Abdelkdair and Richard, 2005) and it is the main risk contributing to food insecurity and overall vulnerability of households. The vulnerability to climate-related hazards and food insecurity closely linked to land degradation, in which about 85% of the land surface in Ethiopia is considered susceptible to moderate, or severe soil degradation and erosion. Moreover, the main reasons for dryland cropland degradation in Ethiopia include complete removal of crop residues at harvest, aftermath overgrazing of livestock, frequent tillage, drought and inefficient use of technologies and practices (Mando, 1997; Taddese, 2001). Farmers in the study areas plough their land 3-5 times for sorghum and maize crops per season using traditional tillage equipment known as 'Maresaha'. Repeated tillage with the same soil depth hurries soil organic matter decomposition (Doran and Smith, 1987) and water runoff and soil erosion (Derpsch et al., 1991), and other physic-chemical and biological soil degradation (Benites, 2008; Kertesz et al., 2008), and it has been reported to be the utmost cause of land degradation in Ethiopia (Tefera, 2002).

The challenges of climate change to agricultures and food security demands a holistic and strategic approach to linking knowledge with action. Among the solutions, conservation farming (CF) practices hold the promise of providing both a strategy for mitigating climate change and working as an adaptive mechanism to cope with climate change. CF is mainly to keep the soil covered (at least 30% residue), to have minimal soil disturbance and to mix and rotate crops as well as local in-situ soil and water conservation practices (Bradford and Peterson, 2000; Verhulst et al., 2010; Rockstrom et al., 2003). It maintains cover of vegetation, raises the organic matter content of the soil, improving fertility (Desale, 2014) protects the soil from erosion and leads to positive changes in the physic-chemical and biological properties of a soil (Bescansa et al., 2006). CF practices emphasize maximum use of available water resources through early and timely planting, soil protection through ground-cover plants. This reduces long-term dependency on external inputs, enhances environmental management, and improves water use efficiency. Positive contribution of CF on crop yields compared to traditional tillage management was also reported, increases in yields of maize (from 3000 to 5000 kg ha^{-1}) and soya (from 2800 to 4700 kg ha^{-1}) and bread wheat (+82% over conventional) in Brazil (Hine and Pretty, 2008).

Keeping CF scenario in view, the present study aimed evaluation of CF technologies implication for enhancing productivity of dry land soils by improving fertility and increasing water and crop productivity in drought prone areas of Tigray.

MATERIALS AND METHODS

The study areas

The study was conducted in moisture deficit areas of Raya Azobo (Genetie and Tsigea) and Raya Alamata (Garjalle and Tao) districts of Tigray, northern Ethiopia from 2013 and 2014 main cropping season (Table 1).

A semi-arid type of climate characterizes the study areas receiving highly variable rainfall. Rainfall is bimodal, with a short rainy season from February-March ('Belg') and the main rainy season from June-September ('Kareem'), but potential evapotranspiration exceeds annual rainfall amount in most of the year. The study areas have annual mean rainfall ranges between 350 and 700 mm. Monthly rainfall distribution in the study period and 7 year average (for Raya Azobo) and 17 year average (for Raya Alamata) rainfall of the study sites is presented in Figure 1 (NMSA, 2014).

