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# Performance of Drip Irrigation at Werer, Middle Awash, Ethiopia

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**Abstract:** Agriculture is the main contributor of the Ethiopian economy as it accounts for about 55% of the GDP, 60% of the foreign exchange earnings and provides livelihood to 85% of the population. The field experiments were conducted to evaluate the performance of drip irrigation systems werer agricultural research station, middle awash, Ethiopia. Middle awash is largest irrigated part of the country. It is well gifted with the land, sunshine and highly fortune in available water resources. Drip irrigation has greater water economy over other systems in arid and semi-arid regions characterized by high evaporation rates and it has the potential to increase yields of crops even with reduced irrigation water application. The performance of drip irrigation system was evaluated on the basis of parameters like emitter flow variation ($q_{var}$), distribution uniformity (DU), application uniformity (Ea), coefficient of variation (CV), statistical uniformity (SU) and Christiansen uniformity coefficient (UCC). High values of uniformity coefficient and uniformity of distribution are attributed to the effect land levelling. The hydraulic performance of drip irrigation result shows the emitter flow variation (0.07%), emission uniformity (92.2%), coefficient of variation (0.07%), Christiansen uniformity coefficient (90.8) and application efficiency of (85%).

**Keywords:** Application, Distribution, Efficiency, Emission, Uniformity

## 1. Introduction

The economy of Ethiopia is heavily dependent on the agricultural sector, which contributes 55% to GDP, 60% of the foreign exchange earnings and provides livelihood to 85% of the population [25]. Drip irrigation can potentially provide high application efficiency and attain high application uniformity [1-5]. Efficient use of available irrigation water is critical for increasing agricultural productivity for the growing Ethiopian population. As the population of Ethiopia is growing, the pressure on agriculture is increasing in the same way. The population significantly increased from 180 million to 962 million from 1950 to 2015 in Sub Sahan African country [6]. Middle Awash is largest irrigated the part of the country. It is well gifted with the land, sunshine and highly fortune in available water resources. Awash River is main source of irrigation. The ideal irrigation system applies water at a rate that allows all water to infiltrate and the water is distributed both in space and time to match crop water requirements in each section of the field [7]. Drip irrigation is familiarized primarily to save water and increase the water use efficiency in agriculture. Across different countries including Ethiopia have confirmed that drip irrigation plays a supreme role in increasing yield and water use efficiency of crops. Potential to use scarce water resources more efficiently to produce crops as water can be delivered precisely to the root zones rather than irrigating the entire field surface as with other methods [8]. The increasing need for crop production for the growing population is causing rapid expansion of irrigation throughout the world. This population growth would inevitably pose additional demand for food and this will result in considerable additional demand of food. Simultaneously, the water demand from non-agricultural sectors will keep growing in both developed and developing countries [9, 10]. On the other hand, severe water scarcity presents the single biggest threat to future food production [11]. Agricultural production continues to face several challenges in Sub-Saharan Africa leading to an insufficient food supply. Generally, the goodness of irrigation performance is associated to two types of indicators: irrigation efficiency and the uniform distribution of water throughout the field [12]. These were mostly applied to irrigation systems in experimental stations to test the technical parameters of drip irrigation [1, 13]. At the farm level irrigation performance depends not only on the technical standards of irrigation equipment but also on farmers' irrigation practices, as well as on the maintenance of the equipment [14, 15]. A system with uniformity coefficient of at least 85% is considered appropriate for standard design requirements [17]. The experiment was undertaken with objective to evaluate the performance of drip irrigation systems laid down in the study area.

## 2. Material Methods

### *2.1. Description of Study Area*

The experiment were conducted at Werer Agricultural Research Center experimental site, from December 2019 to April 2020. The experimental site located 9° 16 '8" N; 40° 9' 41" E in a semi-arid belt of the eastern rift valley escarpment in Afar Regional State and 280 km far away from Addis Ababa having an altitude of 740 m above mean sea level.

