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Original Paper

Enhancing Irrigation Water Management and Malt Barley Practices for Smallholder Farmers at Barneb Irrigation Scheme, Legambo District, Ethiopia

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***Abstract*— A pre-scale-up study was conducted at the Barneb small-scale irrigation scheme to promote improved irrigation technologies for malt barley, aiming to enhance water use efficiency, farm productivity, and the economic benefits of smallholder farmers. Traditional flooding methods were found to be inefficient due to water wastage, soil erosion, and waterlogging. To address these issues, a Farmer Research Group (FRG) consisting of 30 farmers (26 male and 4 female household heads) was established. The improved irrigation practice involved double row raised bed furrow irrigation with a 40 cm bed width, 20 cm furrow width, and 20 cm row spacing, along with recommended fertilizer rates (100 kg ha^{-1} Urea and 100 kg ha^{-1} NPS). Net irrigation depths were 19 mm during the initial stage and 44.3 mm during the mid-season stage, with irrigation applied at 30-day intervals. Results showed that improved seed combined with improved irrigation and agronomic practices yielded 4,250 kg ha^{-1}, a 25% increase over the 3,400 kg ha^{-1} yield from local seed under traditional practices. Water productivity also improved significantly, with the improved method achieving 4.7 kg m^{-3}, nearly double that of the farmer's practice (2.4 kg m^{-3}). The net benefit from improved practices was 133,300 ETB ha^{-1}, which is 55.14% higher (47,375 ETB ha^{-1} more) than the 85,925 ETB ha^{-1} achieved through traditional methods. In conclusion, the study recommends scaling up the improved technologies through collaborative efforts between the Ministry of Agriculture, NGOs, and private sectors via integrated irrigation extension programs.**

Keywords*— FRG, Farmers practices, Improved practices, Scaling, Small-scale irrigation

I. Introduction

Barley is the most ancient food crop being grown in diverse ecologies of Ethiopia with an altitude range from1800 to 3400 m [1]. Ethiopia is the second largest producer in Africa, next to Morocco [2]. The demand for beer and malt industries has been increasing associated with the rise of urbanization and the construction of new malt factories. It is a high-opportunity crop, particularly when connected with the country's commercial brewing industries for profitable expansion [3]. In the Barneb small-scale irrigation scheme, barley is the major crop produced under irrigation and rainfall. However, the productivity is low, and the quality does not meet the standards of imports. Lack of improved varieties, inappropriate fertilizer application and management, broadcast sowing, seed rate and improper irrigation water management are the main issues hindering the quantity and quality of malt barley production in the scheme. The traditional irrigation method (flooding) is a common practice. The weakness of flood irrigation are soil erosion, environmental degradation, and waterlogging that in turn a favorable condition for rust diseases [4]. Whereas the improved irrigation method is preferable for water saving, increasing yield, decreasing water logging and soil erosion, enhancing water productivity and easily for water application than the traditional flooding method [5]. Therefore, this study aims to promote improved irrigation technologies for enhancing water use efficiency, farm productivity, and the benefits of smallholder farmers at Barneb small-scale irrigation scheme. Therefore, the prescale-up aimed to promote improved irrigation technologies to increase grain yield, water use efficiency, and net benefit of malt barley.

II. Methods And Approach

A. Description Of The Study Area

The study was conducted at Barneb small-scale irrigation scheme during 2022 irrigation season which is in Legambo district South Wollo Zone Amhara region. The irrigation scheme is found 80 km from the west of Dessie. Geographically it is located at 518943 Easting longitudes, 1203706 m Northing latitudes (Figure.1).