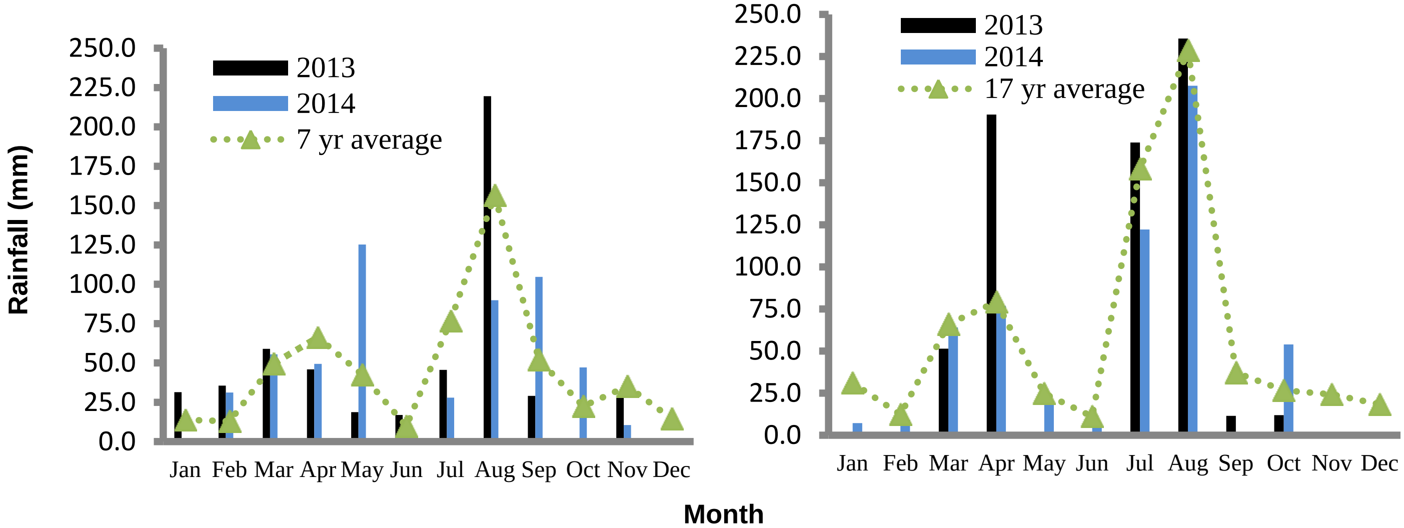

Figure 1. Monthly rainfall (mm) distribution at Raya Azobo (left) and Raya Alamata (right) during the study periods and mean monthly rainfall distribution.

Table 2. The treatments used in the on-staion experiments.

S/N	Treatments	Incorporated packages
1	Conventional tillage without fertilizer	5 times tillage using 'Maresha'
2	Conventional tillage with fertilizer	fertilizer drilling at 64/46 kg N/P_20_5/ha
3	Sub soiling/ripping with fertilizer	
4	Sub soiling + tie ridge with fertilizer	Mulching of residue
5	Sub soiling + tie ridge + inter cropping with fertilizer	Seed hydro priming
6	Sub soiling + tie ridge + inter cropping without fertilizer	Residue retentions
7	Sub soiling + tie ridge +transplanting with fertilizer	fertilizer micro dosing at 64/46 kg N/P_20_5/ha
8	Direct planting on basin with fertilizer	
9	Transplanting on basin with fertilizer	

Experimental treatments, design and procedure

The on-station experiment was layout in randomized complete block design with treatments applied to the same experimental units (permanent plot) each year. Gross plot size was 100 m^2 for each experimental unit. The varieties used in the experiment were long maturing local cultivars (180-210 days maturing) 'Abaere', Medium maturing (150-180 days maturing) 'Kodem' and early maturing improved variety (100-120 days maturing) Hormat. For the conventional/farmers practice plots, tillage and fertilizer application methods was done as per the farmers' practice by farmers' local plowing equipment 'Maresha' without crop residue retentions and moisture conservations (Tables 2 and 3) (Leye, 2007).

Planting basins are pits used for planting many types of crops used to conserve soil and moisture in conservation agriculture and they were prepared at dimension of 0.75 x 0.25 x 0.2cm length, depth and width respectively using hoe which is suitable for sorghum crop planting in a dry land areas. Tie-ridger is an improved tie ridging drawn by animal attached on the 'Maresha' using a pair of metal rods and tying unit and creates a series of basins in the field to retain soil and water. Sub soiling is a modified 'Maresha' where the wooden wings ('Deger') replaced by a pair of rods and rings used to break the soil hard pans that are created after continuous plowing at the same depth of soil (Twomlow, 2008).

