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Participatory Evaluation of Planting Basins and Fertilizer Management Practices Under Conservation Agriculture on Sorghum (*Sorghum bicolor* L. Moench) Yield in the Dryland Areas of Tigray, Ethiopia

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Aim: The aim of the study was evaluate the effect of planting basin and fertilizer management practices on sorghum yield.
Study Design: Treatments were arranged in a randomized complete block design (RCBD) with three replications.
Place and Duration of the Study: The experiment was conducted at Tao Farmers Training Center (FTC), Raya Alamata districts of south Tigray, Ethiopia in 2016 - 2017 seasons.

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Methodology: The treatments in the experiment were; 1) planting basin + fertilizer, 2) planting basin without fertilizer 3) planting basin + farmyard manure, 4) planting basin + fertilizer + farmyard manure, 5) planting basin + fertilizer + cow pea intercropping, 6) planting basin without fertilizer under cow pea intercropping , 7) conventional plots planted sole sorghum and 8) cow pea.
Results: Analysis of variance for grain yield of sorghum revealed that significantly ($P<0.05$) more variation among the tillage practices and fertilizer managements considered in the experiment. Significantly more combined mean sorghum grain yields of 4.61 t ha^{-1} and 4.0 t ha^{-1} with higher net benefits (79,413.6 and 72,446.3 birr/ha respectively) and acceptable marginal rate of retunes of respectively were attained from planting basin + 4.62 g NPS fertilizer $basin^{-1}$ and planting basin + 450g farmyard manure $basin^{-1}$ under the conservation farming practices respectively, whereas, the lowest mean Sorghum grain yield of 2.86 t ha^{-1} was obtained in the conventional tillage. The effect of the tillage and fertilizer managements on soil physico-chemical properties may require longer time to be evident. The respondent of participating farmers have preferred planting basins + fertilizer, planting basin + farmyard manure and planting basin + farmyard + fertilizer first, second and third respectively, based on their own selection criteria.
Conclusion: Planting basin tillage practices with conservation farming components overtakes their conventional farming complements. Permanent planting basin tillage combined with fertilizers micro dosing, mulching of residues and cowpea intercropping can mitigate the effects of frequent dry spells, safeguard food security, and eventually cope the influence of climate change in the moisture deficit areas of Tigray and other similar agro ecologies and soil conditions. Moreover, the main challenges for the future scaling of conservation farming includes how to enhance farmer awareness of conservation farming benefits, and how to effectively apply farmyard manure and how to manage labor cost for preparation of basins and weed managements.

Keywords: Conservation farming; sorghum; basin; economic benefit; fertilizer.

1. INTRODUCTION

Ethiopian agriculture contributes nearly 45% of the GDP and employments 80% of the population and 90% of the foreign exchange and 70% of the country's raw materials for industries [1]. Much of Ethiopia's agriculture is rain fed and food deficit and famines regularly occur for the reason of irregular rainfall and associated droughts [2,3]. “About 80% of Ethiopia's population is involved in rain fed agriculture and about 60% of the Ethiopian farming land is in the arid and semi-arid region, which indicates that rain fed agriculture is the main source of crop production for the increasing human populations in the country. Nonetheless, rain-fed agriculture without moisture management practice and effectual nutrient application is not coping for erratic rainfall and recurrent droughts that leads to consequent production failures” [4]. Integrated soil, water & crop management practices should be addressed simultaneously in order to reduce runoff and soil erosion associated nutrient losses, increase water infiltration, and nutrient availability for crop production in this marginal regions.

Frequent tillage together with complete removal of crop residues at harvest for fire wood fuel and animal feed, and aftermath over grazing & little adoption of moisture conservation techniques are the main contributors for soil degradation and decline of productivity and production in the semi-arid regions Ethiopia [5-7]. These areas have been also suffering with moisture stress and unpredictable rainfalls [8] that contribute highly crop failure and land degradation. Rainfall erraticism has caused important problems on economy & food production [9].

All these practices and challenges over time, cause decline in soil fertility and generally productivity consequential from decline of soils' properties and there is a significant threat of crop failure. Many research findings suggest that continuous tilling of layers accelerates organic matter (OM) decomposition and nutrient leaching and therefore it become difficult to conserve soil fertility [10].

