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Research Article

Participatory Demonstration and Evaluation of In-situ Rain Water Harvesting Technology with Sorghum Production in West Hararghe Zone

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Abstract

The study was conducted in Daro Lebu and Hawi Gudina districts of West Hararghe zone with objective of evaluating the performance of In-situ water harvesting technologies with sorghum production under farmers' condition. Haroresa kile and Ibsa kebeles were selected based on water deficit and potential sorghum production. 4 farmers from Haroresa kile and 3 farmers from Ibsa were participated on the experiment. 10m by 10m area was used and planted side by side on structure verses without structure. The Structure was constructed with 30cm depth, 30cm width and tied ridge at 3m interval and seed was placed on center at 15cm. Melkam Sorghum variety was planted using 75cm *25cm plant spacing. Yield, farmers' preference and production cost were collected and analyzed by descriptive statistics, simple ranking method and cost benefit analysis respectively. Training and mini-field day were organized to promote In-situ water harvesting on Sorghum production. Farmers selected Structure Technology by stay green, stay moist, drought tolerance, disease tolerance and head size. 47Qtha^{-1} and 45.2Qtha^{-1}grain yield were obtained from Sorghum planted with structure and without structure respectively, with 4% yield advantage over without structure. Production of Sorghum variety with structure and without structure generated an income of 169, 250 birr ha^{-1} and 167, 050 birr ha-^{1}, respectively. Based on farmers' preferences and profitability of the technology, planting sorghum with tied ridge/structure/ was recommended for water deficit areas of west Hararghe zone and similar agro-ecologies to increase production and productivity of sorghum.

Keywords

Melkam Variety, Structure, Without Structure, Water Deficit, Tied Ridge

1. Introduction

In Ethiopia Agriculture contributes 45% (GDP), 83.9% of export and 80% of total employment [1]. Despite this importance agriculture production of the country is challenged by rain fed shortage. West Hararghe zone is one of victim of this problem. In this zone, sorghum is the 1st options crop to reduce food insecurity problems. Water harvesting has great impact on crop production and reduces food insecurity [2].

In-situ water harvesting storage can increase the yield of sorghum by 152% [3]. Sorghum planted with tied ridge recorded high yielder than the conventional tillage and 11% yield advantage even without any amendment. Sorghum produced with tied ridge has highest stover and grain yield over

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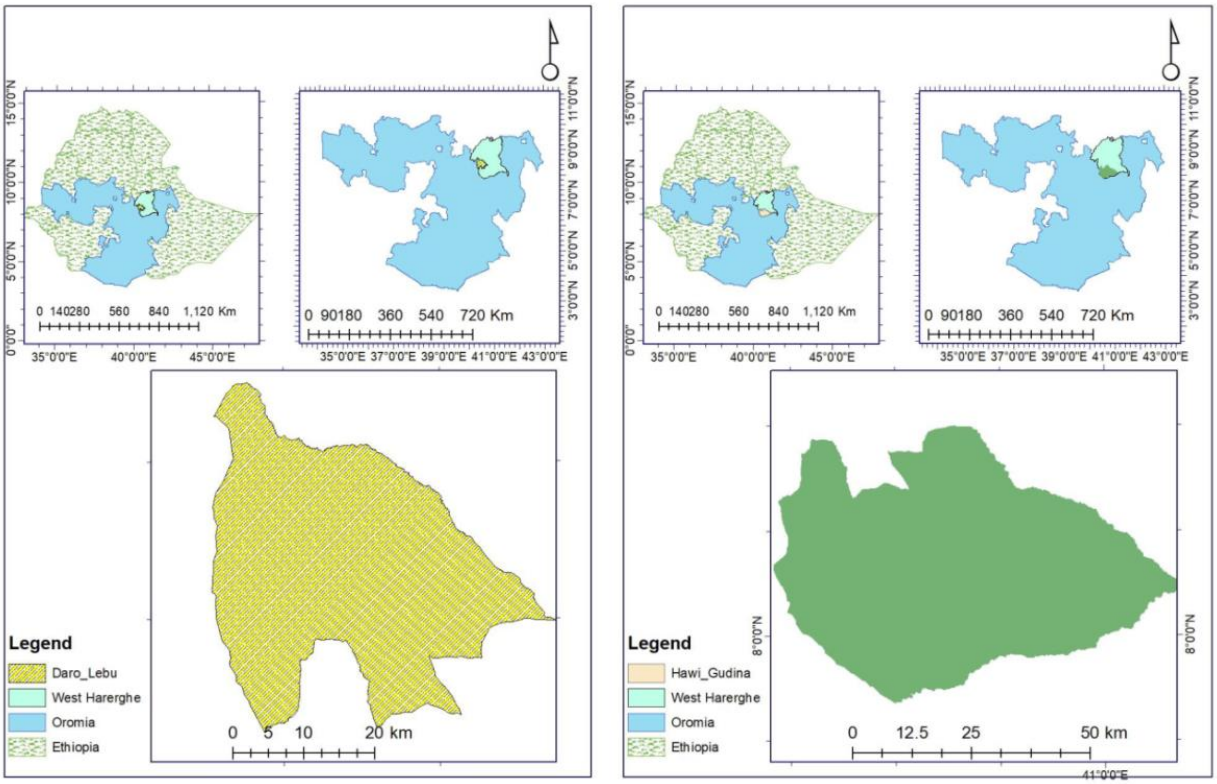
conventional tillage [4]. Integrating in-situ rain water harvesting with crop production can improve production and productivity through improving soil moisture at plant root zone [5]. Plant that has tied ridge recorded high yield more than control and it can reduce run off and increase soil water storage [6]. Sorghum is the 1st crop in terms of its areas and volume of production in West Hararghe zone. The productivity of the crop is low due to frequent occurrence of rain fall shortage [7].

