



# Applied Research and Innovation (ARI)

ISSN: 2993-8988 (ONLINE)

VOLUME 4 ISSUE 2 (2026)

PUBLISHED BY  
E-PALLI PUBLISHERS, DELAWARE, USA

## Adaptation of Low-Cost Drip Irrigation System for Small-Scale Farmers at Dodota District of Arsi Zone

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### Article Information

**Received:** February 08, 2026

**Accepted:** April 23, 2026

**Published:** July 03, 2026

### Keywords

*Cost Benefit Ratio, Emission Uniformity, Emitter Flow Rate Variation, Low Cost Drip Irrigation, Uniformity Coefficient*

### ABSTRACT

Improving access to and adopting water-conserving practices can help irrigation systems cope with water scarcity. By enhancing economic biomass production per unit of water and increasing cropping intensity by growing crops throughout the dry season, low cost drip irrigation offers a way to maximize returns on their cropland. Low cost drip irrigation was therefore designed using locally available components, with preference given to local manufacturing that only requires relatively unsophisticated facilities, but not at the expense of performance and functionality. A field study was conducted on a loam soil at Dodota Alem kebele on Onion crop during the dry seasons of 2022/2023 and 2023/2024 with the objective of adaptation and net return determination of low cost drip irrigation. The experiment was laid out in a randomized complete block design with three irrigation levels (i.e., 100, 80, and 60%) and three replications for determining drip application efficiency, emission uniformity, and emitter flow variation. The analysis of the experimental data showed that the emitter flow rate variation (%), uniformity coefficient (%), emission uniformity (%) and application efficiency (%) ranged from 17.9 to 18.4, 94 to 99, 86.9 to 89.7, 86.9 to 89.7, respectively was obtained at an operating pressure head of 1.5m. Both maximum CWUE and IWUE were obtained at full irrigation while the lowest CWUE and IWUE was recorded at 60%E<sub>Tc</sub> respectively. Even though maximum total onion yield was obtained under control treatment (full irrigation), it is not advisable for arid and semi-arid areas since full water application, which leads to lower CBR (cost benefit ratio), gained relative water applied to deficit treatment and 80%E<sub>Tc</sub> was the most economically attractive treatment with lower cost of production and optimum net benefit and with optimum onion yield than the other application level. It was concluded that low cost drip irrigation system could be recommended for smallholder farmer who cannot afford to buy the commercial drip system for the production of vegetables for household consumption.

### INTRODUCTION

Water scarcity affects around half of the four billion people globally (Tzanakakis, 2020; Nps *et al.*, 2021). Climate change and population growth are the main factors influencing water resources for current and future water availability (Richards *et al.*, 2021; Paulos *et al.*, 2022). Approximately 80% of the world's water is used in developing countries, with the about 70% being used for agricultural purposes. (FAO, 2017; Ingraio *et al.*, 2023; Johnson, 2024; Teferi *et al.*, 2025). In every agro-ecological zone on the planet, water utilized for crop production is becoming more and more scarce. Climate change and rainfall variability, which have been shown to have a detrimental effect on agricultural production systems, especially in Sub-Saharan Africa (SSA), have made this worse. (Aigbojionu *et al.*, 2024; Olarewaju *et al.*, 2025). Water levels in water-rich nations can also be impacted by climate change and water scarcity (Lu *et al.*, 2019). For instance, there is typically enough water in the UK to support human requirements, with the exception of extended dry spells when reservoir levels fall. However, England and Wales have experienced frequent water shortages in recent years, which, when combined with population growth, calls for careful management of water resources during such dry periods (Caraballo *et al.*,

2016; Environment Agency UK, 2018).

Ethiopia is also, known as the 'water tower of East Africa' (Abusamak, 2022; Bojer, 2025). The population of the country's depends on rainfed agriculture. However, rainfall is very erratic, drought occurs very frequently, and the dependency of farming system on rain-fed agriculture has made the Ethiopia's agricultural economy extremely exposed to weather and climatic effects. Which is making it one of the most vulnerable nations in Africa to the effect of climate change and water shortage (Conway & Schipper, 2011; Alemayehu & Bewket, 2017; Gezie, 2019; Marie *et al.*, 2020). The diverse agro-ecological zones in Ethiopia pose different levels of sensitivities to climate change impacts (CRFS, 2022); Sinore & Wang, 2024). Central Rift valley of Ethiopia is highly vulnerable to climate change the main climate-induced risks include drought and high temperature extremes. Shortage of rainfall for agriculture is one of the major challenge in the area, with significant impacts on agricultural productivity and related impacts on incomes and food security (Gezie, 2019; Temesgen, 2022).