Data collection

Grain (GY) yield was taken from each plot by excluding the border rows and adjusting to 12.5% moisture level, and then converted to hectare basis. Rainwater use efficiency (RWUE) was calculated according to Oweis (1997) as the percentage of total grain yield (t/ha) to growing season precipitation (mm):

$$\mathrm{RWUE}(\%) = \left(\frac{\mathrm{GY}}{\mathrm{RF}}\right) * 100$$

Percent deviation (D) of conservation farming (CF) from the conventional tillage (CT) was calculated according to Zamboni (2018) as:

$$\mathrm{D}\ (\%) = \left(\frac{\mathrm{CF\_CT}}{\mathrm{CT)}}\right) * 100$$

Where, CF and CT represent the measured data (grain yield, straw

Table 3. The treatments used in the onstaion experiments.

S/N	Treatments	Remark
1	Conventional tillage with fertilizer Sub soiling + tie ridge with fertilizer	Tested on 20 farmers using Hormat, kodem and Abaere variety
2	Direct planting on basin with fertilizer Conventional tillage with fertilizer	Tested on 20 farmers using Hormat, kodem and Abaere variety
3	Transplanting on basin with fertilizer Conventional tillage with fertilizer	Tested on 17 farmers using Hormat variety

yield, soil and net benefit) obtained in the CF and its corresponding value in the CT treatments respectively.

Farmers' insight

The cumulative crop performances in each of the plots were evaluated with 57 local farmers from 2013 -2014 cropping season. The farmers carried group discussion during their visit to each treatment to evaluate the overall crop overall performance. The farmers gave grading having one corresponding to the best crop performance while with nine to the lowest one.

Soil sampling, sample preparation and analysis

Composite surface soil samples were collected using standard Auger from five spots of each experimental block (0-20 cm depth) to form one composite soil sample per block for initial soil fertility evaluation of the experimental fields. Similarly, soil samples were collected after crop harvest from each plot and then composited by replication to obtain one representative sample per treatment. Particle-size distribution was determined using hydrometer method (*Pawluk* et al., *1992)*. Soil pH and electrical conductivity (EC) were measured in soil: water extracts (1:2.5) (Rhoades, 1982). Soil Organic matter (SOM) content was determined by the Walkley and Black method (Walkley and Black, 1934). Total nitrogen (TN) content was analyzed by Kjeldhal method (Bremner et al., 1982). Available phosphorus (Av.p) was Analysed using Olsen method (Olsen et al., 1954). One molar neutral ammonium acetate (pH = 7) was used to determine the exchangeable cations (Ca, Mg, K and Na) (Cottenie, 1980).

Statistical analysis

The Analysis of Variance (ANOVA) on the selected agronomic traits were computed using SAS software version 9.4 (SAS, 2013) following the standard procedures of ANOVA for randomized complete block design (Montgomery, 1991) for the on-station trial. The differences among the treatments were considered significant if the P-values were ≤ 0.05 and least Significance difference was used to compare among treatments (Williams and Abdi, 2010).

Partial budget analysis

Partial budget analysis of conservation farming effect was assessed using the CIMMYT economic training manual (CIMMYT, 1988), which included step-wise procedures of partial budgeting, dominance, and marginal analyses (MR). The partial budgeting used were, total variable cost (TVC), gross benefits (GB) and net benefits (NB) under each scenario. The variable costs included human labor; oxen rent land preparation, and costs of seed, fertilizer, and fertilizers. The unit of human labor was based on labor day ha^{-1} and was calculated by recording the time required for each activity and converting them to labor days (eight hour being equivalent to one labor per day).