Despite its low yield, the farmers seek sorghum for grain yield and stalk for animal feed. In study areas some farmers practice soil water conservations with horticultural production. However, soil water conservation with cereal crop production is not well known. Therefore, to increase yield and stalk of sorghum, planting the crop with different soil water conservations structure is very essential. Mechara Agricultural Research Center has conducted the research on In-situ rain water harvesting with Melkam sorghum variety at Daro Lebu and Boke districts of West Hararghe Zone. According [5] In-situ water harvesting practice of tied ridge with single rows of sorghum (TS) and farmer practice produced 29.3 $Qtha^{-1}$ and 17.4$Qtha^{-1}$ of sorghum yield at Daro Lebu district and 19$Qtha^{-1}$and 19.9$Qtha^{-1}$ of sorghum yield at Boke district respectively Therefore, the study was initiated with objective of:

1) To evaluate performance of In-situ rain water harvesting with sorghum production under farmers conditions.
2) To create awareness on In-situ rain water harvesting for different stakeholders.
3) To analyze profitability of In-situ rain water Harvesting with sorghum production.

2. Materials and Methods

2.1. Description of Experimental Sites



Source [8]

Figure 1. *Map of study areas.*

The study was conducted in West Hararghe zone, at Daro Lebu and Hawi Gudina districts in the year 2021and 2022. Daro Lebu geographically bordered by Shebele river in South, Arsi in West, Guba Koricha in North West, Habro in North and Boke in East directions. The district has 1350 to 2450 meter above sea level. Farmers lived in this areas practice crop productions, mostly cereals, horticulture, coffee, chat, fatting, trade and rearing cattle to sustain their life. The district en-

dowed three agro ecological zones namely highland (10%), Midland (34%) and lowland (56%) [9, 10]. Hawi Gudina is one another district of West Hararghe zone and bordered by Daro Lebu in North, Amigna in West, Burqa Dintu in East and Belto in South directions. Bu'i is the capital city of Hawi gudina district and located between 1200 to 1800 meter above sea level with latitude 8110º 35′ 33.311″N and longitude 6185º8′8.841″E. Hawi Gudina has annual temperature of 27-30°C and annual rain fall 200-1500mm/year [11, 12].

2.2. Site and Farmers Selection

One kebele from each district; two kebeles were selected based on rain fall shortage and potential for sorghum production. Accordingly, Haroresa Kile kebele from Daro Lebu and Ibsa kebele from Hawi Gudina districts were selected for implementation of the activity. Three farmers from Ibsa kebele and four farmers from Haroresa Kile kebele were selected based on their interest, capacity to allocate land and manage trail. Farmers and sites were selected with collaboration of Extension workers, Researchers and SMSs respective of district Agricultural offices.