“Depletion of soil OM is approximately 4% of the stock lost every year, resulting in dangerously low organic carbon levels after 15–20 years of farming. At levels below 0.5% carbon, the soil supplies less than 50 kg N ha^{-1} which is appropriate for only about 1 t ha^{-1} of maize grain at normal levels of N use efficiency” [11]. Removal of crop residues from the farm also unswervingly expresses to a release of the corresponding quantum of carbon. Rain-fed crop production is a risky venture in Ethiopia and the recurrent famines and rainfall inconsistency because of El Nino influence and soil erosion has been a severe threat to those engaged in agriculture [12]. “Improving cropland management is essential to raise crop productivity without extra degrading of soil & water resources” [13]. “At the same time, sustainable agriculture has the potential to deliver co-benefits in the form of reduced greenhouse gases emissions (RGHGE) while increasing carbon sequestration, that contribute to climate change mitigation and adaptation” [14,15].

Addressing the aforementioned challenges and issues is a pre-requisite to adapt the changing climate and warrant food security in dry lands. Conservation farming (CF) techniques like planting basin and tie-ridging supported with mulching of crop residues and fertilizer micro dosing application offered encouraging effects together in crop production & soil fertility improvement [16]. In areas where soil moisture is a key limitation on yields, conservation farming can have immediate yield benefits. Soil and water conservation through CF application is utmost for crop productivity in Ethiopia. CF is a farming that targets at generating more yields whereas reducing production costs, maintaining the soil fertility and conserving rainwater [17]. CF comprises practical techniques to decrease soil erosion, reestablish SON and conserve soil moisture & soil fertility [18]. Many research studies reports that positive effects of CF on crop yields compared to conventional tillage practices.

Accordingly, to realize an integrated cropping systems for crop, water & soil productivity and then enhance natural resource management and climate change adaptation in drylands of Tigray region, application of holistic approach is utmost significant. Developing sorghum-legume cropping system with moisture conservation techniques of conservation farming techniques such as permanent planting basin can be encouraged at small-scale farm level. The introduction of improved varieties of legume crops may also have an impact on the existing crop biodiversity and human nutrition, as farmers may only opt for limited improved varieties of crops. Hence, the impact of introduction of improved varieties on crop biodiversity should also be given due emphasis [19]. Adoption of the culture of sorghum– legume cropping integration would enable farmers benefit from improved crop yields and other associated economic gains and contribute for the sustainable management of natural resources. Therefore, the adoption of planting basins as conservation farming practices in the dry land areas of Tigray mainly aims increase soil fertility, crop and water productivity.

Hence, the aim of this research was to investigate agronomic and economic effect of planting basin under conservation agriculture technologies and fertilizer monuments on sorghum yields in Raya Alamata districts of south Tigre, Ethiopia.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

The study was conducted in low rainfall areas of Raya Alamata, Tao district (39^{o} 38' 52" E longitude and 12^{o}30'01"N latitude and having an elevation ranges from 1560 to 1615 m.a.s.l.) districts of southern Tigray, northern Ethiopia in 2016 and 2017 main cropping season.

The study area receives long-term mean annual average rainfall ranges between 350 and 700 mm. The mean minimum and maximum daily temperature of the experimental site is 10 and 26 °C, respectively.

2.2 Soil Sampling Sample Preparation and Analysis

Five composite soil samples were collected randomly at the 0–20 cm soil depth from the entire investigational field beforehand imposing any treatment at the beginning of the study period in 2016. The soil samples were combined and mixed methodically in a basket and a sub-sample was taken for analysis following standard procedures for soil sampling & sample preparation (Andreas & Berndt-Micheal 2005*)*. Parameters analyzed were particle size distribution (content of sand, clay and silt in g/cm^3) soil texture, soil organic matter, cation exchange capacity, pH-in 1:2.5 soil: water, total nitrogen content (%) and available phosphorus (mg/kg), Cation exchange capacity (CEC) Cmole (+)/kg using standard methods of physico-chemical analysis [20]. Soil texture was determined by the modified sedimentation hydrometer techniques [21] with fractions defined according to USDA texture grading (clay<0.002, Silt <0.05 & sand <2mm). Soil organic matter content was determined the Walkley and Black procedure [22]. Total nitrogen conten was analyzed determined by Micro-Kjeldhal method