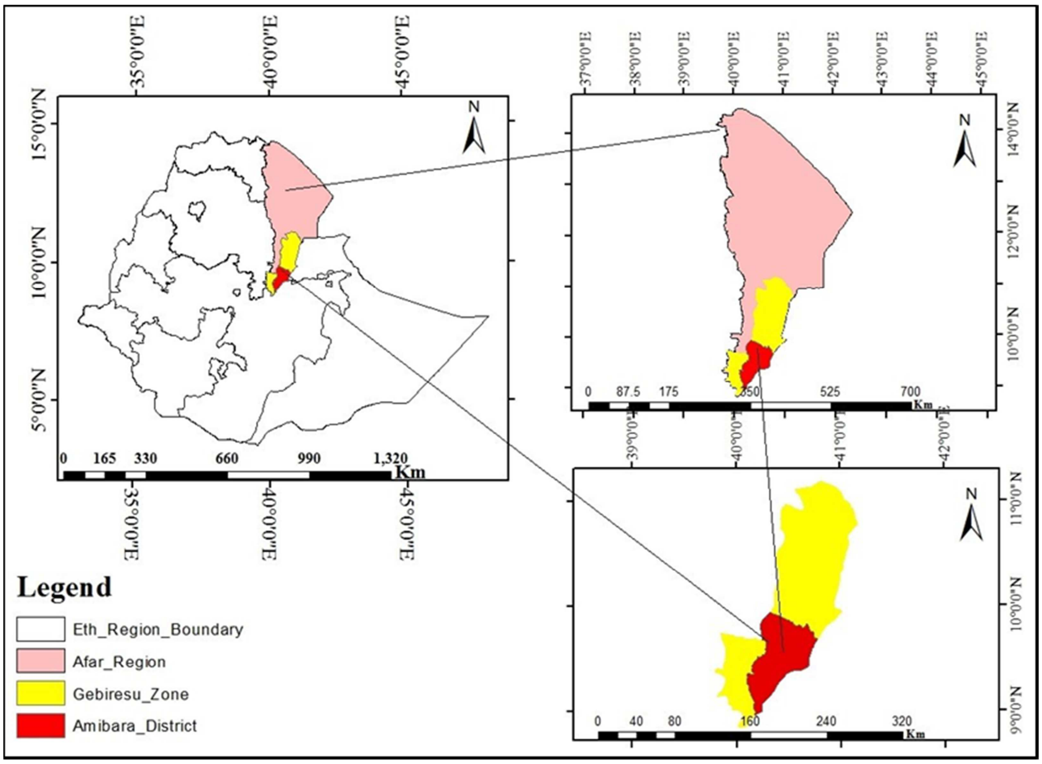


***Figure 1.*** *Study Area Map.*

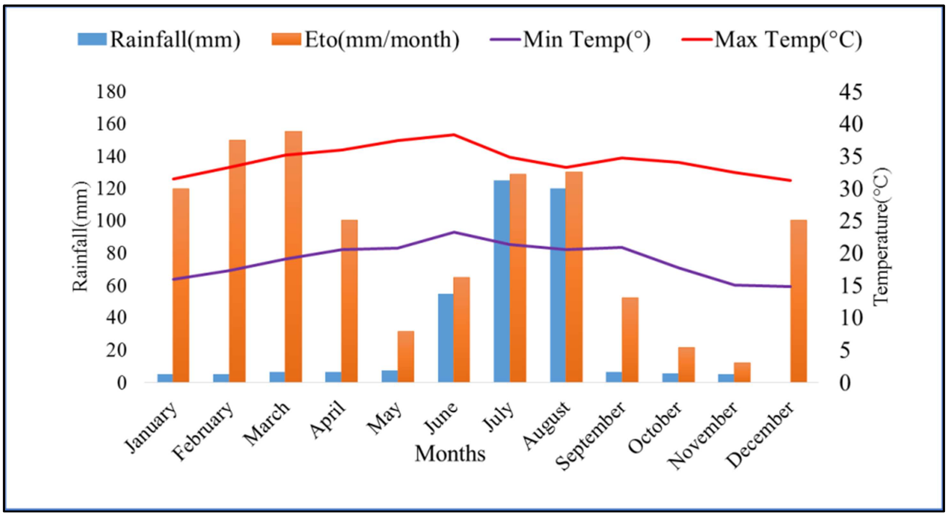


***Figure 2.*** *The climate condition of the study area.*

The area experiences low erratic rainfall with dry hot climatic condition. The topography of the middle awash valley reflects the history of the middle Awash Valley, through which deposits from the Awash River have constructed an extensive alluvial plain.

### *2.2. Performance Indicator of Drip Irrigation*

Partitioning of applied irrigation water underlies the estimation of certain performance indicators. Expressed as percentages, these are fractions of the irrigation water volume that are destined for certain functions.

#### *2.2.1. Importance of Irrigation Uniformity*

The uniformity of each type of irrigation system is influenced by different factors. The factors that affect the uniformity of surface drip irrigation systems are given by [18].

$$DU = f\ [P, D_P, x, E_C, FI]$$

where,

P pressure at the emitter
$D_P$ variation in pressure in operating set
$x$ characteristic discharge exponent of emitter
$E_C$ emitter characteristic related to variation in discharge
$FI$ filtering capabilities of the system

#### *2.2.2. Application Efficiency*

Irrigation efficiency is generally linked to fractions of the irrigation water that are intended for certain purposes, including transpiration, evaporation and infiltration. Precise water application in using drip irrigation is possible making irrigation much more efficient, and is an attribute that makes the drip irrigation method especially attractive if water is scarce or expensive [19, 20]. It is an important irrigation concept that is very important both in the system selection and design, and in irrigation management. Application efficiencies are affected by cultural practices that water storage in the plant root zone and by irrigation management practices [21].