Irrigation plays a crucial role in addressing the main challenges caused by food insecurity and rainfall uncertainty (Mulu & Alamirew, 2012), and crop production can only be a success if grown under irrigated

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conditions (Dlamini & Khumalo, 2019). However, the availability of irrigation water during the dry period is very important for supplementing the shortage and variability of rainfall during critical growth stage of crop. To increase agricultural production and living standards in the dry lands of Ethiopia, greater priority must be given to enhancing the efficiency of water collection and utilization (Kidus Ephrem, 2018). Improving access to and adopting water-conserving practices can help irrigation systems cope with water scarcity (ASAE, 1998). Currently Ethiopian government is addressing water scarcity through constructing various water harvesting structures in Central Rift valley part of the country, but the issue of efficient use water for irrigation is given little attention (Yohannes *et al.*, 2017) and small-scale irrigation is a policy priority in Ethiopia for rural poverty alleviation and growth (PASDEP, 2006), as well as climate adaptation (NMA, 2012). Hence, improving the water shortage in agriculture due to climate change and reconsidering the traditional method of irrigation was critical. The use of modern systems and technologies in irrigation that achieve an increase in productivity of water per unit volume by reducing the water during irrigation work become mandatory (Ismail, 2010). Improvements in water-saving irrigation practices are needed to mitigate water shortages in irrigation (Richter *et al.*, 2017; Nouri *et al.*, 2019; Chen *et al.*, 2025). This can be achieved through micro irrigation system particularly drip irrigation system. Drip irrigation technology is becoming more and more crucial for enhancing land production and conserving fertilizer and water (Guan *et al.*, 2024). It is one of an irrigation technology which giving high efficient use of irrigation and nutrients are delivered to the crop root zone, but the capital cost is beyond the reach of most rural farmers, hence for gaining the advantage of being a water-smart technology through its affordability, simplicity, easy maintenance and operation, and big water saving the low cost drip irrigation system offers a feasible option for economic production in areas of low rainfall or during periods of water scarcity (Thorat, 2016; Wang & Ma, 2019; Tesfaye *et al.*, 2021).

In Central rift valley of Ethiopia Dodota District are one of the food insecure districts in the Oromia region since the last ten years. In this district, there is unpredictable pattern of rainfall and thus the farming communities are frequently suffered from the shortage of rainfall during the critical growth stage of crops. The area is under the effects of climate change and livelihoods of the mass are generally vulnerable to climate change induced impacts (Shumi & Hundera, 2022). Different organization built rainwater harvesting structure in Dodota District for supplementing the shortage of rainfall during critical crop growth period through irrigation. However, because to its extremely low water use efficiency, traditional irrigation methods like furrow irrigation have faced difficulties. There is a need for "water-smart" technologies that can guarantee improved yields and boost water use efficiency and increase the water use efficiency and water

productivity are needed. Irrigation systems can adapt to water constraint by increasing access to water and implementing water-saving measures. By maintaining cropping intensity and offering chances for expansion, water-saving technology can produce high-value crops and reduce reliance on rain-fed field crops. Improper irrigation management practices do not only waste scarce and precious water resources but also decrease marketable yield and economy stated in FAO, (2002).

In District, most farmers produce Onion by irrigation due to high domestic and export markets, its yield per unit area, availability of suitable cultivable variety, and ease of propagation by seed and lower incidence of diseases. However, the production of onion was suffered by shortage of rainfall during the development stage. Hence, for amending the shortage of rainfall problem on crop production, harvesting runoff water and using it with low cost drip irrigation is an optimum solution. Therefore, this study was done with the objective of adapting and determine the net return of low cost drip irrigation system for small-scale farmers.

## MATERIALS AND METHODS

### Location of Study Area

During the dry seasons of 2022–2023 and 2023–2024, the study was carried out on farmers' fields in Dodota Alem Kebele of Dodota District of Arsi Zone, using onions as an experimental crop. The region lies in Ethiopia's Central Rift Valley. Geographically, it lies between latitudes 8012'0" and 8016'30" N, longitudes 39015'0" and 39021'0" E, with an average elevation of 1400 to 2500 m.a.s.l as shown in Figure 1. It lies roughly 98 kilometers east of Ethiopia's capital, Addis Ababa.

### Materials Used

Before beginning any attempt to achieve the study goal, relevant and appropriate materials are crucial. Locally produced and readily accessible components, including 32mm HDP, 25mm HDP, 20mm conduit, 20mm connector, 25mm Tee connection, 25mm Elbow, 32mmX25mm reducer, 32mm filter, and 25mm ball valve, were used in the drip irrigation system's design. A core sampler, auger, stopwatch, double ring infiltrometer, meter tape, rope, hammer, spatula, plastic bag fertilizer (Urea and Dap), barrel, treadle pump, digital caliper, Catch Can, stopwatch, and Nafis onion seed are among the material and tools used.

### Drip Installation Procedure

The water should be drawn from the reservoir to the barrel using a treadle pump. To generate enough pressure, the wood frame raised the 1000-litter barrel 1.5 meters above the ground. To prevent dust and debris from entering, the barrel top was covered. The drain exit was attached to the barrel that was bored slightly upward underneath. The drain outlet was attached to the ball valves so that they could be maintained and repaired as needed. Clean water is supplied by the filter, which is attached to the drain

