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(Research Article)

Participatory demonstration of Irrigation Scheduling on Wheat Yield and Water Productivity at Lintala Irrigation Scheme in Humbo District, Wolaita Zone South Ethiopia Region

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Abstract

The study aimed at participatory demonstration of irrigation scheduling and assess farmers' preferences on wheat yield and water productivity in Fango-Lome Kebele Humbo District, Wolaita Zone South Ethiopia Region. The study indicates that irrigation scheduling technology significantly affects the grain yield of wheat and water productivity. The study revealed that the maximum grain yield (38.22Qt/ha) was acquired from the treatment level of (100%MAD) and minimum yield (30.22Qt/ha) was obtained from the farmers practices. The maximum value of water productivity (0.83kg/m^3) was obtained in treatment level of 100% of MAD and minimum value (0.567kg/m^3) obtained from farmers practices. Supplying fixed amount of water in fixed irrigation interval of five days in initial stage, seven days in development and mid stages and eight days interval in late stages can enhance grain yield of wheat and water productivity. Farmers were preferred irrigation scheduling technology by putting different criteria's as best water saving technology and increases grain yield of wheat that ensures food security of livelihood. Therefore it should be recommended that the technology must be disseminated as the best finding to the neighboring farmers and irrigation schemes with the same agro ecology.

Key words: Irrigation Depth; Interval; Grain Yield; Water Productivity

1 Introduction

Wheat (*Triticum aestivum* L.) is a major food crop in the world, which plays an important role in ensuring food security [1]. Irrigation water is scarce and costly input, its economic and scientific utilization and optimal allocation among the different crops grown becomes quite imperative. Wheat is highly sensitive to water stress during the flowering stage but over irrigation may lead to excessive vegetative growth and shortening of reproductive period and ultimately decrease the yield [2]. Irrigation missing at some critical growth stage sometime drastically reduces grain yield [3] due to lower test weight. Efficient water management, being one of the good agronomic management practices, it not only leads to improve crop productivity but also minimize susceptibility from disease and insect pest under favorable environment for flourishing these biotic stresses [4]. Furrow-irrigated raised-bed planting system is a form of tillage wherein sowing is done on raised beds, this optimizes tillage operation, saves water, and reduces lodging, [5]. The use of CROPWAT to decide on an irrigation regime is one of the most popular approaches to assessing irrigation performance and WP in irrigated areas [6]. Irrigation scheduling optimizes the soil moisture and makes the soil suitably fine for better production. Therefore the study conducted to demonstrate irrigation scheduling and assess farmers' preference of the technologies in the area.

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2 Materials and Method

2.1 Description of study area

The study was carried out at Lintala Irrigation Scheme in Humbo District Wolaita Zone Southern Ethiopia. The irrigation scheme was funded by IFAD project that covers irrigable command area 98ha and serves 124 HH of beneficiaries. The irrigation scheme was geographically located at latitude of 6.6328°N and longitude of 37.5945°E with altitude of 1238m.