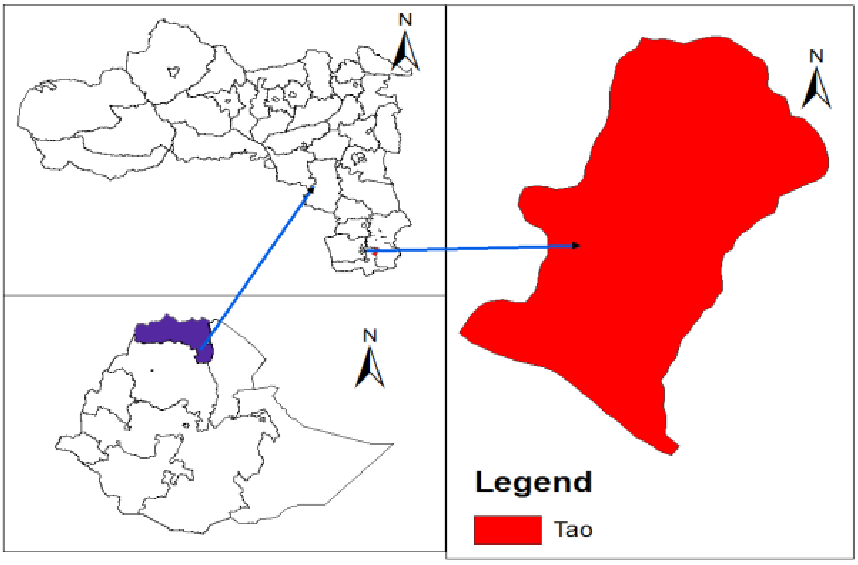

Fig. 1. Geographic map of the study area

[23]. Soil pH was determined in 1:2.5 (weight/volume) soils to water dilution ratio using pH meter [24]. Av.p was determined using Olsen method [25].

2.3 Experimental Procedures

The investigational treatments were arranged in a randomized complete block design replicated three times. The plot sizes for each treatment were 10m x 10m=100m^2. Permanent planting basins are small pits in the ground mostly used for planting many kinds of crops used to reserve moisture. The planting basins with sizes of 75cm length, 20 cm and 25 cm were prepared using hand hoes at an inter row spacing of 75 cm and intra-row spacing of 20cm. The seed of sorghum was sowed (known as seed hydro priming) in water for 10 hours before sowing to facilitate early germination and planted at 5cm & 15cm depth and plant spacing respectively. Fertilizers were applied according to the requirements of each test crop in each respective site as micro dosing. NPS (19% N +38% P_2O_5 + 7% S) and urea (CO $(NH_2)_2$, 46%N) fertilizers were applied at a rate of 5.62 g basin^{-1}. Well-decomposed farmyard manure was applied at a rate of 450g basin^{-1}. The full dose of NPS fertilizer & farmyard manure was applied at the time of planting while urea was applied in splits, 33 kg ha^{-1} at planting and 67 kg ha^{-1} at knee height stage of growth of the plant. Sorghum and cowpea seeds were planted at rate of 12 and 30 kg ha^{-1} respectively. Full of sorghum plant population and half of the legume plant population was used for intercropping treatments.

For the all the conventional plots, plowing was done as per the farmers practice by farmers' equipment locally known 'Maresha' with no mulching and moisture conservation practice; However, mulching of available weeds on the plot and 30% residue left after harvest were done for all the conservation plots.

Table 1. Treatments used in the experimentation

Trt No.	Treatments	Fertilizers rate
1	Planting basin + fertilizer	5.62 g NPS basin^{-1}
2	Planting basin + fertilizer + farmyard manure	5.62 g NPS + 450g FYM basin^{-1}
3	Planting basin + farmyard manure	450 g FYM basin^{-1}
4	Planting basin +fertilizer + cowpea intercropping	5.62 g NPS basin^{-1}
5	Planting basin without fertilizer with cowpea intercropping	0
6	Planting basin without fertilizer	0
7	Conventional (sorghum)	100 kg NPS+100 kg urea ha^{-1}
8	Conventional (cowpea)	50kg NPS ha^{-1}