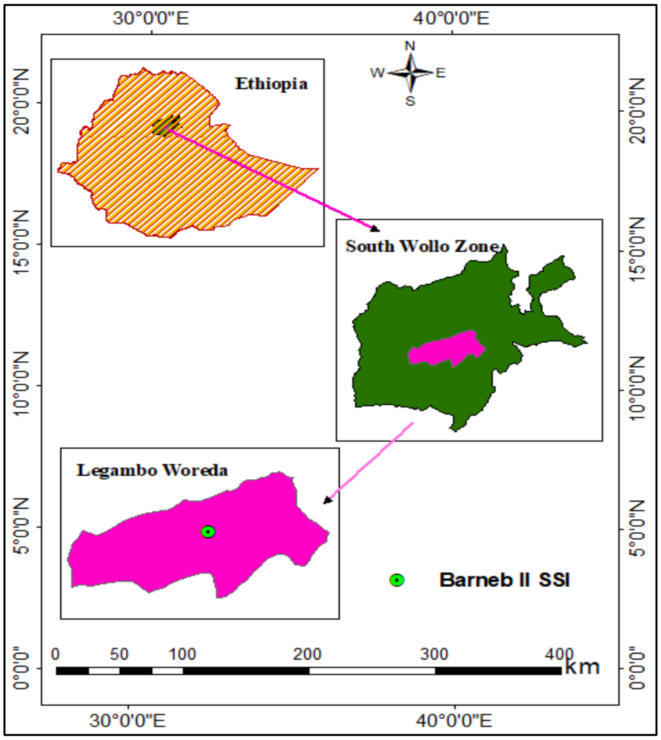

Fig. 1. Study area map

Based on the traditional Ethiopian agro-ecological zone classification [6] the scheme is categorized under the Dega agro-climatic zone. The mean annual minimum and maximum temperatures are 4.32 °C and 17.39 °C respectively. The soil nature of the scheme is dominated vertisols. Crops commonly grown under irrigation are wheat, barley, fenugreek, garlic and potato.

B. Study Approach

One Farmers Research Extension Group (FREG) with 30 (26 male and 4 female household heads) members was formed for to promote the improved irrigation practice of malt barley. The training was given to agricultural expert (1), extension agents (3) and 30 farmers (26 male and 4 female) about the improved irrigation method (furrow irrigation, irrigation schedule and amount) and agronomic practices (row planting, plant spacing, seed rate, recommended fertilizer application, and diseases management). The economic, social, environmental and policy direction criteria were considered for commodity-based value chain selection. Therefore, malt barley was selected based on its potential to provide higher and more sustainable benefits with the higher number of associated value chain actors. The activity was monitored and supervised by Sirinka Agricultural Research Center (SARC) and International Crop Research Institute for Semi Arid Tropics (ICRISAT). The seed inspection and quality declaration tasks was done by Dessie Seed Quality Control and Assurance Authority. Whereas, the fertilizer was supplied by district agricultural office.

Fig. 2. Discussion with beneficiaries and irrigation water user associations (IWUs)

C. Agronomic Practices

500 kg improved malt barley seed (Ibon-174) was supplied by SARC and ICRISAT to FREG host farmers (12) with the seed rate of 100 kg/ha. Whereas, NPS (500 kg) and urea (500 kg) fertilizer were distributed by the district office of agriculture. The fertilizer was applied as 100 kg ha^{-1} Urea and 100 kg ha^{-1} NPS rate. Double-row raised bed furrow technology with 40 cm bed width, 20 cm furrow width, and 20 cm row spacing were applied. Totally, five ha of land was done by the improved practice. CROPWAT 8.0 model was used for the determination of irrigation scheduling. Based on the model output, the net irrigation applied depths were 19 mm for initial stage and 44.3 mm for mid-season stage with 30-days irrigation interval. Because the irrigation scheme is attributed by Vertisols and the cooled climate can hold water for a long time. In the farmer's practice broadcast sowing (200 kg/ha), flood irrigation 38-days interval, inadequate fertilizer

rate and management (50 kg/ha urea and 75 kg/ha NPS) and local seed (Nechita barley) were the common practices.