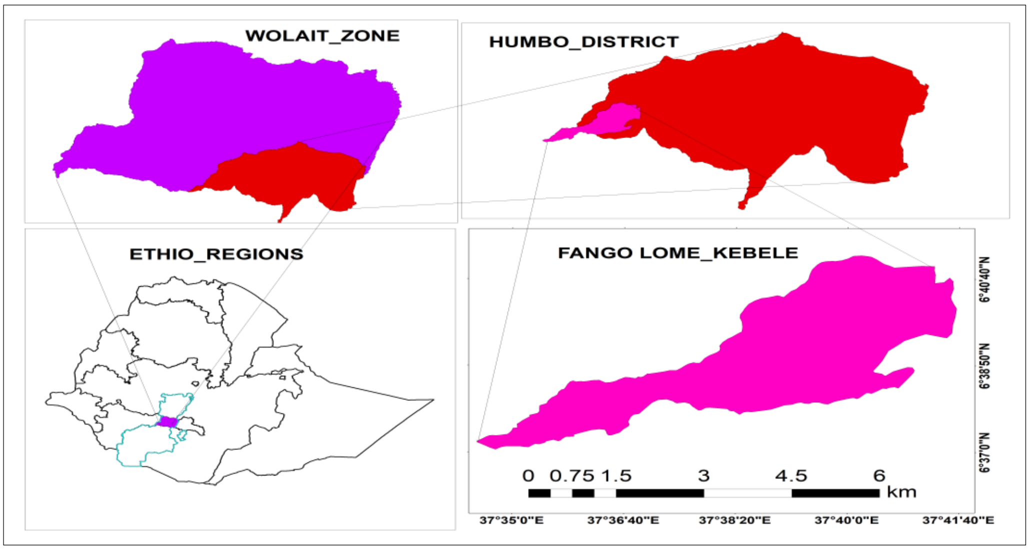

Figure 1 Map of Study Area

2.2 Implementation approach of the project

Participatory on farm demonstration approach was implemented to boost adoption of the irrigation scheduling practices on selected wheat crop in the area. All members of Farmers Research Extension Groups (FREGs) were actively involved on trainings, land preparation, irrigation furrows preparation, plantation and weed management practices up to harvesting. The activity was conducted by the respective agricultural research centers under Southern Agricultural Research Institute (SARI) jointly with Participatory Small Scale Irrigation Development Program (PASIDP-II); project coordinators, project focal persons, district and kebele experts. Accordingly periodical supervision and monitoring was jointly conducted by the SARI, PASIDP coordinators, the respective zonal and districts focal persons. Moreover, close follow was conducted by the corresponding center researchers, members of FREGs, Kebele experts and focal persons of the project in the areas.

2.3 Experimental design and treatments

The experiment has two level of treatments 100% MAD (Crop WAT 8.0 based) and Farmer practice were replicated six times and laid out in Randomized Complete Block Design (RCBD). The wheat (King bird variety) was sown in broad casting system with seed (125kg/ha), NPS (150kg/ha), and Urea (100kg/ha). Urea was applied after main stem leaf emergence nearly after planting or beginning of tillers (30-45) days of after sowing. Plot size was 20m*20m and space between furrows prepared with oxen was adjusted in 40cm. That the furrow can carry sufficient water to the plot. Furrow can at the same time dig ditch for water and also covers both seed and NPS at the ridge. After sowing and furrowing the plot; plots were irrigated within two days' time to avoid extended dry condition after sowing which can cause desiccation of seed. The first irrigation was applied with serious follow up since that the first irrigation stabilizes the plot and follow up irrigations easier.

2.4 Crop water requirements

Crop water requirement refers to the amount of water that needs to be supplied, while crop evapotranspiration refers to the amount of water that is lost through evapotranspiration [7]. To determine crop water requirement, it is important to consider the effect of crop coefficient (Kc) and the effect of climate on crop water requirement, which is the reference crop evapotranspiration (ETo) [8]. The daily climate data like maximum and minimum air temperature, relative humidity, wind speed, sunshine hour and rainfall data of the study area were collected to determine reference evapotranspiration. Crop data like crop coefficient, growing season and development stage, effective root depth, and critical depletion factor for the wheat crop were also used as input data.

$$ETc = ETo \times Kc \quad (1)$$

Where: ETc-Crop Evapotranspiration, Kc-Crop Coefficient, ET_0-Reference Evapotranspiration.

2.5 Irrigation water management

The bulk density is also the ratio of the oven dried mass of soil to its volume for undisturbed soil condition and is expressed on a dry weight basis of the soil: -

$$Bd = \left(\frac{Md}{V_C}\right) \quad (2)$$

Where: Bd-Bulk density, Md- dry mass of the soil and V_C-Volume of core sampler

The total available water (TAW), stored in a unit volume of soil.

$$TAW = \frac{(FC - PWP) * Bd * Rd}{100} \quad (3)$$

TAW-Total Available Water, FC-Field Capacity, PWP-Permanent Wilting Point, Bd-Bulk density and Rd-Root depth.