2.3. Experimental Design

Tied Ridge (structure) was evaluated verses without structure (farmers practice) on 10m by10m area. The structure was constructed with 30cm depth, 30cm width and tied ridge at 3m interval, and the seed was planted on the center at 15cm. Melkam Sorghum variety was planted with 12kgha^{-1} seed rate, 100kgha^{-1} of NPSBr and 70kgha^{-1} of Urea and plant spacing of 75cm*25cm.

2.4. Data Collected and Methods of Data Analysis

Yield, production costs and farmers' preference were collected through interview, measurement and observation methods. Descriptive statistics, simple ranking methods, cost benefit analysis and t-test were used to analyze the collected data.

3. Results and Discussions

3.1. Awareness Creation

Awareness is important to implement agricultural technology on the ground. For this activity awareness for different stakeholders was created through training and mini-field day. Training was organized and delivered at Mechara Agricultural Research Center. On this training; 13 experimental farmers, 3 extension workers and 6 SMSs were participated on in-situ rain water harvesting technologies (Table 1).

Table 1. *Stakeholders participated on training and Mini field day.*

Promotion method	Stakeholders	Male	Female	Total
Training	Framers	11	2	13
	Extension workers	3	0	3
	SMSs	6	0	6
	Total	20	2	22
Mini field day	Farmers	40	11	51
	Extension workers	2	0	2
	SMSs	3	0	3
	Others	10	1	11
	Total	55	12	67
Ground Total		102	62	51

Source: own computation (2021)

Mini-field day was held at Hawi Gudina District, Ibsa kebele. On the event, 51 farmers, 2 extension workers, 3 SMSs and other 11 stakeholders were participated. As well as 52 leaflets were distributed for the participants to promote the technology.

Figure 2. *Mini-field day on In-situ water harvesting Technology at Ibsa kebele, 2021.*

3.2. Technology Selection

Farmers preference was collected through group using mini field day held to select the best technology. Accordingly Melkam sorghum variety planted with structure (tied ridge) was selected by farmers due to its stay green, drought tolerance, disease tolerance, stay moist and head size.

Table 2. Farmers' preference ranked by simple ranking method.

Technology	Parameters								Mean	Rank
	PH	EF	EM	SG	DRT	SM	HS	DT		
With Structure	3.7	3.4	3.3	4.9	4.8	4,8	4.8	4.7	4.3	1
Without structure	3.8	4.4	4	3.2	3	2.9	3	3	3.4	2

Source: own computation (2021),
Hint: PH: plant height, EF: Early flowering, EM: Early maturity, SG: stay green, DRT: drought tolerance, DT: Disease tolerance and SM: stay moist

3.3. Yield Performance

During the evaluation Sorghum planted with structure was highly preformed at Daro Lebu with 29.3Qtha^{-1}, but lower performance was observed at Boke 19 Qtha^{-1} [5] and best performance was also repeated at Daro Lebu during demonstration. In general, potential of Sorghum with structure was observed batter during demonstration than during evaluation But Sorghum planted without structure recorded lowest yield during evaluation at Daro Lebu with 17.4 Qtha^{-1} [5] and lowest performance also observed during demonstration at Hawi Gudina district. Variation of yield during evaluation and demonstration might be due to different soil fertility, rainfall, temperature and other factors.

Table 3. Yield performance Sorghum at different stage (Qtha^{-1}).

Technology	Evaluation		Demonstration	
	Daro Lebu	Boke	Daro lebu	Hawi Gudina
With structure	29.3	19	54.5	39.34
Without structure	17.4	19.9	53.8	36.67

Source: Own computations (2021)

Figure 3. Performance of Sorghum with In-situ water harvesting at Haroresa Kile kebele (2021).

Figure 4. Status of sorghum at flowering stage, at Haroresa kile kebele, 2021.

At Daro Lebu, sorghum planted with structure gave the yield of 54.5 Qtha^{-1} with 1.3% yield advantage whereas without structure gave 53.8Qtha-^{1}. At Hawi Gudina, sor-

ghum planted with structure recorded 39.34 Qtha^{-1} followed by without structure 36.67 Qtha^{-1} and 7.3 yield advantage of with structure over without structure. This yield difference might be due to location difference and environmental factors like soil fertility, soil structure and texture, temperature, rain fall, humidity and the others.

Table 4. Yield performance of Sorghum during demonstrations.