Fig. 3. Field performance of improved barley (Ibon-174)

Fig. 4. The flooding irrigation practice at Barneb irrigation scheme

At the improved and farmer practice, the straw and grain yield, water productivity, labor and input cost, and farm gate price were collected. The cost-benefit analysis was done following [7] and the water productivity was calculated as [8].

$$WP = \frac{\text{Grain yield (kg)}}{\text{Total amount of water supplied m}^3} \text{.........................(1)}$$

$$MRR = \frac{\Delta \text{ Gross return}}{\Delta \text{ Total variable cost}} \text{..(2)}$$

The field-day was conducted at the crop grain filling stage and FREG members 30 (26 male and 4 female household heads were attend. The perception was collected from 16 selected FREG member farmers using semi-structured questionnaire. The Seed Quality Control and Assurance Authority, diction makers, Agricultural experts were invited attend the field day. The agronomic and perception data were analyzed by R version 4.4.2. software and drown using a five-point Likert scale method.

III. Results And Discussion

A. Grain Yield And Straw Yield Performances

Based on the result (Figure.5 and Figure.6) indicates that the improved practices likely enhance grain yield compared to traditional framer practices under irrigation. This suggests that adopting these advanced practices could be a highly effective strategy for maximizing malt barley yield.

The result shows that the higher grain yield (4250 kg ha−1) was obtained from the improved seed with improved management (IP) practices whereas, the lower yield (3400 kg·ha−1) was recorded from the local seed with farmers practices (FP). Hence, improved seed with improved irrigation practices gave 25% grain yield advantage over the local seed with farmer's irrigation management practices (Figure. 6). The study agreed with many findings reported that the furrow irrigation practices were significantly increases the grain yield, straw yield and malt quality of barley [9, 10, and 11].

The relatively maximum straw yield (2200 kg ha−1) was obtained from the local seed with local management whereas, the improved seed with improved management (IP) practices gave 1600 kg ha−1 straw yield. Based on the genetic characteristics the local seed (Nechita variety) has a higher canopy cover than the improved one (Ibon-174) resulting in a high straw yield (Figure. 6).

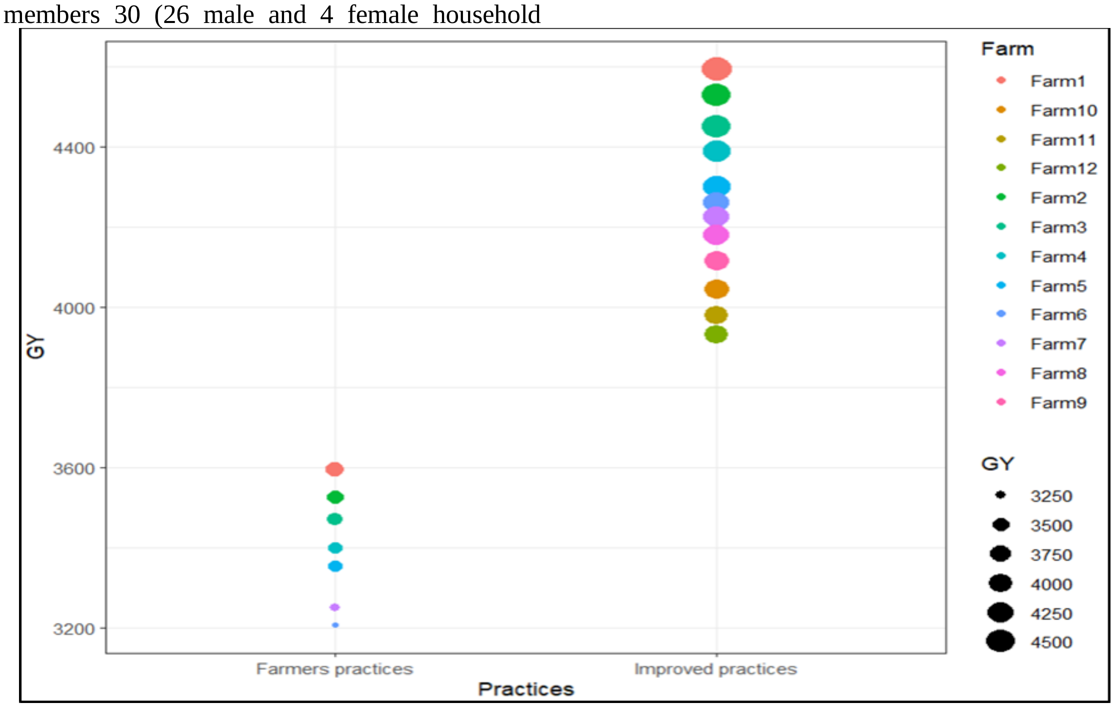

Fig. 5. Data distribution across farmers malt barley (Ibon-174)
Where GY: Grain yield