For onion production, the irrigation scheduling was fixed based on readily available soil water (RAW).

$$RAW = (TAW * p) \quad (4)$$

RAW-Readily Available Water in mm, P (25%)-Allowable moisture depletion for no stress

$$NI = (ETc_{mm} - Peff_{mm}) \quad (5)$$

NI-Net irrigation, ETc-Seasonal crop water requirement, Peff-Effective rain fall.

$$GI = \frac{NI}{Ea} \quad (6)$$

GI-Gross Irrigation, NI-Net Irrigation and Ea- application efficiency but Ea=Application Efficiency for surface irrigation (60%).

The time required to deliver the desired depth of water into each furrow was be calculated using the equation:

$$t = \frac{l * w * dg}{6Q} \quad (7)$$

Where: - dg- gross depth of water applied (cm), t-application time (min), l- furrow length in (m), w- furrow spacing in (m), and Q-flow rate (discharge) (l/s).

The amount of irrigation water depth to be applied at each irrigation application was measured using calibrated 3-inch Parshall flume.

2.6 Water Productivity

Water Productivity plays a crucial role in modern agriculture which aims to increase yield production per unit of water used, both under rain fed and irrigated conditions. Water productivity with dimensions of kg/m^3 is defined as the ratio of the mass of marketable yield (Y) to the volume of water consumed by the crop (Wa). Mathematically water productivity can be represented as follow in equation [9].

$$WP = \frac{Y}{Wa} \quad 8$$

WP-Water Productivity (Kg/m³), Y-Economic Yield (kg), and Wa- Total Water applied (m³).

2.7 Partial budget analysis

Economic analysis, was carried out to compare the effects of water applied, input cost, and return to the producers between treatments of irrigation scheduling technology and farmers practices. Economic analysis was employed as suggested by CIMMTY [10] to determine water application levels based on cost and benefits and recommend feasible treatments.

2.8 Data collection and analysis

Data like number of tiller per plant, plant height, biomass weight, total yield and amount of water applied were measured from the net harvested area of each plot in the field. The data collected for all relevant variables were subject to analysis of variance (ANOVA) which is appropriate for Randomized complete Block Design (RCBD) [11]. The combined analysis of variance across years was conducted by using the analysis for statistix 10.0 to determine the differences between the treatments. A comparison of means was carried out by employing the least significant differences (LSDs) [11] at 5% levels of significance.

3 Result and Discussions

3.1 Soil physical and chemical properties

Soil is classified as fine clay with particle approximate size diameter of <0.002 mm. The field capacity and permanent wilting points were 38.0% and 24.8% respectively. Other chemical property values were pH (6.3), Electric Conductivity of soil (0.73dS/m), Organic Carbon (2.1%), and Organic Matter (3.08%), which area appropriate values are for agricultural purpose.

Table 1 Soil physical properties of study site

Soil	Clay (%)	Sand (%)	Silt (%)	Textural Class	FC (%)	PWP (%)
Value	40	32	28	Clay Loam	38.0	24.8

Table 2 Soil chemical properties of study site

Parameters	PH	ECe(dS/m)	OC (%)	OM (%)
Values	6.3	0.73	2.1	3.62

3.2 Wheat response for irrigation scheduling technology

Table 3 Intermediate Result of wheat for Irrigation scheduling Technologies

Treatments	NTPP	PH(cm)	SL	BMW(Qt/ha)	TY(Qt/ha)	WP(kg/m³)
100%MAD	2.00	63.45	6.48	109.93	38.22a	0.83a
Farmers Practices	1.8	62.19	6.21	99.56	30.22b	0.56b
GM	1.9	62.82	6.35	104.74	34.22	0.69
CV	16.64	1.52	3.03	8.03	11.17	12.29
LSD	NS	Ns	Ns	NS	6.71	0.15