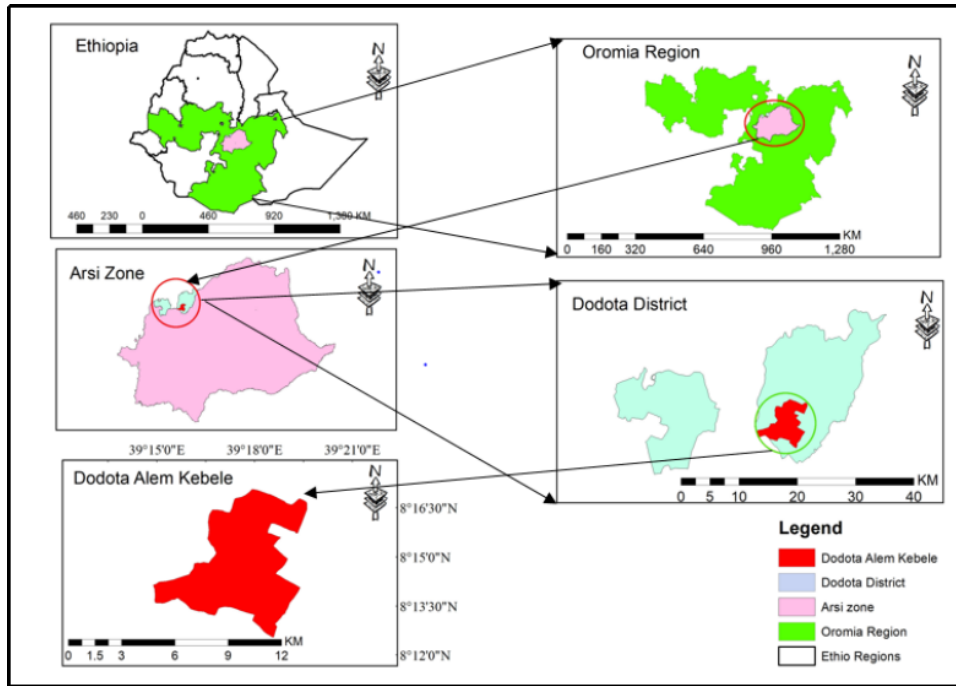


Figure 1: Location of study area

exit. Water was filtered and transferred to a 25 mm sub-mainline via the main line, which had a diameter of 32 mm. To regulate the water flow for each replication, a ball valve with a 0.75 mm diameter was installed between the mainline and the sub-mainline. To regulate the flow out, an end cup was installed on the sub-main line's tail. The sub main was drilled using a puncher at 20 cm intervals, and a 20 mm diameter connector was used to link the sub main and conduit (lateral) through the punched hole. Electric conduit with a diameter of 20 mm and a drill bit with a diameter of 1 mm spaced 20 cm apart made up the lateral employed in this study. Cotton was placed over the drip hole to reduce excessive water leakage. In order to regulate the water flow, the conduit lateral was finally

folded and tied at the end.

### Experimental design and field layout

The system was set up on a 12 m<sup>2</sup> (2 m\*6 m) well-prepared experimental plot. Plots and blocks were separated by a buffer zone of 1.0 and 1.5 meters respectively. As shown in figure (2), there were nine plots comprising 108m<sup>2</sup>. Each plot had eight laterals spaced 20 cm apart, as well as 30 emitter points spaced 20 cm apart. There were 60 plants each lateral, with a 10-cm gap between each plant. Three replications with a one-factor randomized complete block design (irrigation level) were used in the experiment. The experiment consists of three treatments, which were 100%ETc, 80% ETc and 60% ETc.

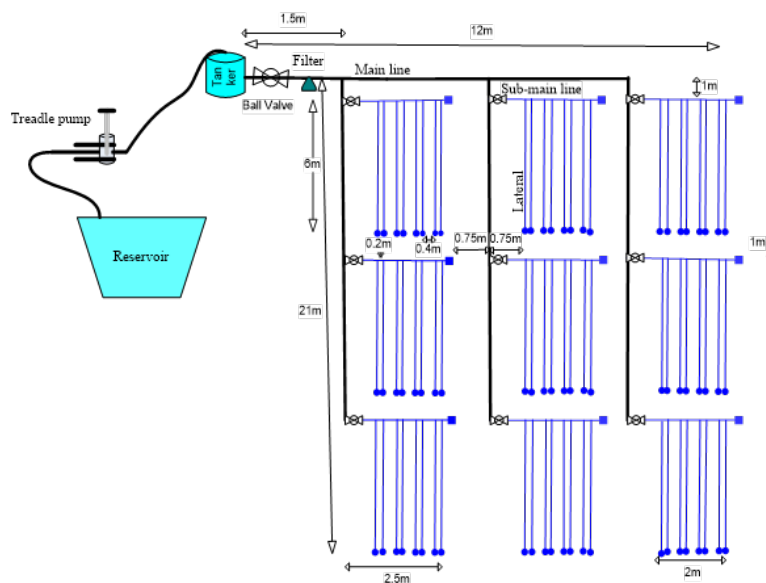


Figure 2: The experimental field layout

**Data Collection**

**Soil Sampling and Analysis**

Soil samples were collected before crop planting. Soil samples were taken from the top soil down to a depth of 60 cm at intervals of 20 cm using an auger at three representative locations. five sub-samples from the same treatment and depth were combined to create composite samples. The physical characteristics of the soil, including its textural class, field capacity (FC), and permanent wilting point (PWP), were determined using about 1kg of soil. Disturbed soil samples from representative field locations were used for soil textural analysis, and the pipette method was used in a lab to determine the textural class.