Key: FYM is farmyard manure, TrtN is Treatment number

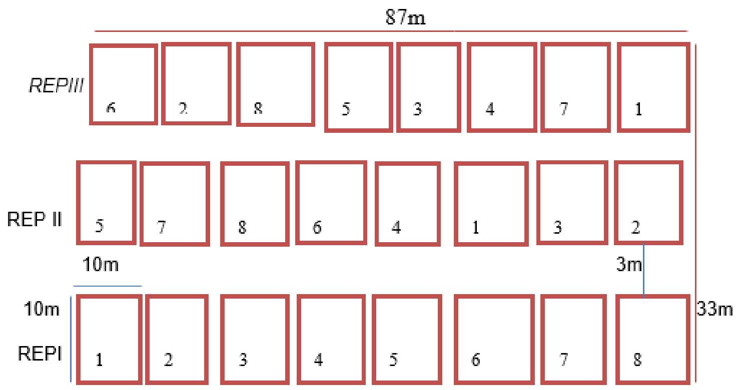

Fig. 2. Schematic diagram of the layout of the treatment arrangement

2.4 Data Collection

Sorghum grain yield (gram plot^{-1}) was taken from each plot by without the border rows, adjusted to 12.5% moisture level, and then converted to hectare basis. Percent deviation of conservation farming from the conventional tillage was calculated as:

$$\text{Deviation (\%)} = \left(\frac{\text{Yield in consrvation farming}}{\text{Yield in consrvation farming} - \text{conventional tillage}}\right) * 100$$

2.5 Partial Budget Analysis

Sorghum grain and biomass yield data for the organic and inorganic fertilizers effects, costs for basin preparation, costs for fertilizer application, costs for seed, tillage costs were subjected to economic analysis, using the CIMMYT [26] partial budget procedures to estimate the economic viability of permanent planting basin in CF farms.

The total returns were computed based on grain & biomass yield and grain and biomass prices obtained from the local market of the study areas. At local market sorghum, grain price was 15.64 Birr kg^{-1}. Total variable costs were calculated from labor and input cost. Labor cost was estimated from labor incurred for seedbed preparation, planting, fertilization, mulching, weeding, harvesting and threshing. Input cost was determined from the cost of fertilizers (NPS, manure and urea) and seeds (sorghum and cowpea). Local market NPS and urea prices per were 1.05 and 0.95 ETB kg^{-1} respectively. For each experimental treatment, the time spent for each activity (seedbed preparation, planting, fertilization, mulching, and basin making, thinning, weeding, harvesting and threshing) was recorded.

2.6 Statistical Analysis

The analysis of variance (ANOVA) for the studied variables was computed using the GLM procedure of R software version following the standard procedures for RCB design. The data were analyzed using R programming software (version 4.0.0) with the updated statistical package R Core Team (2020). Tukey's HSD test ($\alpha = 0.05$) was used for mean separation when the treatments were significantly different at the 5% level.

3. RESULTS AND DISCUSSION

3.1 Soil Physical and Chemical Properties

Soils in the study area are dominantly clay loam in texture and slightly basic. The soil organic carbon contents, phosphorus and total nitrogen was low [27], indicating the low fertility status of the soil aggravated by continuous cereal based cultivation, lack of incorporation of organic materials in to the soils through mulching or crop residues and frequent tillage.

3.2 Effect Planting Basin Conservation Farming Practice on Grain Yield

Table 4 depicts the effects of planting basin and conservation farming technologies on grain yield of the test crops grown in 2016 and 2017 at Raya Alamata. The use of planting basin associated with fertilizer micro dosing (organic, inorganic or integrated of them) significantly ($P<0.05$) increase sorghum yield. Direct planting of sorghum seeds at planting basin supported with micro dosing of chemical fertilizer and farmyard manure gave mean grain yield of 4.61 (61.4% over the conventional) and 4.1 t ha^{-1} (43.7% over the conventional) respectively. These treatments gave consistence grain yield over the variable two cropping seasons. These results show significantly higher yields ($p < 0.05$) for planting basin + fertilized treatments over nonfertilized planting basin treatments, increasing from with 8–31.8% in grain yields. In agreement to this findings research results in Abergelle areas of Tigray revealed that sorghum yield increment by 7 to 48% due to tie-rging at planting time and NP fertilization [32] more yields for CF+ fertilizer treatments over conventional treatments with increscent of 1.2 to 2 t ha^{-1} (20–120%) for maize yield [33].