RESULTS AND DISCUSSION

Soil physico-chemical properties

According to the soil pH rating developed by Tekalign et al., (1991), the mean pH values of the composite surface soil samples of the experimental sites falls under the slightly neutral soil reaction class. The soil organic matter (SOM) contents were in the range of 1.15–2.87% (Table 4) thus, these values fall under low to moderate range based on the ratings of soil test values established by Tekalign et al., (1991). Total nitrogen (TN) levels of the study sites ranges between 0.098 and 0.16% and taken as low while those below 0.1% are very low for tropical soils (Beyene, 1988). It, therefore soils of the study areas are low to very low in their total nitrogen status (Table 4). Moreover, according to phosphorus rating developed by Olsen et al. (1954), the available phosphorus (Av.P.) contents of the soil of the experimental site fall under the medium phosphorus status (Table 5). This indicate the low level of fertility status of the soil aggravated by long term cereal based cultivation, lack of incorporation of organic materials in to the soils through mulching or crop residues retention after harvest and frequent tillage. Continuous mono cropping and inadequate replacement of nutrients removed in harvested materials or lose through erosion and leaching has been the major causes of soil fertility decline (*Matson et al., 1998)*. The electrical conductivity (EC) ranged from 0.05 to 0.21 dSm^{-1} indicating that these soils have a low content of soluble salts and that there is no danger of salinity in the study areas (Tekalign et al., 1991).

The total nitrogen content of the conservation plots increased from 0.06 to 0.12% and from 1.15 to 1.55% in soil organic matter content. Thus, increment of the some

Table 4. physical and chemical properties of the study sites before planting.

Site	Avai.P. (ppm)	Total N (%)	pH (H_20)	SOM (%)	EC (ds/m)	CEC (Meq/ 100 g)	Ex.K (ppm)	Ex.Na (ppm)	Ex .Ca (Meq ca/L)	Ex. Mg (meqMg /L)	Textural class
Gargalle	10.50	0.098	7.03	1.15	0.05	44.70	571.5	128.8	7.70	4.50	Clay loam
Genetie	17.83	0.15	7.18	2.87	0.21	11.93	710.3	141.0	5.60	5.00	Clay loam
Tsigea	16.73	0.16	7.01	2.40	0.15	16.79	680.4	126.8	4.28	2.43	Clay loam
Tao	25.06	1.13	7.39	47.5	0.19	47.50	2.6	0.13	4.4	2.6	Clay loam

Ex is exchangeable.

Table 5. Effect of conservation tillage (CF) on some soil chemical properties of the study sites (Garjalle).

Tillage method	Organic matter (%)	Total nitrogen (%)	Available phosphorus (ppm)	CEC (meq/ 100g soil)	pH
Sub soiling/ripping with fertilizer	1.26	0.12	15.4	39.5	7.1
Sub soiling+ tie ridge with fertilizer	1.21	0.11	10.9	42.3	6.9
Sub soiling + tie ridge + intercropping without fertilizer	1.46	0.10	9.2	46.4	7.0
Sub soiling + tie ridge + intercropping with fertilizer	0.97	0.12	10.3	42.7	7.0
Sub soiling + tie ridge + transplanting with fertilizer	1.23	0.11	11.9	44.2	6.9
Direct planting on basin with fertilizer	1.01	0.12	10.0	39.8	7.1
Transplanting on basin with fertilizer	1.55	0.10	9.0	41.8	7.2

soil properties in the study site is mainly from mulching of different weeds, nitrogen fixation from the intercropped cowpea, and residue retentions from the conservation plot after first year experimentation. In agreement to this, research findings conducted on highland of Ethiopia on the effect of tillage reported that 0.30 and 0.03% SOM and TN respectively increase in no-tillage over conventional tillage method (Desale, 2014).

Effect of conservation farming on yield and yield and related traits of sorghum

On station trial

Grain yield and rainwater use efficiency were significantly (P<0.05%) affects by tillage methods and planting system (Table 3).

Direct planting of sorghum seeds and transplanting of sorghum seedlings at planting basin with 64/46 kg ha^{-1} N/P_2o_5 fertilizer micro dosing in CF plots recorded mean sorghum grain yield of 2.5 t ha^{-1} (+150 and +178% than conventional tillage with and without fertilizer respectively) and 2.4 t ha^{-1} (+140 and 166% than conventional tillage with and without fertilizer respectively) respectively. In agreement to these study research findings reported by Belay et al. (1998), Lal (2000) and Temesgen et al. (2008) indicate that the main reasons for the increment of in yields were better soil moisture availability, enhanced soil fertility and better crop root growth because of conservation tillage techniques. Similar result on ripping with sub-soiling techniques resulted in 60% maize grain yield enhancement (Temesgen et al., 2009). Other findings in semi-arid areas of Zimbabwe planting basins + 10–30 kg ha^{-1} of N (micro-dose) were superior to farmers practice in 59% of the experiments (Nyamangara et al., 2014). According to Rockström et al. (2009), ripping + ridging + fertilizer yielded improved maize grain yields with 40% over conventional practice (using Maresha and no fertilizer).