Districts	Technology	Yield (Qt/ha), (N=7)				
		Mean	Min	Max	Std. dev	Yield Adv (%)
Daro Lebu (Haroessa kile)	With structure	54.5	50	60	5	1.3
	Without structure	53.8	48.5	61.5	6.79	
Hawi Gudina (Ibsa)	With structure	39.34	22.9	47.5	11.29	7.3
	Without structure	36.67	19.1	43.8	11.8	

Source: own computation (2021), where Adv (%) is yield advantage

In general at both locations, Sorghum planted with structure recorded 47 Qtha-^{1} and without structure 45.2 Qtha-^{1} and 4% yield advantage over without structure. Even though there is no statically difference; there is numerical difference between them. Tied ridge is significantly increased yield of sorghum from 9% to 11% than sorghum planted on flat space or without structure [13]. Similarly In-situ rain water harvesting can increase productivity of Sorghum when applied and practiced by small holder farmers on areas that frequently affected by rain fall shortage [3]. Soil water conservations attached with crop is very important in water deficit areas to increase yield [2]. From field observations farmers may obtain more yields if properly managed and renewed the structure on time continuously during production time. Sorghum planted with Structure had 7.3% yield advantage at Hawi Gudina and 1.3% at Daro Lebu districts respectively.

Table 5. Yield summary during demonstration.

Technology	Yield (Qtha^{-1}); (N=7)				Yield	t-test	
	Mean	Min	Max	Std. dev	adv. (%)	t-value	Sign
With Structure	47	36.45	53.75	8.1	4	0.94	0.384^{NS}
Without structure	45.2	33.8	52.65	9.2			

Source: own computation (2021)

3.4. Cost Benefit Analysis

In this research farmers haven't spent extra cost, but they incurred cost to construct and renew tied ridge/structure. During demonstration cost incurred by farmers on fertilizer, seed, ploughing and labor were collected. Production of sorghum variety (Melkam) with structure and without structure could generate an income of 169,250 birr ha-^{1} and 167,050 birr ha^{-1} respectively. This showed that farmers who plant sorghum with tied ridge could get more financial return from with structure than without structure. In addition to this tied ridge is important to conserve the soil moisture in the long run.

Table 6. Profitability of In-situ water harvesting with sorghum (ETB).

Parameters	Sorghum planted	
	With structure	without structure
Yield (Qtha-^{1})	47	45.2
price per quantal (Birr)	4,000	4,000
Total revenue (TR=Y*P)	1,88,000	1,80,800
Cost incurred (Birr)		
Seed cost (Birr)	1,200	1,200
Fertilizers (Birr)	6,550	6,550
Labour cost (only for tied ridge)	5,000	0
Ploughing cost (Birr)	6,000	6,000
Total variable cost (Birr)	18,750	13,750
GM=TR-TC (Birr)	1,69,250	1,67,050

Source: own computation (2021)

4. Conclusions

Water harvesting in water deficit areas is crucial for crop production to increase production and reduce food insecurity problems in West Hararghe zone. Evaluation and demonstration of different water conservations structures in moisture stress area is important for sorghum production. The result of the demonstration showed that Sorghum planted with structure had 1.8Qt yield advance (4%) than without structure. Farmers' also preferred sorghum planted with structure due to its stay green, stay moist, disease tolerance, drought tolerance and head size. From result the of group discussion conducted with farmers, farmers gave positive feedback toward tied ridge on sorghum yield in terms of improve seed color, seed size and strong stalk than without structure. This tied ridge is very important to conserve soil and retain water in the soil for long period of time.

5. Recommendations

In study areas, farmers still depend on different aid to sustain their life due to prolonged drought that cause yield reduction. So water conservation with crop production very essential to increase yield. Based on grain yield obtained, farmers' preference, profitability of technology and moisture retentions for long period; planting of Sorghum with structure (tied ridge) is recommended for pre-scaling up in water deficit areas of west Hararghe zone and similar agro-ecologies.

Abbreviations

GDP	Gross Domestic Product
TR	Total Revenue
TC	Total Cost
ETB	Ethiopian Birr
SMSs	Subject Matter Specialists

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Author Contributions

Adem Hirpo: Conceptualization, Data curation, Formal Analysis, Software, Supervision, Writing – original draft, Writing – review, editing and presenting

Gemechu Terefe: Data curation, Supervision, Writing – review editing and presenting

Fekede Gemechu: Project administration, Resources, Supervision, review & editing

Nimona Sime: Conceptualization

Gemechu Ayala: Conceptualization, Supervision

Conflicts of Interest

The authors declare no conflicts of interest.

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