Using undisturbed soil samples taken from the field at three depths (0-20 cm, 20-40 cm, and 40-60 cm) with a cylinder core sampler of 5 cm in diameter and 5 cm in height, the bulk density was calculated. oven dried at 105°C for 24 hours, then weighed to determine the dry mass. The bulk density was calculated as(Michael, 2008).

$$\rho_b = \frac{M_s}{V_t}$$

Where;  $\rho_b$ : is the bulk density of the soil in  $g/cm^3$ ;  $M_s$ : Is dry mass of the soil (g);  $V_t$ : Total Volume of the soil ( $cm^3$ )

For irrigation, monitoring, determining soil moisture is crucial. Field capacity (FC) and permanent wilting point (PWP) soil moisture were measured. For this, soil samples were taken at the three depth mentioned above, sun-dried, crushed, and then soaked in water for a full day (24 hours). Using a pressure-plate device, field capacity and permanent wilting point were measured in the lab. A saturated soil sample was subjected to 1/3 bar of pressure for field capacity and 15 bars of pressure for permanent wilting point. The soil moisture was measured using a gravimetric technique.

**Crop and Irrigation Water requirement**

he CROPWAT 8.0 model software was employed to calculate reference evapotranspiration (ET<sub>0</sub>) using the FAO Penman-Monteith equation. For estimating the crop water requirements (ET<sub>c</sub>), ET<sub>0</sub> value was multiplied by the calculated Kc value.

$$ET_c = ET_0 * Kc$$

Where, ET<sub>c</sub> is Crop evapotranspiration (mm/day); ET<sub>0</sub> is Reference crop evapotranspiration (mm/day) and Kc is Crop coefficient (fraction).

Frequent measurements of soil moisture content using the gravimetric method were used to test the experiment's soil water availability. After weighing the moist soil samples, they were dried for 24 hours at 105 °C in an oven. The gravimetric water content was converted to equivalent depth (D).

$$D = \frac{W_w - W_d}{W_d} \times \rho_b \times drz \tag{3}$$

where  $W_w$  is the wet soil weight (gm),  $W_d$  is the dry soil weight (gm), and  $D$  is the depth of accessible soil moisture (mm);  $Drz$  is the sampling depth within the crop root depth (mm), and  $BD$  is the soil dry bulk density ( $gram\ cm^3$ ).

The amount of soil moisture that was depleted between irrigations was obtained by the following equation

$$IRn = (FC - D) \tag{4}$$

Where,  $IRn$  is the required net irrigation (mm) and  $FC$  is the soil moisture content at field capacity (mm).

The following formula was used to calculate total accessible water (TAW) from the moisture content of field capacity and permanent wilting point.

$$TAW = (FC - PWP) \times BD \times Dz \tag{5}$$

**Irrigation water application method**

To irrigate the experimental plot, water was pushed from the source into the above tank using a treadle pump. The net depth of irrigation necessary to replenish the soil moisture deficiency and raise the soil moisture to field capacity was used to determine the control irrigation application. The percentage of control irrigation or no deficit irrigation application during the same irrigation cycle was used to determine the depth for other treatments.

**Percentage wetting area**

The term "wetting area" (w.a.) was developed to describe the partial wetting of a drip-irrigated field because drip irrigation does not totally wet all farmed fields like surface irrigation do. The percentages of wetted area was determined using (Gultekin *et al.*, 2022) method.

$$P = 100 * \frac{A_w}{C_a C_w} \tag{6}$$

$$W_a = W * C_w \tag{7}$$

Where,  $p$  = is wetting percentage (%),  $A_w$ =is the wetted area( $m^2$ ),  $C_a$ =is row spacing of crops (m),  $C_w$ =crop to row distance(m) and  $W$ = is the wet strip's width, m

The irrigation's  $IRn$  was calculated using the formula

$$IR_n = TAW * P * W.a \tag{8}$$

where  $w.a.$  is the wetting area (fraction) and  $IR_n$  is the net irrigation requirement (mm).

The following formula was used to estimate the irrigation interval,  $f$ .

$$f = \frac{IR_n}{ET_c} \quad (9)$$

where  $ET_c$  is the average crop water requirement (mm day<sup>-1</sup>) and  $f$  is the irrigation interval (day). The  $IR_n$  was derived from the equation whenever there is rainfall in between irrigations.

$$IR_n = ET_c - P_{eff} \quad (10)$$

Where,  $P_{eff}$  is effective rainfall (mm)

The effective rainfall,  $P_{eff}$  was estimated using the method given by (Allen *et al.*, 1998):

$$P_{eff} = 0.6 * P - 10 \quad \text{for month } P \leq 70 \text{ mm} \quad (11)$$

$$P_{eff} = 0.8 * P - 24 \quad \text{for month } P > 70 \text{ mm} \quad (12)$$

Where,  $P$  is daily rainfall (mm)

Using a field application efficiency ( $E_a$ ) of 90% for the drip irrigation system, the gross irrigation demand ( $IR_g$ ) was calculated. The following equation was used to calculate the gross irrigation requirement .

$$IR_g = \frac{IR_n}{E_a} \quad (13)$$

where  $E_a$  is the field application efficiency (%) and  $IR_g$  is the gross irrigation requirement (mm).

### Drip performance parameters

The hydraulic properties of the drippers, such as emitter flow rate, emitter flow variation, uniformity coefficient, coefficient of variation, and emission uniformity, were identified after the installation of the drip irrigation system. At the beginning and end of the trial, the irrigation system's water application uniformity test was also determined.

Emitter flow rate,  $q$  –by using catch cans and volumes of flow caught over a time the average flow rate of emitters used in the experimental plot was measured. The following equation was used to estimate the discharge, or flow rate, out of a single outlet emitter at a given head.

