On Farm Evaluation of Conservation Tillage Techniques: An Option for Vulnerable House Hold at Dry Land Areas of Northern Ethiopia

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Abstract: Participatory evaluation of conservation tillage practice was conducted at low rain fall areas of South Tigray, Ethiopia in 2014 cropping season. The treatments were tie-ridge with mulching, planting basin (direct and transplanted) with mulching and conventional with minimum of 5 times tillage. The experiment was conducted on farmer’s field and a total of 35 farmers were participated. Early maturing (Hormat), medium maturing (Kodem) and late maturing (Abaere) sorghum varieties were used in the experimentation. Significantly (P<0.05) more variation were observed among the tillage practices and varieties tested. In the early maturing variety, the highest grain yield 2.39 t/ha and 2.37 t/ha were recorded from tie ridging and direct panting at planting basin, while the lowest mean grain yield 0.9 t/ha was obtained from the conventional treatments. For the Kodem and Abaere sorghum land race the higher grain yield were obtained from planting basins (3.87 and 5.59 t/ha, respectively). About 68% and 27% of the total respondents also select basin and tie-ridging, respectively. This finding provides evidence to scale up the culture of conservation tillage techniques (tie ridging and planting basin) with component package in dry land areas of Tigray and allowing farmers to enhance crop yield in the low rain fall areas.

Key word: Conservation tillage - Planting basin - Mulching - Sorghum - Tied ridges

INTRODUCTION

In Ethiopia smallholder rain fed agriculture is largely dominant and tillage takes place with a pair of oxen pulling the hard plough or ‘Marasha’ [1, 2]. Tillage is the mechanical disturbance of the soil (through plowing, cultivation or digging) and has been used by farmers since the first settled agricultural production systems tens of thousands of years ago [3]. However, not all outcomes of this practice are positive; it has been stated that tillage operations, over time, cause a decline in soil fertility and overall productivity resulting from deterioration of soils’ physical, chemical and biological properties [4-7]. Low and erratic precipitation is the most important climatic factor that limits crop yields in most semi-arid regions [8].

In Ethiopia cereal grain yields are low (<2.5 t ha⁻¹) [9]. Research findings suggested that poor soil fertility and degradation severely limit food security for many smallholder farmers in southern Africa. In Tigray region productivity on rain-fed farms is low due to infertile soils; unreliable rainfall [10] patterns often associated with prolonged dry spells, sparse infrastructure and restricted access to markets.

Removal of crop residues from the fields is known to hasten soil organic carbon decline especially when coupled with conventional tillage [11, 12]. Typically in southern Tigray, there is a removal of crop residue from fields after harvesting and animals clear the remaining crop residues as they roam freely during the dry season and crop residues are also removed for fire wood and house roofing.

Among the solutions being floated to mitigate the impact of climate change is adapting to droughts through sustainable farming methods. Conservation farming (CF) practices hold the promise of providing both a strategy for mitigating climate change and also working as an adaptive mechanism to cope with climate change. In CF crops are grown using conservation tillage and legumes
are included in rotation with other crops. Conservation tillage leads to positive changes in the physical, chemical and biological properties of a soil [13].

Research findings in Ethiopia indicated that ripping + ridging + fertilizer yielded maize grain yields with 40% over conventional practice. It was also indicated that conservation agricultural practices with increasing tef grain yields with 20-50% for ripping + ridging as compared to conventional non-fertilized tillage using maresha [14]. Conservation agriculture is based on the principles of minimum soil disturbance, which means not tilling the land, leaving the remainder of the crop after harvest as a form of mulch to help soil retain moisture and rotating cereals such as maize with other crops such as legumes [15]. Therefore, the present study was initiated to evaluate the effect of planting basin and tie ridging conservation technologies on sorghum productivity with farmers’ participation.

**MATERIALS AND METHODS**

**The Study Area Description:** The study areas (Raya Azobo and Raya Alamata) are situated in the Raya Valley cluster, in the South zone of Tigray national regional state. The study sites districts are Garjelle tabia in Raya Alamata (located between 39° 34' 01" E and 12° 23' 03" N) and, Genetie (located between 39° 37' 231" E and 12° 46' 36" N) and Tsigea Tabia (located between 39° 38' 38" E and 12° 47'59" N ) in Raya Azobo. A semi-arid type of climate characterizes the study areas receiving highly variable rainfall. To reduce risks of unexpected drought periods at any time of the growing season, whenever available flooding of (spate irrigation, exploiting over land flow of water from the highlands of ofla (for raya Alamata), Maichew and Emba Alaje (for raya Azobo).