In the 100:50 sorghum/cowpea intercropped plots, mean cowpea grain yield of 1.7 ha^{-1} were recorded in addition to the sorghum grain yields in the on station trial. However, the major benefit of legumes incorporation in CF farm is in improvement of SOM and TN content and protects soil form exposing to sun light. According to the research findings by Reddy et al. (1992) in pearl millet-cowpea, intercrop the SOM was increased 29%) compared to the sole crop of pearl millet. Research output in semi-arid Kenyan conditions, cowpea intercrop recycles 30 kg N ha^{-1} (Rao and Mathuva, 2000).

Similarly, intercrops give substantial enhancement in water use efficiency (Reddy and Willey, 1981; Morris and Garrity, 1993).

Conservation farming technologies are relevant, especially with increasing variability in rainfall, due to the

Table 6. Effect of CF on agronomic traits of sorghum at Garjalle in 2013 and 2014 cropping season.

Tillage system	Grain yield (t ha^{-1})			Rain water use efficiency (%)		
	2013	2014	Mean	2013	2014	Mean
Conventional tillage without fertilizer	0.3	1.6	0.9	0.1	0.5	0.3
Conventional tillage with fertilizer	0.2	1.8	1.0	0.1	0.5	0.3
Sub soiling/ripping with fertilizer	0.2	2.1	1.2	0.0	0.7	0.3
Sub soiling + tie ridging with fertilizer	0.8	2.2	1.5	0.2	0.7	0.4
Sub soiling + tie ridging + intercropping with fertilizer	1.0(1.6)	1.8(1.8)	1.4	0.2	0.6	0.4
Sub soiling + tie ridging + intercropping without fertilizer	0.9(0.9)	1.9(1.2)	1.4	0.2	0.6	0.4
Sub soiling + tie ridging + Transplanting with fertilizer	0.7	1.9	1.3	0.2	0.6	0.4
Direct on basin with fertilizer	2.6	2.3	2.5	0.6	0.7	0.7
Transplanting on basin with fertilizer	2.2	2.7	2.4	0.5	0.8	0.7
CV (%)	37.5	5.6		36.5	5.8	
LSD (5%)	0.64	0.19		0.16	0.06	

Grain yield in the parenthesis are grain yield of cow pea.

effects of ELNO and climate change, which will lead to an increase in both inter- and intra-seasonal drought events and high uncertainty about the onset of the rainy seasons. Mostly crops use only 36–64% of the seasonal rainfall on average (Barron et al., 2003), while the remaining proportion (50%) of non-productive water, which is relevant for stable plant growth if properly managed (Nyamadzawo et al., 2012).

The mean rainwater use efficiency (RWUE) of Sorghum was found significantly ($p<0.05$) higher at transplanted sorghum seedlings in planting basin tillage method under the conservation farming and direct planting on basin, compared to other treatments (Table 6). The 2-years average RWUE was higher at planting basins compared to conventional treatments and other treatment while, the lowest RWUE was recorded in the conventional tillage.

Partial budget analysis

Partial budget analysis was computed for the conservation and conventional plots. Hence, 24,437 (+325% over the conventional) and 20,519 (+256% over the conventional) birr/ha net return was obtained from direct planting and transplanting at basin respectively. Although the cost of producing sorghum was higher under the CF basin system, the higher net returns achieved with this technology resulted in significantly better returns in production compared to the conventional tillage system (Table 7). Hassane et al. (2000) evaluate the impact of planting basin conservation tillage and use of fertilizer and farmyard manure on millet crops in Niger and reported that yield increment of up to 511%. It is easy to make and use planting basins, elderly people, children and disabled people can all use them to grow the food they need. The required equipment (a hoe) is readily available for every male and female farmer in the community (Otim et al., 2015).