Where,  $q$  is single emitter discharge (liter/hour);  $V$  is

$$q = \frac{V}{\Delta t} \quad (14)$$

volume of water collected from emitter, (liters) and  $\Delta t$  is time duration (hour).

### Emission Uniformity, EU

Emission uniformity (EU) is calculated as a function of the relationship between the mean flow emitted by all emitters and the average flow released by 25% of emitters with the lowest flow using equation (Zamaniyan *et al.*, 2014) below:

where: -  $Eu$  is Emission uniformity (%); = average

$$Eu = 100 * \frac{q_{25\% \min}}{q_{mean}} \quad (15)$$

of 25% of the lowest values of flow rate (l/h);and  $q_{25\% \min}$  is average discharge rate of all observed emitters (l/hr). The evaluated system is classified according to the EU values, following Merriam and,keller (1978). EU is always between 0 and 1. The larger the value of EU, the better the uniformity.

### Emitter flow variation, qvar

It is calculated using(ASAE, 1998).

where  $q_{\min}$  is the lowest emitter flow rate (l/h) and  $q_{\max}$

$$qvar = \left( \frac{q_{\max} - q_{\min}}{q_{\max}} \right) \quad (16)$$

is the highest emitter flow rate (l/h).

### Coefficient of variation, CV

It determines the relative variability between the treatments and is computed using (Ortega *et al.*, 2002). where  $q_a$  is the average emitter flow rate (l/h) and  $S$  is the

$$CV = \frac{S}{q_a} \quad (17)$$

standard deviation of emitter flow rates (l/h).

### Uniformity Coefficients, UC

It is used to determine the uniformity coefficient (CU) of a drip irrigation system Irrigation Coefficient of Uniformity, is used to determine the irrigation efficiency by the catch can method(ASAE, 1998). It was calculated by equation of by(Christiansens , 1942).

Where, UC is uniformity coefficient (%);  $q_i$  is emitters flow rate (l/h) ,  $q_{mean}$  is average emitter flow rate (l/h) and  $n$  is number of observation.

$$UC = 100 \left( 1 - \frac{\sum_{i=1}^n |(q_i - q_{mean})|}{q_{mean} n} \right) \quad (18)$$

### Application Efficiency, $E_a$

The overall application efficiency of the drip irrigation system was estimated from the relationship of (Vermeiren and Jobling, 1980) as cited by (Ramalan *et al.*, 2010)

Where  $E_a$  = Application efficiency, %;  $K_s$  = Average water stored in the root zone over average depth of water applied and is a coefficient which expresses the storage efficiency of the soil taking into account the pressure variation in the drip system ( $K_s=1$  for loam soil) as in

$$E_a = K_s * E_u \quad (19)$$

(Vermeiren and Jobling, 1980) and  $E_u$  = as given in eqn (15).

### Yield and yield parameters

The total crop yield per net plot was noted and translated into tons per hectare as

### Irrigation Water productivity ( $Kg/m^3$ )

Irrigation water productivity was determined by dividing the total yield obtained in kilograms by the water volume

$$Yield \left( \frac{t}{ha} \right) = \frac{Yield \left( \frac{kg}{plot} \right) \times 10}{Net \text{ harvested area of plot } (m^2)} \quad (20)$$

in cubic meters or hectares. (Araya *et al.*, 2011).

Where,  $IW$  = irrigation water productivity ( $kg/m^3$ ),  $Y_a$  is crop yield obtained ( $Kg/ha$ );  $ET_c$  is the seasonal crop water consumption by evapotranspiration ( $m^3/ha$ ).

$$IWP = \frac{Y}{ET_c} \quad (21)$$

Water saving with deficit irrigation was calculated according to (Bekele *et al.*, 2023);

Where,  $Ws$  = is water saved due to deficit irrigation in percent,  $TWUFI$  = is total water using full irrigation (mm) and  $TWUDI$  = is total water using deficit irrigation (mm)

$$Ws(\%) = \frac{(TWUFI - TWUDI)}{(TWUFI)} * 100 \quad (22)$$

Percent of yield increase or decrease in deficit irrigation in relation to full irrigation was calculated using the equation of (Bekele *et al.*, 2023).

Where  $YI/D$  = is percent of yield increase or decrease due to deficit irrigation,  $YFI$  = is yield in ( $Kg/ha$ ) obtained from full irrigation and  $YDI$  = is yield obtained

$$\frac{YI}{D} = \left( \frac{YFI - YDI}{YFI} \right) * 100 \quad (23)$$

from deficit irrigation in ( $kg/ha$ ).

### Economic Analysis

In order to adjust for yield losses, 10% of the total yield was subtracted from the mean yield ( $kg \ ha^{-1}$ ). Bulb yield was multiplied by its manufacturing cost to determine the overall net return (CLMMYT, 1988). Both fixed and running expenses were computed in order to evaluate the drip irrigation system's economic viability (Mebrahtu & Tamiru, 2018). Estimates were made of the total cost, gross return or revenue, and net return or profit. Fertilizer and material costs are included in the fixed cost, whereas labor costs make up the operating cost.

The following formula was used to calculate the percentage of the marginal rate of return (MRR).