Table 2. Soil physico-chemical properties the study site

Soil physical and chemical properties	Value	Critical level	Reference
pH(1:2.5 H_2O)	7.39	6.6-7.3	[28]
Available phosphorus (mg kg^{-1} soil)	25.06	<10	[29]
Total nitrogen (%)	0.13	<0.2	[27]
Soil organic matter (%)	1.83	<2	[30]
Electrical conductivity (EC) (ds/m)	0.19	>2	[28]
Cation exchange capacity(CEC) (cmol kg^{-1} soil)	47.5	<25	[31]
Exchangeable k^+ (cmol (+) kg^{-1} of soil)	0.59	<0.4	[31]
Exchangeable Na (cmol (+) kg^{-1} of soil)	0.13	<40	[31]
Exchangeable Ca^{2+} (cmol (+) kg^{-1} of soil)	4.4	<5	[31]
Exchangeable Mg^2(cmol (+) kg^{-1} of soil)	2.6	<0.5	[31]
Textural class	clay loam		

Table 3. Effect of planting basin Conservation farming on grain yield of sorghum and cow pea

Treatment	Grain yield (t ha^{-1})		
	2016	**2017**	**Mean**
Planting basin with fertilizer	4.68	4.54	4.61
Planting basin with farmyard manure	4.08	4.13	4.11
Planting basin with fertilizer and farmyard manure	3.94	3.84	3.89
Planting basin with fertilizer and cow pea intercropping	3.72 (1.09)	3.84 (1.1)	3.78(1.09)
Planting basin + cow pea intercropping without fertilizer	3.60 (0.98)	3.47 (1.0)	3.53 (0.99)
Planting basin without fertilizer	3.55	3.44	3.50
Conventional (sole Sorghum)	2.81	2.90	2.86
Conventional (sole cow pea)	0.94	3.05	2.00
CV (%)	5.4	6.6	6.0
LSD (5%)	0.36	0.45	0.26

Key: figures in parenthesis are the grain yield for cowpea

Table 4. Panelist (n=49) ranking of the treatments

Treatment	Total score	Preference rank	Remark
Planting basin with fertilizer	7	1	High yielding, better moisture conserved, low risks of soil erosion.
Planting basin with farmyard manure	6	2	
Planting basin with fertilizer & farmyard manure	5	3	
Planting basin with fertilizer & cowpea intercropping	4	4	High yielding, better moisture conserved, alternative animal and human feed
Planting basin with cowpea intercropping without fertilizer	3	5	
Planting basin without fertilizer	2	6	High yielding, better moisture conserved
Conventional tillage	1	7	Low grain and biomass yield, low moisture conserved

Where 1 is the highest score and 7, the lowest score.

Planting basin in the sorghum/cow pea intercropping supported by fertilizer micro dosing also gave mean sorghum and cowpea grain yield of 3.78 and 1.09 t ha-1 respectively. The intercropped cowpea have great role in soil nutrient replacement and source of protein in the low lands of south Tigray. Research findings in Ethiopian dry lands revealed that CF can decrease soil erosion and runoff [34], increase crop yields [35,8), SOM, and mineral nutrients [35].The lowest grain yield (2.86 t ha^{-1}) was obtained from conventional tillage (4 times tillage, no moisture harvesting, no mulching and fertilizer broad casting) method, which indicates that the importance of integration of fertilizer management practices and moisture harvesting system for enhancing agricultural productivity in the dryland areas of Tigre. The overall crop performance was generally worst (Fig. 3) for conventional tillage treatmnets, this might be due to no organic matter residue incorporation, frequent tillage practice that also facilitates soil erosion and nutrient depletion and soil moisture loss. Reduced tillage with integration of mulching in fact increase water availability to plants improving the capacity of the soil surface to intercept rainfall, reducing direct evaporation and increasing water storage [36]. Several researchers have also stated increased yields from CF application [5,37].

“The CF packages in the semi-arid regions of Tigray include dry-season land preparation using reduced tillage techniques (hand hoe basins), crop residue retention, and precision input application and intercropping pulse crops. These techniques improve soil structure and water retention and reduce the need for chemical fertilizers while at the same time increasing yield. The major reasons for the increase in yields were better moisture availability, improved soil fertility and better root growth because of conservation tillage use” [38]. “Similar findings ripping and sub-soiling/rippering practices also caused in 60% yield increase” [8]. In drier environments, practices that allow plants to make better use of the limited amount of water available result to be most productive. The increased crop yield in conservation plots is primarily due to rainwater harvested in planting basins. In areas where soil moisture is a key constraint on yields, CF can have immediate yield benefits. Planting basin offers the promise of a locally adapted, low-external-input agricultural strategy that can be adopted by resource-constrained farming communities and female farmers. In the research findings of [39] “stated that permanent basins reducing oxen requirement under conservation tillage in Northern Ethiopia”.