Farmers' insight

Different field visits, experience sharing and group discussions were held at different plant growth stages each districts with farmers, development agents, experts, and local NGOs representatives working on agriculture. Thus, the respondent have selected direct planting and transplanting on planting basin first and second respectively based on population stand of the crop, stay green, biomass and yielding potential (Table 8). Participants observed good performance, increased plant height, more grain yield, soil healthy, soil moisture and both sorghum planted using conservation farming methods. Our results also show that local farmers' evaluation of overall crop stand under treatments is increasing with increasing yield (Tables 6 and 8)

Farmers managed on farm trial

On farm evaluation of selected conservation tillage practices were conducted at Raya Alamata (Garjalle and Tao), and Raya Azobo (Genetie and Tsigea) areas on 57 volunteer farmers' field in 2013-2014 cropping seasons. Direct planting of sorghum seeds at planting basin gave more grain yield, 3.90 t/ha (+40% over conventional) and 5.60 t/ha (+120% over conventional) for the land races Kodem and Abaere respectively (Table 9). Transplanting of 30 days old seedling Hormat variety at planting basin also gave 2.38 t/ha (+150 % than conventional). Similar research findings indicated that, the grain yield of

Table 7. Partial budget analysis for different tillage system.

S/N	Tillage system	GY adjusted (t ha^{-1})	GB From GY (ETB ha^{-1})	BY (t ha^{-1})	GB From BY (ETB ha^{-1})	Total GB (ETB ha^{-1})	TVC (ETB ha^{-1})	NB (ETB ha^{-1})
1	Conventional without fertilizer	0.261	2349	13.0	5200	7549	1800	5749
2	Conventional with fertilizer	0.207	1863	14.7	5880	7743	4100	3243
3	Sub soiling with fertilizer	0.162	1458	13	5200	6658	2700	3958
4	Sub soiling + tie ridging with fertilizer	0.747	6723	17.8	7120	13843	2700	11143
5	Sub soiling + tie ridging + intercropping with fertilizer	0.909	8181	16.9	6760	14941	3100	11841
6	Sub soiling + tie ridging + Intercropping without fertilizer	0.792	7128	17.2	6880	14008	2700	11308
7	Sub soiling + tie ridging + transplanting with fertilizer	0.657	5913	9.2	3680	9593	2700	6893
8	Direct planting on basin with fertilizer	2.313	20817	19.8	7920	28737	4300	24437
9	Transplanting on basin with fertilizer	1.971	17739	17.7	7080	24819	4300	20519

GY=grain yield, BY=biomass yield, GB=Gross benefit (ETB ha^{-1}), TVC=Total variable cost (ETB ha^{-1}) and NB=Net benefit.

Table 8. Pair wise ranking of the tillage method (n=35).

	CT_F	Con.WF	SS+F	SS+T+SC	SS+T+F+SC	SS+T+F	SS+T+TP	TPB+F	DPB+F	Total score	Priority order
CT_F										0	9
CT+F	Con.WF									1	8
SS+F	SS+F	SS+F								2	7
SS+T+SC	SS+T+IC	SS+T+IC	SS+T+IC							3	6
SS+T+F+SC	SS+T+F+SC	SS+T+F+SC	SS+T+F+SC	SS+T+F+SC						4	5
SS+T+F	SS+T+F	SS+T+F	SS+T+F	SS+T+F	SS+T+F					5	4
SS+T+TP	SS+T+TP	SS+T+TP	SS+T+TP	SS+T+TP	SS+T+TP	SS+T+TP				6	3
TPB+F	TPB+F	TPB+F	TPB+F	TPB+F	TPB+F	TPB+F	TPB+F			7	2
DPB+F	DPB+F	DPB+F	DPB+F	DPB+F	DPB+F	DPB+F	DPB+F	DPB+F		8	1