#### *2.2.3. Emitter Flow Variation*

The emitter flow variation calculated by using equation 2.

$$q_{var} = 1 - \frac{q_{min}}{q_{max}} \quad (1)$$

$q_{var}$: Flow variation
$q_{min}$: Minimum flow
$q_{max}$: Maximum flow

#### *2.2.4. Drip Uniformity Coefficient*

Uniformity coefficient was defined with Christiansen uniformity coefficient [22].

$$UCC = \left[1 - \frac{\sum_{i=1}^{n} |q_{avg} - q_i|}{n * q_{avg}}\right] * 100 \quad (2)$$

where,

UCC Christiansen uniformity coefficient
$q_{avg}$ average emitter flow
$q_i$ individual emitter flow
n number of emitters evaluated

#### *2.2.5. Distribution Uniformity*

Distribution uniformity, DU [2, 23], was calculated by using equation:

$$DU = \left[\frac{\bar{q}_{lq}}{\bar{q}}\right] * 100 \quad (3)$$

where,

DU distribution uniformity
$\bar{q}_{lq}$ mean of lowest one-fourth of emitter
$\bar{q}$ mean emitter flow rate

#### *2.2.6. Coefficient of Variation (CV)*

Co-efficient of variation determines the flow rate uniformity of the drippers [24].

$$Cv = \frac{\sigma}{q_{avg}} \quad (4)$$

where,

Cv Coefficient of variation
σ Standard deviation of emitter flow rate
$q_{avg}$ average emitter flow rate

#### *2.2.7. Statistical Uniformity*

The statistical uniformity of an irrigation system can be defined by using the coefficient of variation (CV).

$$SU = 100(1 - CV) \quad (5)$$

where,

SU Statistical uniformity
CV Coefficient of variation

#### *2.2.8. Drip Lateral Hydraulics*

A drip irrigation system was made by a combination of different size of plastic pipes which are usually considered as smooth pipe. One empirical equation frequently used is the Hazen and Williams formula. Also, because of the possibility of laminar, turbulent or fully turbulent flow in trickles Darcy Weisbach equation was used to compute the head loss due to pipe friction.

$$H_f = \frac{fLV^2}{2gd} \quad (6)$$

Where,

$H_f$: Head loss due to friction (m)
f: Friction factor
L: Length of pipe (m)
V: Velocity (m/s)
g: Acceleration due to gravity (m/s$^2$)
d: Pipe diameter (mm)

## 3. Results and Discussion

During field installation of drip irrigation before planting the drip emitter discharge rate was calibrated at field condition and the emitter distribution uniformity were estimated. According to the result, the actual discharge rate of the emitter was 0.87l/hr while the designed discharge rate of the emitter was 1.1l/hr. The lateral is designed for 20% emitter flow variation plus sub mains is designed for a 10% lateral flow variation and the overall irrigation application efficiency was about 85%.

***Figure 3.*** *On field installation of catch can Calibration of emitter.*

### *3.1. Emission Uniformity (EU)*

Emission uniformity estimated as a function of the relation between average flow emitted by the 25% of the emitters with the lowest flow and the mean flow emitted by all emitters. The evaluated system is classified as excellent.

### *3.2. Flow Variation Coefficient*

The drip line is laid on the leveled ground. When the drip irrigation system line is laid on level ground the pressure variation along the line will follow the energy gradient curve. Generally, the pressure drop ratio (ΔPi/P) have been kept constant by varying the ratio length (l/L) and controlling the head inside the barrel.

### *3.3. Christiansen's Uniformity Coefficient*

The uniformity coefficient or Christiansen's uniformity coefficient. The evaluated system is classified as excellent.

***Table 1.*** *Hydraulic Evaluation of drip irrigation.*

| No | Hydraulic Parameter | Calculated Value | Classification |
|---|---|---|---|
| 1 | Emitter flow variation | 8% | Desirable |
| 2 | Field Emission Uniformity | 92.2% | Excellent |
| 3 | Coefficient of variation | 0.07 | Average |
| 5 | Coefficient of uniformity | 90.8% | Excellent |
| 6 | Application uniformity | 85% | good |
| 7 | Statistical uniformity | 93% | good |

## 4. Conclusion

In conclusion, as per the results of different parameters like emitter flow variation ($q_{var}$), field emission uniformity (EU), coefficient of variation (CV), distribution uniformity (DU) and statistical uniformity (SU) of drip irrigation system installed was satisfies the ASAE standards. High values of uniformity coefficient and uniformity of distribution are attributed to the effect land levelling. Average application efficiency has been found good value due to high evaporation rate. Irrigation efficiency of the drip irrigation system at the study area was high this could due to high application efficiency and distribution uniformity.

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