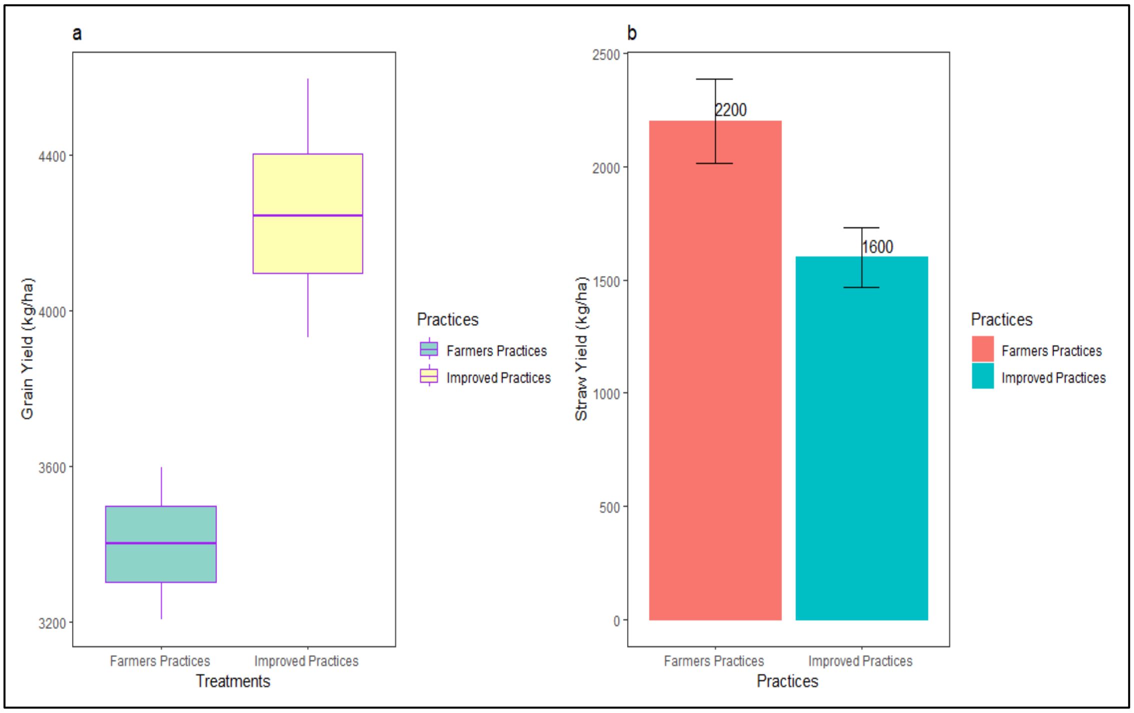

Fig. 6. Mean grain and straw yields (kg ha-1), a: Grain yield; b: Straw yield

B. *Grain Yield And Straw Yield Performances*

The result shows that the application of improved seed with improved management (IP) practices had nearly doubled water productivity (4.7 kg m-3) over the farmer's practice (2.4) kg m-3) (TABLE I). The improved practices consumed a lower seasonal net irrigation depth (90.3 mm) and 50.34 mm (35.79%) of water had saved than the farmer's practices (140.64 mm). Based on the field observation, the farmers flooding irrigation practices had an adverse effect to aggravate soil erosion and water logging (Figure 4), water computation, and water loss. Therefore, improved irrigation practices create a chance to expand 55.75% of additional irrigable land. This means that with the same amount of water, farmers can now cultivate a much larger area than before. The study's findings are consistent with many other research outcomes, which have shown that improved irrigation methods like furrow and raised bed techniques not only boost crop yields and water productivity but also help reduce water loss, soil erosion, and waterlogging. These improvements make it easier for farmers to manage their fields and sustainably increase production. In essence, by shifting from traditional flooding to more efficient irrigation systems, smallholder farmers can make better use of their limited water supplies and unlock more of their land's potential. This reinforces the broader understanding that smart water management is key to transforming agriculture in water-scarce areas [12, 13, and 14].