The study areas receives annual average rainfall between 450 and 700 mm. Eutric Vertisols, Lithic Leptosols (Cambic) and Lithic Leptosols (Orthic) are the soil types covering most of the land in the woredas. The fertility level is below the critical (un published data ATA). In the study areas, land preparation is done using traditional oxen drawn implement ‘Maresha’. The major crops grown in the area are Sorghum (*Sorghum bicolor* L.), Maize (*Zea mays* L.) and Teff (*Eragrostis tef*).

**Experimental Design and Procedure:** The experiment was conducted in 2014 cropping season on 35 farmers field on which each farmer was receiving one conservation tillage treatment to compare with their conventional method of tillage system. Gross plot size for each treatment was 10m x 10m. The varieties used in the experiment was long maturing land race(180-210 days), medium maturing land race (150-180 days) and improved early maturing variety (100-120 days). For the control plots plowing were done as per the farmers practice by farmers’ equipment (‘Maresha’) with no mulching and
Table 1: Soil physical-chemical properties of the farmers’ field before planting

<table>
<thead>
<tr>
<th>Soil properties</th>
<th>Soil chemical properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH 7.5-8.0</td>
<td></td>
</tr>
<tr>
<td>Organic carbon (%)</td>
<td>1.13-1.97</td>
</tr>
<tr>
<td>Available P (mg kg$^{-1}$)</td>
<td>2.6-17.2</td>
</tr>
<tr>
<td>Total N (%)</td>
<td>0.06-0.17</td>
</tr>
<tr>
<td>CEC(meq/100 g soil)</td>
<td>39-49</td>
</tr>
<tr>
<td>Soil physical properties</td>
<td></td>
</tr>
<tr>
<td>Clay (%)</td>
<td>32</td>
</tr>
<tr>
<td>Silt (%)</td>
<td>47</td>
</tr>
<tr>
<td>Sand (%)</td>
<td>21</td>
</tr>
</tbody>
</table>

moisture conservation practice. Planting basins are small pits in the ground used for planting many types of crops used to reserve moisture and they were prepared with 75cm length, 75cm spacing, 25cm depth and 20cm width. Tie-ridger is an improved animal drawn tie ridging implement attached on the ‘Maresha’ using a pair of metal rods and tying unit and creates series of basins in the field to retain water in place and reduce runoff. Ripper/subsoiler is a modified ‘Maresha’ where the wooden wings (‘Deger’) are replaced by a pair of rods and rings. It is useful to break hard pans that are created after repeated plowing at the same depth. Sorghum seedling was raised at nursery for one month and was transplanted at 30 days age. All the phosphorus fertilizer and 1/3 of the nitrogen fertilizer was applied at rate of 100 kg/ha at micro dosing at 7-10 cm depth along furrows at planting and the seed of sorghum planted at 3-5m depth and 15cm plant spacing. Then a total of 5 plants was maintained per basin after thining. 2/3rd of the nitrogen fertilizer was applied 35-40 days after planting at a 50 kg/ha rate and fertilizer is placed 5 cm below and to the side of the seed.

Data Collected

Soils Data Collection and Analysis: Composite soil samples were collect from the plow layers (0-30cm) at each farmer’s field before applications of the verification trial. The results of the laboratory analysis of some physico-chemical properties of the soil are presented in Table 1. Accordingly, Soil samples were analyzed for texture, organic carbon, total nitrogen, cation exchange capacity (CEC), available P and pH, total nitrogen and available phosphorus. The methods used for physico-chemical analysis were: organic matter content was determined by oxidation of organic carbon with acid potassium di-chromate ($K_2Cr_2O_7$) by the Walkley and Black method [16]. Total nitrogen was analyzed by Micro-Kjeldhal method [17]. Soil pH was determined in 1:2.5 (weight/volume) soil to water dilution ratio [16]. Cation exchange capacity was measured after saturating the soil with 1N ammonium acetate (NH$_4$OAC) and displacing it with 1N NaOAC [18]. Available phosphorus was determined using Olsen method [19].

Agronomic and Farmers Perception

Grain Yield: The grain yield was taken from each plot by excluding the border rows and adjusted to 12.5% and then converted to hectare basis.