Furthermore, to the sorghum grain yields, a 1.09 t ha-1 cowpea grain yield was obtained from the intercropping (100:50% sorghum cow pea ratios). Besides long-term improvement SOM and TN, legumes have abundant role in improving inputs of nitrogen through nitrogen-fixing plants is significant in increasing productivity [40]. Other findings also indicate that intercropping of maize with haricot bean followed by application of NPS significantly increased biomass, grain yield and kernel weight of maize in western Ethiopia.

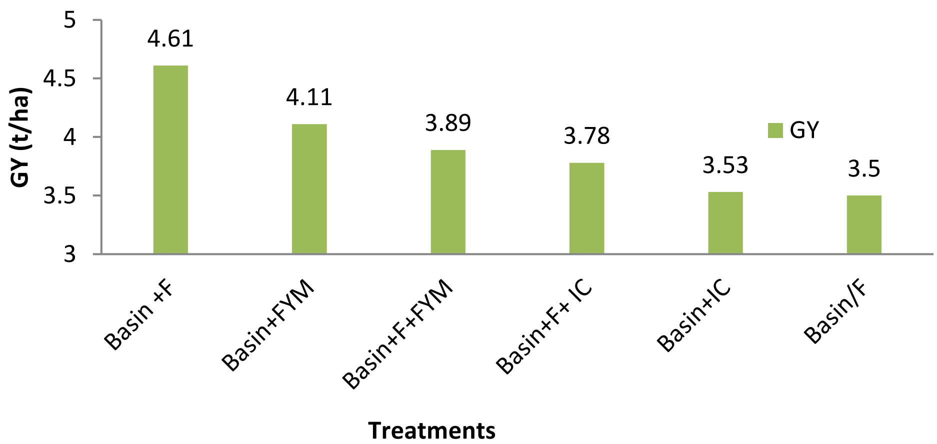

Fig. 3. Effect of Fertilize management on grain yield of Sorghum

Key: Basin/F = Basin without fertilizer, Basin+IC = Basin with intercropping, Basin+F+IC = Basin with fertilizer & intercropping, Basin+F+FYM = Basin with fertilizer and farmyard manure, Basin+FYM = Basin with farmyard manure & B+F =Basin with fertilizer.

Fig. 4. Comparison of CF (left) and conventional (right) tillage at Tao FTC, R/Alamata in 2016

3.3 Farmers Evaluation

Farmers were involved in evaluating CF technologies at different crop growth stages, therefore all the respondents specified that permanent planting basins with conservation farming practices can rise biomass yield, kernel yield, enhance soil moisture content & reduce soil erosion than the conventional tillages practices, however weed management practice the panelist stated that higher labor requirement in CF than in CT as there is repeated tilling & inter-row cultivation (locally known as 'Shelshalo') which is at ease for weed control. Farmers select basin + fertilizer; basin + farmyard manure and basin +fertilizer +farmyard manure treatments as first, second and third respectively, while the conventional method of tillage was least scored from all the treatments referencing whole performance of the test crops (Table 4).

Perceptions of farmers are commonly very powerful in policy directions and recommendations for CF and other technologies as they participating in each occasions, concussions and evaluation of the technologies.

Like the farmers observation in the experiment field, many research findings reported that advantages of some CT & CF practice with their limitations (Table 6).

3.4 Partial Budget Analysis

The costs of NPS and urea organic fertilizers, costs for diggings of basins, tilling of conventional plots, weeding and costs of seed were considered for this economic analysis (Table 7). The results of the economic analysis indicated higher net return of 79,413.6 birr/ha with acceptable marginal rate of returns (MRR=3850.%) was obtained from direct planting of sorghum seeds on permanent planting basin integrated with mulches and fertilizers micro dosing. Nonetheless, the effectiveness and viability of integrated cropping & moisture conservation in CF cannot conclude

Table 5. Farmers comparative evaluation of conservation farming (CF) & conventional tillage (CT)