TABLE I. IRRIGATION REGIME AND WATER PRODUCTIVITY FOR MALT BARLEY

Practice	Growth stages	Irrigation Events	Net Irrigation (mm)	Seasonal net irrigation (mm)	Net seasonal CWR (m^3)	WP (kg/m^3)	Saved water (mm)
IP	Initial	1 time	19	90.3	903	4.7	50.34
	Mid	1 time	44.3				
	Development	1 time	27				
FP	Initial	1 time	37.4	140.64	1406.4	2.4	
	Mid	1 time	57.64				
	Development	1 time	45.6				

Where, IP: Improved practice; FP: Farmers practice; WP: Water productivity

C. *Farmer's Perception And Cost Benefit Analysis*

1) Farmers Perception

The result showed that the overall farmer's perception about the improved technologies laid on strongly agree and agree category. The farmers express that the furrow irrigation technology is easy for water application, water saving and preferable to control erosion (Table II).

TABLE II. FARMER'S PERCEPTION OF MALT BARLEY TECHNOLOGIES ATTRIBUTES.

Variable	Obs	Mean	Std. Dev.	Min	Max
IP decrease diseases occurrence	16	1.81	0.4	1	2
IP saves time for watering	16	1.63	0.5	1	2
IP minimize water loss	16	1.81	0.4	1	2
IP increase yield	16	1.75	0.45	1	2
IP minimize environmental impact (salinization, waterlogging…)	16	1.81	0.66	1	3
IP minimize agriculture labor	16	3.75	0.45	3	4
Generally demand of the IP (to apply next time)	16	1.81	0.54	1	3

Where, 1-1.8 = strongly agree; 1.81-2.6 = agree; 2.61-3.4 = Neutral; 3.41-4.2 = disagree; 4.21-5 = strongly disagree.

2) *Cost Benefit Analysis*

The result showed that (TABLE III), the maximum net benefit (133,300.00 ETB ha^{-1}) was recorded from the improved practices (improved seed, furrow irrigation and agronomic packages). Therefore, it had 47, 375 ETB ha^{-1} (55.14%) net benefit advantage over the farmers' practices (85,925 ETB ha^{-1}). Even though, the improved practices encore the marginal cost of 6,325.00 ETB ha^{-1} however, extra benefit (47,375.00 ETB ha^{-1}) achieved than the farmer's practices.

TABLE III. FINANCIAL COST-BENEFIT ANALYSIS FOR IRRIGATED GREEN MAIZE

Income And Expense	Improved Practices (IP)	Farmers Practice (FP)
Gross benefits	184,900.00	131,200.00
Grain yield	178,500.00	122,400.00
Straw yield	6,400.00	8,800.00
Total Variable costs	51,600.00	45,275.00
Fertilizer cost	8,600.00	5,375.00
Seed cost	4,500.00	7,600.00
Labor cost	37,200.00	29,700.00
Agrochemicals	1,300.00	2,600.00
Net benefit	133,300.00	85,925.00
MC	6,325.00	
MR	47,375.00	
MRR (%)	749.01	

IV. CONCLUSION AND RECOMMENDATION

From the result, the study concludes that the application of improved seed with improved irrigation management practices (furrow irrigation and agronomic packages) was efficient to enhance higher grain yield, water saving, net benefit, water productivity and preferable by the farmers. Hence, the study suggested that improved irrigation management and agronomic practices (irrigation depth, interval, furrow, row planting, seed rate, and fertilizer) should be promoted to the extension packages for further scale-up.

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