CT_F=conventional tillage without fertilizer; CT+F= Conventional tillage with fertilizer; SS+F= Sub soiling + fertilizer; Sub soiling +T+SC= Sub soiling + tieridger + intercropping without fertilizer; Sub soiling + T + F + SC= Sub soiling + tie ridging + intercropping fertilizer; Sub soiling +T+F= Sub soiling +tie ridging with fertilizer; Sub soiling +T+TP Sub soiling + tieridger + Transplanting; TPB+F= Direct planting on basin + fertilizer and DPB+F= Transplanting on basin + fertilizer.

transplanted sorghum gave an extra grain yield of 1043 and 1797 kg ha^{-1} at Mehoni and Alamata area respectively (Assefa et al., 2007). Raising sorghum seedlings in nurseries using small amounts of water and transplanting the seedlings 28-30 days old could be a way of extending the growing season and to couple the late onset and early off rain fall characteristics of the rainfall in the study areas. Rainfed smallholder agriculture in low rainfall area is subject to numerous constraints including low rainfall with high spatial and temporal variability, and significant loss of soil water through evaporation and erosions have limited crop production (Mupangwa et al., 2007).

In the tie ridging conservation tillage grain yield of 4.60 t/ha (+36 % over the conventional) and 2.40 t/ha (+100% over the conventional) were recorded from variety Abaere and Hormat

Table 9. Effect of planting basin tillage on grain yield of different sorghum variety (N=57) in 2013-2014 cropping season.

Sorghum Variety/land race	Tillage system	Grain yield (t/ha) + Se	Remark
Kodem	Direct planting on basin	3.90±0.77	Medium maturing local land race
	Conventional tillage	2.77±0.84	
	Sub soiling + tie ridging	3.55±0.11	
	Conventional tillage	3.1±0.20	
Hormat	Transplanting on basin	2.38±0.04	Early maturing variety
	Conventional tillage	0.94+0.18	
	Sub soiling + tie ridging	2.39±0.15	
	Conventional tillage	1.19±0.38	
Abaere	Direct planting on basin	5.6±0.56	Late maturing local land race
	Conventional tillage	2.60±0.15	
	Sub soiling + tie ridging	4.60±0.20	
	Conventional tillage	2.90±0.33	

Fertilizer was applied at rate of 64/46 kg/ha N/P_2o_5 in drilling for the conventional plots and as micro dose for the conservation plots.

Table 10. Farmers perceptions on CF (n=35).

Contribution of the practice	Farmers response	
	Agree (%)	Dis agree (%)
Conservation farming increase soil fertility	90	10
Conservation farming conserve soil moisture	100	0
Conservation farming can reduce soil erosion	100	0
Conservation farming save labor and cost	30	65
Conservation farming decrease weed problem	0	100
Conservation farming increase yield	86	14

respectively (Table 6). This related to greater crop water availability with tied-ridge tillage. This is in agreement with those of Brhane et al. (2006) research findings at Abergelle, northern Ethiopia, which indicate that Tie-ridging improved sorghum grain and biomass yield and resulted in greater soil water availability than other traditional tillage practices. Maize and sorghum yield improvement of 15-50 and 15-38% due to tied ridges was also reported on eastern Ethiopia (Gebrekidan and Uloro, 2002).

Most of the farmers also explained that contribution of conservation farming plots over the conventional/farmers practice for soil fertility enhancement, soil moisture increase; reduce soil erosion and finally yield improvement. However, some farmers also suggest their fear for CF difficult for weed control and need more labor in the first year (Table 10).

CONCLUSION AND RECOMMENDATIONS

Even if the rainfall in the study districts is the low and erratic, planting basins tillage methods under the conservation farming consistently gave the more grain yield with optimum net returns for all local land races and improved sorghum varieties. Therefore, from the study, the planting basin (direct planting of sorghum seeds or transplanting of sorghum seedlings) and tie ridging with micro dosing of 64/46 kg/ha N/P_2o_5 fertilizer in under conservation farming component can further help to mitigate the effects of prolonged dry spells and enhance crop yield and soil fertility and rainwater use efficiency sustainably. Local, national and regional policy and decision makers and Universities could support development of strategies and mechanisms for dissemination and scaling up the planting basin conservation farming technology in the dry land areas of Ethiopia.

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CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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