Contribution of the CF practice	Farmers response (n=49)	
	Agree (%)	Dis agree (%)
Enhance soil fertility and soil health	75	25
Conserve soil moisture	100	0
Reduce soil erosion	100	0
Save labor cost	30	70
Decrease weed problem	0	100
Increase yield and biomass	100	0

Table 6. Advantages and limitations of Some CT and CF practices

Practices	Advantage	Limitations
Mulching crop residue	Mulching controls soil erosion, reducing the speed of runoff and increasing rate of water infiltration and increase the activity and species diversity of soil flora and fauna [41,42]. Mulch controls weed by covering the soil and suppressing their growth.	Compete feed and local fire wood fuel. The cost of some materials can be a drawback to large-scale mulching.
Seed hydro priming	It can shorten germination time, reduce disease incidence in seeds [43].	Primed seeds are difficult to store in some cases.
Fertilizer micro dosing	Increase crop yields [44-46] with low investment of fertilizer cost. Improve fertilizer use efficiency, nutrient uptake by plants and lowers excess that can cause harm through leaching or run-off, reduce the emissions of nitrous oxide from nitrogen fertilizers and hence help to reduce global warming.	Labor requirement is higher [16]
Free grazing		Soil erosion, land degradation [6] & cause spread of weeds. loss of valuable species
Fréquent tillage	Seed bed preparation, weed suppression, improve soil aeration, burying heavy crop residue, leveling the soil, incorporating manure fertilizer in to the root zone and activating pesticides.	Cause land degradation (5; 39). Higher moisture loss [47]. Highest labor costs.

Table 7. Partial budget analysis

Treatment	TVC (Birr ha^{1})	GY (t ha^{-1})	BY (t ha^{-1})	Gross benefit (Birr ha^{-1})	Net benefit (Birr ha^{-1})	MRR (%)
Conventional (sole cow pea)	5010.0	2.00	9.1	62540.5	57530.5	-
Planting basin without fertilizer	5800.0	3.50	10.3	78276.7	72476.7	1890
Planting basin + IC without fertilizer	6215.0	3.53	11.4	84667.1	78452.1	1440
Planting basin + farmyard manure	6660.0	4.11	9.8	79106.3	72446.3	D
Conventional (sole sorghum)	7660.0	2.86	10.2	73983.2	66323.3	D
Planting basin + fertilizer	8000.0	4.61	10.7	87413.6	79413.6	3850
Planting basin + fertilizer + IC	8494.0	3.78	9.0	72843.3	64349.3	D
Planting basin with FYM +fertilizer	8710.0	3.89	9.5	76223.6	67513.6	1460

Keys: Birr is Ethiopian currency (1USD=27 birr), GY= grain yield, BY= Biomass yield TVC= Total variable costs (Birr ha^{-1}), and MRR=marginal rate of return, D=dominance, IC=Intercropping, FYM= Farmyard manure.

by its economic return with this two year study periods as the mulching's, nodules from intercropped legumes and crop residues left had beneficial residual effects not only on crop yield but also on soil nutrient build up that can progressively reduce the use of chemical fertilizer and adapt the changing climate.

4. CONCLUSION AND RECOMMENDATIONS

Permanent planting basin technologies under conservation farming practices (like fertilizer and or farmyard manure micro dosing/localized fertilizer application) are recommended for the moisture deficit areas of the study areas and other similar agro ecology and soil conditions.

Conversely; implementation of conservation farming technologies in areas with over grazing is greatly experienced and more demand of sorghum stalk fire wood, retaining 30 -50 % crop residue left was found challenging & treat to disseminate good practices of conservation farming. Consequently pilot scaling of planting basin combined with CF technologies in watershed level can mitigate the treat, changing the mindsets of farming communities who have been farming using conventional agriculture for many years need to be addressed to further increase the sustainable uptake of CF and consequently its impact on food security and climate.

Even if the condusive policy for agricultural transformation and climate smart agriculture (CSA) in Ethiopia is already there, the transition from conventional farming to conservation farming requires more concrete implementation modalities including, among others.

Therefore, it is understood that the two year research on evaluating planting basin under conservation farming has contribute a lot and continue to influence the policy towards including the conservation farming best results in the regional strategy, working manuals as well as working towards the free grazing issues, but further detailed study and dissemination period is required for transformation from locally to climate smart technologies.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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