Farmers’ Perception: As part of participatory evaluation tillage and planting system, field days were held at different plant growth stages (vegetative, flowering, maturity and harvesting) in selective farmers’ fields. Farmers’ selection criteria were also assessed and farmers were encouraged to include their own selection criteria. The panelist (n=29) farmers/participant farmers were then given chance to evaluate the conservation tillage and rank each plots.

Statistical Analysis: The Analysis of Variance (ANOVA) on grain yield was computed using the GLM procedure of SAS version 9.2 [20]. The differences among farming practice were considered significant if the P-values were ≤ 0.05 and Leas Significance Difference (LSD) was used to compare among tillage methods at 5% probability level.

RESULT AND DISCUSSION

Soils Result: Laboratory analytical results of selected physicochemical properties of the soils on which these on-farm experiments were conducted are presented in Table 1. Soils in the study areas are dominantly clay loam in texture and vary from to neutral slightly basic. The soil organic carbon contents, total N was low indicating the low fertility status of the soil aggravated by continuous cereal based cultivation, lack of incorporation of organic materials into the soils through mulching or crop residues. The available phosphorus was also below critical.

Grain Yield: Grain yield is the important component of plant performance under a set of growing conditions and any physiological or agronomic trait at a given stage of growth would be of further use only when its effect is reflected on yield either way. On farm verification of selected conservation tillage practices were conducted at 52 farmers of which sample data were collected from 35 farmers filed (Table 2).
From Table 2 and Table 3 the results of yield obtained from the conservation tillage is highly significance (P<0.5) difference for all tillage system and varieties used in the experiments.

Planting basin supported with mulching gave more grain yield 5.59 t/ha (+120 over the conventional) in the long maturing Abaere land race. Transplanting of early maturing sorghum variety (Hormat) on planting basin also gave grain yield of 2.37 t/ha (+160% over farmers practice). Similar findings in study area indicated that, the grain yield of transplanted sorghum gave an extra grain yield of 1043 and 1797 kg ha$^{-1}$ at, Mehonni and Alamata area, respectively [21]. Raising sorghum in nurseries using small amounts of water and transplanting seedlings could be a way of extending the growing season and to couple the late onset and early off rain fall characteristics of the rain fall in the study area. Rain fed smallholder agriculture in low rain fall area of southern Tigray 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.

In the tie ridging grain yield of 4.55 t/ha (+36 % over the conventional), and 2.40 t/ha (+100% over the conventional) were obtained from variety Abaere and Hormat, respectively. This may be related to greater crop water availability with tied-ridge tillage. These results are in agreement with those obtained by Gebreyesus et al. [22], who indicated that tied-riding before or at planting resulted in the best soil water status and the best crop performance, especially when planting was in-furrow.

As part of participatory evaluation and selection of planting method and tillage practices, field days and group discussion were held at different plant growth stages. The panelist farmers/participant farmers were then given chance to evaluate the technology and 68% and 27% of the total respondent (n=29) have selected planting method and tie ridging 1$^{st}$ and 2$^{nd}$, respectively. Only 5% of the participants have selected the conventional method tillage.

**Conclusion and Recommendations:** Access to water in rained farming, special in areas receiving in low and erratic type of rain fall can be improved through a package of conservation farming techniques. Despite the rain fall is the study area for both location is the low and erratic (500-700 mm), planting basins consistently gave...
significantly the highest grain yield for all land race and improved varieties. Planting basin supported with micro dosing of fertilizer and mulching can further help mitigate the effects of frequent dry spells and gave significantly more grain yield than farmers practice for early, medium and long maturity variety. Planting basins help to concentrate rainfall in the field at the root zone and decrease runoff and soil loss. Conservation farming offers the promise of a locally adapted, low-external-input agricultural strategy that can be adopted by resource-constrained farming communities and female farmers. Therefore, from the study the following technologies combined with package component are recommended for the dry land areas of Ethiopia: Planting basin (25cm depth, 20 cm width and 75cm length and spacing ),trans planting (30 days old sorghum seedling) to couple with late onset and early off rain fall characteristics and Tie ridging (35 cm height, 75 cm spacing, 3m intervals tied).

However, policy changes within government and changing the mindsets of farming communities who have been farming using conventional agriculture (especially free grazing, frequent tillage and residue managements) for many years need to be addressed to further increase the sustainable uptake of conservation tillage and consequently its impact on food security.

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REFERENCES