Where,  $MRR$  = Marginal Rate of Return  $NP$  = net profit

$$NP = TR - TV \quad (24)$$

difference,  $VC$  = is a variable cost in birr

$$MRR = \frac{\Delta NP}{\Delta VC} * 100 \quad (25)$$

### Data Analysis

Analysis of variance (ANOVA) variables were calculated for every measured response data set. The R software was used to evaluate the data for variability. The Least Significance Difference (LSD) approach was used to separate the means at the 5% probability level.

## RESULT AND DISCUSSION

### Soil Physical Properties Analysis

According to the results of the soil texture laboratory study, the average percentages of sand, silt, and clay were 41, 33, and 26, respectively, as shown in table 1. Thus, the soil textural class was identified in loam soil based on the USDA soil textural categorization. In the study area, the average field capacity of the soil for common root depth (0–60 cm) is 30%, and the permanent wilting threshold is 17%. The total available water is 151 mm/m at a soil depth of 60 cm.

Where,  $FC(\%)$  = field capacity in %,  $PWP(\%)$  = Permanent Wilting Point in %,  $BD(g/cm^3)$  = Soil bulk density in gram per centimeter cub,  $TAW(mm/m)$  = Total Available water in millimeter per meter

### Flow rate of low cost drip irrigation evaluation

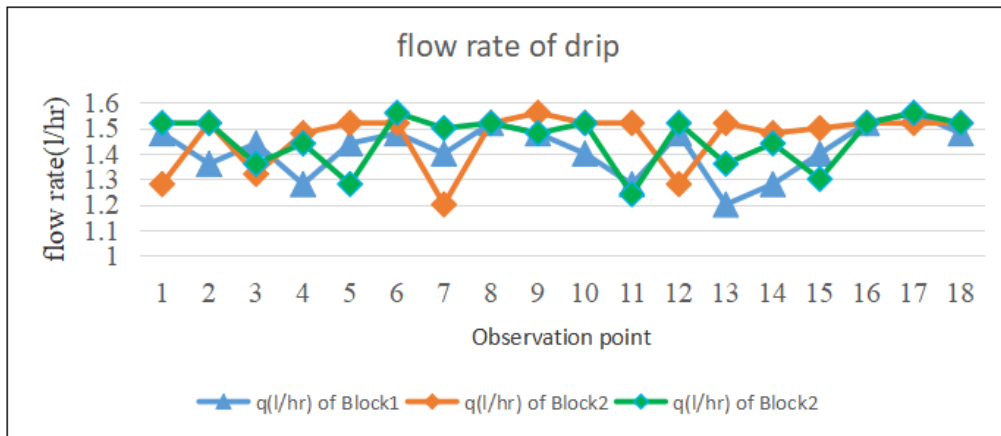
The volume of water dropped through emitter was collected by catch can in 0.5 hour from a sample of 18 emitters per blocks, accordingly the mean flow rate of emitter was varies from 1.4l/hr to 1.5l/hr. According to research conducted by (Tilaye Robi, 2023) on conventional drip irrigation (CDI) the average emitter flow rate varies from 0.45 and 0.40 liter/hr. similarly as Genemo *et al.* (2023) conducting research on conventional drip irrigation (CDI) on coffee production the mean flow rate of

**Table 1:** Experimental soil's physical characteristics

Depth (cm)	FC(%)	PWP (%)	BD (g/cm <sup>3</sup> )	TAW (mm/m)	Sand (%)	Silt (%)	Clay (%)	Textural class
0-20	31	18	0.93	120.9	40	34	26	loam
20-40	29	16	1.24	161.2	42	31	27	loam
40-60	31	17	1.22	170.8	41	34	25	loam
Average	30	17	1.13	151.0	41	33	26	loam

dripper was range from 1.1 to 1.35l/hr. Performance evaluation of low cost drip irrigation Along laterals, the average emitter flow rate fluctuated

between 17.9% and 18.4%.The results of in Michael (1978) and Jensen (1983),which indicated that the mean variance of individual emitters' discharge rates in a field



**Figure 3:** Flow rate low cost drip irrigation

should not exceed 20%,which was in close agreement with this value. The uniformity coefficient mean varied from 94% to 99%, indicating an even distribution of water throughout the system, while the average emission uniformity varied from 86.9% to 89.7%. According to Merriam and Keller (1978) a drip system with a discharge fluctuation of less than 20% and an emission uniformity and uniformity coefficient of 85% or higher should be considered acceptable, which supports these findings. Similar research was done on conventional drip irrigation (CDI) by Tilaye Robi, (2023),who discovered an average

emitter uniformity of 94.76% and a uniformity coefficient of 99.66%.86.9% to 89.7% was the range of the average application efficiency. This was in line with the findings of Postel *et al.*(1998),who reported that micro drip irrigation systems are 70–90% more efficient at the field level than surface irrigation.

Where; B-Block ,O.p-Observation Point,SDV-Standard Deviation, EU-Emission Uniformity in%, Ea- application efficiency in %,qvar(%)-Emitter flow variation, Cv(%)-Coefficient of variation and UC-Uniformity coefficient in %.