Where: NTPP-Number of tillers per plant, PH-Plant Height, SL-Spike length, BMW- Biomass Weight, TY-Total Yield, WP- Water Productivity

Average maximum yield (3.822t/ha) was produced from wheat irrigated using 100%MAD followed by irrigation frequency as suggested by the farmer practices (3.022 t/ha). This acquired result was higher than earlier research report findings of (2.6t/ha) based on irrigation scheduling with Chameleon Sensor [12]. Generally maximum yield acquired in this study were much higher than prior studies (3.05 t/ha) and wheat productivity in Oromia region is (3.3 t/ha) [13] and 3.56t/ha [14]. The water productivities recorded were: 0.83kg/m^3, and 056kg/m^3 from 100%MAD, and Farmers practice respectively and the maximum value is in the range of (0.6-1.7kg/m^3) for wheat [15].

3.3 Irrigation water management technologies

Irrigation water should be managed in the field and aim of the project is participatory field water managements through irrigation scheduling. Save water was used for another extra field irrigation farming and farmers were learned about how to manage, save and disseminate the technology.

Table 4 Irrigation water depth applied

Technologies	Amount of water applied (mm)	Water Saved(mm)	Advantages of water saved (%)
(100%MAD)	403	142	26.06
Farmers practices	545	-	-

Figure 2 Photo of Soil Sampling

Figure 3 Performance of wheat on the field during urea application

Figure 4 Photo of grain yield data collection

Table 5 Cost benefit analysis on ha base

Variable	**Cost (ETB) Items**	**100%MAD**	**FP**
	Seed	6972.5	6972.5
	Land preparation	4800	4800
	Fertilizer	6000	6000
	Pesticide chemicals	2000	2000
	Watering	12000	16000
	Harvesting	4000	4000
	Trashing	5000	5000
	Transportation	6000	6000
Total Cost (ETB)		**46,772.5**	**50,772.5**
Yield(kg/ha)		3822	3022
10% Adjusted yield(kg/ha)		3,439.8	2719.8

Gross revenue (ETB/ha)		191,872.04	151,710.4
Net Benefit (ETB/ha)		**145,099.54**	**100,937.9**
Benefit Cost Ratio		**3.1**	**1.9**

Where: - MAD-Maximum Allowable Depletion (0.4), FP- Farmer Practice

Table 6. Farmers' perception on Irrigation Scheduling Technology

Criteria used on improved irrigation tools selection and participants feedback(N=12)						
Criteria's	Labour saving	Water saving	Yield increment	Technology easiness to manage	Grand Total	Rank
100%MAD	9	10	7	8	34	1
Farmer Practice	3	2	5	4	14	2

4 Conclussions and Recommendations

The study illustrates that farmers improve the overall water management Practices of their irrigated wheat crop productions. The irrigation scheduling technology with 100%MAD; saves labour, reduces the amount of irrigation water applied, and increases wheat grain yield. Maximum grain yields obtained from irrigating every five days at initial stage and seven days intervals for development and mid stages and eight day intervals for the final stages. The study further concludes that irrigation scheduling technology is also an important technology for different planning strategies under irrigated wheat production and managing water sustainably. Therefore it was recommended that scaling up of the technology and knowledge to neighboring farmers should be a successful approach for improving yield and water productivity in the whole of Lintala irrigation scheme and in areas with same agro ecology.

Compliance with ethical standards

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Disclosure of conflict of interest

No potential conflict of interest was reported by the author(s) that hinder the publication process.

Author contributions

For this manuscript, Markos Habtewold contributed in stages of proposal development, field work, data analysis, data interpretation, draft preparation and final manuscript write up. The second Co-author Demeke Megist was contributed in filed follow up and field data collections.

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Data availability

All necessary data will be made available on request according to the journal policy

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