**Table 2:** Performance Evaluation of low cost drip irrigation

B	O.P	1	2	3	4	5	6	7	8	9
1	q(l/hr)	1.48	1.36	1.44	1.28	1.44	1.48	1.44	1.5	1.5
2		1.28	1.52	1.32	1.48	1.52	1.52	1.24	1.5	1.6
3		1.52	1.52	1.36	1.44	1.28	1.56	1.52	1.5	1.5
B	O.P	10	11	12	13	14	15	16	17	18
1	q(l/hr)	1.4	1.28	1.48	1.2	1	1.44	1.5	1.56	1.5
2		1.52	1.52	1.28	1.52	1	1.52	1.5	1.52	1.5
3		1.52	1.24	1.52	1.36	1	1.28	1.5	1.56	1.5
B	Mean	SDV	EU(%)	Ea(%)	qvar(%)	CV(%)	UC(%)			
1	1.4	0.1	89	89	17.9	7.1	94			
2	1.5	0.1	86.9	86.9	18.4	15.8	95			
3	1.45	0.1	89.7	86.9	17.9	7.1	99			

B	Mean	SDV	EU(%)	Ea(%)	qvar(%)	CV(%)	UC(%)
1	1.4	0.1	89	89	17.9	7.1	94
2	1.5	0.1	86.9	86.9	18.4	15.8	95
3	1.45	0.1	89.7	86.9	17.9	7.1	99

### Impact of Deficit Irrigation on Onion Growth Components

Table 3 illustrates how deficit irrigation affects plant heights, leaf heights, and number of leaves depending on data taken at the physiologically maturity stage. The statistical analysis showed a significant difference in plant height and Leaf height with a probability of 5%. The result showed that full irrigation produced the tallest plant height of 56.6cm and leaf height of 46.87cm, while 60% ETC irrigation produced the shortest plant and leaf height of 36.30cm and 31.5cm respectively. The results showed that as moisture levels decrease the vegetative growth of onion decrease. Furthermore, there

is no statistically significant difference between 100% and 80% ETC on Leaf number. These findings are consistent with those of Worku *et al.*( 2020), who found that full irrigation produced the maximum growth components of onions, whereas high-stressed treatment produced the lowest heights.

Where, Trt=Treatment,PH(cm)= plant height in cm,LH(cm)=Leaf height in cm,LNO= leaf number, LSD = Least Significant Difference at 5% level; CV = Coefficient of Variation. Values are Mean  $\pm$  SD.Means in columns followed by the same letters are not significantly different at a 5% level of significance.

**Table 3:** Deficit irrigation's effect on onion growth components

Trt	PH(cm)	LH(cm)	LNO
100%ETC	56.6 $\pm$ 1.57 <sup>a</sup>	46.87 $\pm$ 1.55 <sup>a</sup>	10.43 $\pm$ 0.4 <sup>a</sup>
80%ETC	50.7 $\pm$ 1.95 <sup>b</sup>	41.6 $\pm$ 1.5 <sup>b</sup>	10.2 $\pm$ 0.2 <sup>a</sup>
60%ETC	36.3 $\pm$ 2.052 <sup>c</sup>	31.5 $\pm$ 1.08 <sup>c</sup>	8.07 $\pm$ 0.3 <sup>b</sup>
CV	3.49	3.31	4.65
LSD	3.74	2.79	0.63

### Effects of Deficit Irrigation on Yield and Yield Components of Onion

The findings of the analysis of variance (ANOVA) indicated that irrigation levels had a significant ( $p < 0.05$ ) impact on onion total bulb output. According to Table 4, the treatment that received 100% ETC produced the highest total bulb yield of 31.46 t/ha, while the treatment that received 60% ETC produced the lowest total bulb yield of 19.34 t/ha. This indicates that there is a statistically significant difference ( $P \leq 0.05$ ) between the treatments on total bulb yields at 100% ETC and 60% ETC. Onion bulb yield generally decreased accordingly when the amount of irrigation water applied dropped from 100% ETC to 60% ETC. These findings confirmed the results reported by Mubarak and Hamdan (2018) and Tilaye Robi (2023), who found that the non-stressed treatments (100%ETC) had the highest bulb yield of onions, whereas the most stressed treatment (50%ETC) had the lowest. At the same period, full irrigation treatment yielded the greatest average bulb weight, bulb

diameter, and bulb height of 119.97gm, 6.19cm, and 5.77cm, respectively. There was no statistically significant difference in bulb weight or height between irrigation levels of 100% ETC and 80% ETC. Conversely, there is a statistically significant variation in bulb diameter between irrigation levels at  $P < 0.05$ . The findings indicated that the components of onion yield declined as water deficit levels increased, and Plots with the highest water application yielded more than those with the lowest. These findings were consistent with those of Alemnesh Ayza (2018), who found that the mean yield components were highest in the treatment with the largest water supply and lowest in the treatment with the lowest quantity.

Where,Trt=treatment,BW(gr)=BulbWeight in gram, BD(cm)=Bulb diameter in cm,BH(cm)=Bulb Height in cm,BY(kg/ha) = bulb yield per hectare. Values are Mean  $\pm$  SD, CV=Coefficient of Variation, LSD =List Significance Difference. At the 5% level of significance, the means in columns that are followed by the same letters are not different significantly..

**Table 4:** Effect of deficit irrigation on onion yield and yield components

Trt	BW(gr)	BD(cm)	BH(cm)	TBY(t/ha)
100%ETC	119.97 $\pm$ 1.67 <sup>a</sup>	6.19 $\pm$ 0.18 <sup>a</sup>	5.77 $\pm$ 0.68 <sup>a</sup>	31.46 $\pm$ 0.36 <sup>a</sup>
80%ETC	113.1 $\pm$ 4.30 <sup>a</sup>	5.65 $\pm$ 0.18 <sup>b</sup>	5.63 $\pm$ 0.97 <sup>a</sup>	28.34 $\pm$ 0.74 <sup>a</sup>
60%ETC	90.2 $\pm$ 7.35 <sup>b</sup>	4.65 $\pm$ 0.26 <sup>c</sup>	4.60 $\pm$ 1.51 <sup>b</sup>	19.34 $\pm$ 1.34 <sup>b</sup>
CV	39.88	4.23	6.77	3.18
LSD	12.19	0.45	3.44	3.44

### Water productivity of drip irrigation

Table 5, illustrates the relationship between the total bulb yield and seasonal water applied to onions. Water supply and yield are related in a way known as crop water productivity. The seasonal water applied for onion ranged from 2442 to 4070m<sup>3</sup>/ha, whereas the water productivity estimated by dividing the total bulb yield to irrigation water applied(m<sup>3</sup>/ha). The water productivity for onion ranged from 7.73 to 8.7kg/m<sup>3</sup> and the highest water productivity 8.7kg/m<sup>3</sup> was recorded from treatment receiving 80% ETc. This implies that an irrigation treatment receiving 80% ETC can bring 0.25 ha area of

land into production and 7.1ton of onion obtained from saved water. Therefore, farmers in water scarce areas have to use the low cost drip with deficit irrigation for improving the irrigation water productivity.

Trt=Treatment,AW(m<sup>3</sup>/ha)=applied water in meter cub per hectare,WP(kg/m<sup>3</sup>)= water productivity in meter cub per hectare,WS(m<sup>3</sup>/ha)= saved water in meter cub per hectare,YR(t/ha)=yield reduction in ton per hectare, AL(ha)= additional land irrigated from saved water in hectare,AYLD(t)=Additional yield gained from saved water in ton.

**Table 5:** Water productivity, yield reduction, water saved, additional land and yield gained from saved water using deficit irrigation

	TBY	AW	WP	WS	WS	YR	YR	AL	AYLD	(AYLD - YR)
Trt	(t/ha)	(m <sup>3</sup> /ha)	(kg/m <sup>3</sup> )	(m <sup>3</sup> /ha)	(%)	(t/ha)	(%)	(ha)	(t/ha)	(t/ha)
100%ETc	31.46	4070.0	7.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00
80%ETc	28.34	3256.0	8.70	814.00	20.0	3.12	9.91	0.25	7.10	3.97
60%ETc	19.34	2442.0	7.92	1628.0	40.0	12.12	38.5	0.67	12.89	0.78

### Economic analysis of low cost drip irrigation

Adjusted yields were calculated with the methodology presented in (CLMMYT, 1988). The partial budget analysis revealed that the highest net benefit of 519,683.2 birr/ha was obtained under drip irrigation with full irrigation. However, the lowest net benefits of about 405,288.7birr/ha obtained under drip irrigation of 60%ETc as indicated in table 6. Benefit cost ratio (BCR) of onion was computed for each treatment combination as the ratio of yield earned to the cost expended. Accordingly, drip with 80% ETc has a higher net benefit value to cost ratio of 1.61, which was the higher value as compared to other

treatment. According to research conducted by (Mubarak & Hamdan, 2018),economic feasibility of irrigating onions within the range of 60% to 80% ETc has been found to depend on water availability.

Where :-Trt-treatment ,AIW-Applied Irrigation Water ,TBY –total bulb yield, AYLD- Adjusted yield, MRR- Marginal Rate of Return and B/C –Benefit Cost Ratio.

### CONCLUSIONS

The result of study showed that the performance of locally made low cost drip irrigation evaluation under different water level at Dodota Alem Kebele experimentally

**Table 6:** Effect of irrigation level and drip on onion production costs and net return

Trt	TBY	AYLD	Total Return	Total Variable cost	Net in come	MRR (%)	B/C
	(t/ha)	(Kg/ha)	birr/ha	birr/ha	birr/ha		
100%ETc	31.46	28.31	849313.8	329630.60	519683.2	0.00	1.58
80%ETc	28.33	25.50	765127.8	292731.70	472396.1	128.15	1.61
60%ETc	19.34	17.40	696212.4	290923.70	405288.7	295.54	1.39

field. The performance evaluation of locally made low cost drip irrigation is essential to reduce water losses in fields and maximize farmer's returns. In this study, the performance of the drip with the low-pressure (gravity) low cost drip-irrigation system was found significant for a 1.5m overhead tank. The uniformity of water application varies 86.9 to 99.7% indicated an even distribution of water in the system after installation. The average discharge rate was 1.45l/h. The uniformity coefficient (UC %) for the locally made low cost drip irrigation system varies 94 to 99%, indicating excellent water application and the treatment with 80%ETc higher net benefit value to cost ratio of 1.61 value was obtained as compared to other treatment. Therefore, in order to

obtain higher marketable yield and irrigation production efficiency of onion during the growing season the crop should be irrigated at 80% of irrigation water requirement and locally made low cost drip irrigation system could be recommended for smallholder farmer who cannot afford to buy the commercial drip system for the production of vegetables for household consumption.

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