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On-station Evaluation of Family Drip Irrigation System in North-West Ethiopia

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Authors' contributions

This work was carried out in collaboration with all authors. Authors KMT and SH designed the study, performed the statistical analysis, wrote the protocol, managed the literature searches, and wrote the first draft of the manuscript. Author BY managed the analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

The study was carried out at the effect of drip and surface irrigation (Furrow irrigation) methods on onion and sesame crops from December 2011 to May 2012 in the Tigray region of Northwest Ethiopia. The objective was to evaluate the family drip irrigation system in comparison with furrow irrigation system in terms of irrigation water productivity (using 100% ETc for both commodities). The water saved in drip irrigation over furrow irrigation was found to be 33% for onion and sesame crops. The irrigation water productivity of onion was 0.9 kg/m^3 and 0.55 kg/m^3 under drip and furrow irrigation methods respectively. The irrigation water productivity of sesame was 0.14 kg/m3 and 0.045 kg/m3 under drip and furrow irrigation methods respectively.

Keywords: Drip irrigation; furrow irrigation; sesame; onion; water productivity.

1. INTRODUCTION

Drip irrigation is the most efficient irrigation method. It applies small and steady volumes of water and nutrients directly into the root zones for immediate uptake [1]. Under normal circumstances, drip irrigation has got a high degree of water application uniformities,

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efficiencies, distribution and storage efficiencies. In addition, it reduces labor requirements, weeds, insect pests, and disease attacks and it is adaptable in wide range conditions. Smallholder drip irrigation systems (family drip irrigation system) operate under pressures of 0.5–25 m head. The area coverage is not more than 500 m^2 [2].

Despite its remarkable gains, modern irrigation has got high initial investment and it has failed to meet the widespread need for very inexpensive divisible irrigation systems particularly in the Western part of Tigray.

Recently, prospects for the expansion of drip irrigation has brightened with the development of spectrum of systems keyed to different income levels and small farmers to attain resource-poor household food security through an introduction of modern low-cost affordable drip irrigation at a fraction cost and much greater reliability.

According to Haregeweyn et al. [3], different low-cost affordable drip irrigation (such as; Bucket and drum or FDK (farmer drip kits) has been practicing in some developing countries for the following advantages: Affordability; the cost and labor requirement is reduced so much that even resource poor households (particularly, female-headed) can use, operate, manage and afford it easily. Divisibility and expandability; can be adaptable to varying sizes particularly for home gardens so that it can be used to produce food crops and vegetables having high nutritional values near his/ her house and adds food allowance. The sizes can be scaled as the income of users' increases.

In addition, it increases uniformity and quality of products with efficient utilization of water, nutrient and labor particularly, in dry land areas [4].

Efforts are going on to introduce and disseminate family drip irrigation even in the Western low land of Tigray through agriculture and rural development bureau.

However, the efforts of introducing family drip irrigation systems faced some difficulties and the technology is by far below expectation. According to the information obtained from field visits and informal interviews with farmers as well as development agents, farmers had rejected and even ignored to use it due to improper scheduling, poor awareness, and management problems. Hence, if family drip irrigation is to be further disseminated the bottleneck should be first addressed through on-farm evaluation, demonstration, and popularization under the prevailing local condition to provide the best basis for the sound choice and increased adoption rate of intended new irrigation technologies by farmers.

It is thus suggested that clear technical backups and increasing farmers' awareness of the value of water would be essential for the efficient and sustainable use of the available water resources [5].

This paper is therefore aimed to evaluate the family drip irrigation system in comparison with furrow irrigation system in terms of irrigation water productivity.

2. METHODOLOGY

2.1 Description of Study Area

The experiment was conducted at Humera Agricultural Research Center which is found in Tigray Region, North-west Ethiopia.

The site Fig. 1 is located at a distance of 1440 km from Addis Ababa. The average elevation is about 580 m.a.s.l and it lies between 14°9'36" N latitude and 36°34'48" E Longitude.

2.2 Crop Water Requirement

Crop water requirement was determined using Penman-Monteith with CROP WAT version 8.1 using long term climatic data, location, and crop data for onion (Bombay red) and Sesame (Setit-1) as shown in Table 1 and Table 2 while considering irrigation application efficiency of 60% and 90% for regulated furrow and drip irrigation.

The experiment was carried out during 2011 dry season on Onion (Bombay red starting from Dec-28 and Sesame (Setit-1) starting from Feb- 25 2012, in Ethiopia, Tigray Regional state at Humera Agricultural research Center in simple observation trial in which the amount of water applied to the experimental unit was regulated using regulated furrow irrigation and flow meter in flat slope in case of furrow irrigation and simple flow meter in case of drip irrigation as shown in Fig. 2.

Land and input preparation (a rate of 100 kg/ha DAP and 150 kg/ha Urea fertilizer and all necessary kits of drip system) was conducted before installation of the drip system. All crop management activities i.e. weeding, chemical spray for disease occurrence, harvesting and weighting grain at right time were made.

A significant feature of drip irrigation is that the system can be used to deliver agricultural chemicals.

Fertilizers and pesticides can be dissolved in water, injected into the irrigation system, and distributed directly to the plant's root zone [6]. Considering the common recommended family drip irrigation installation assumptions assumed by Agricultural and Rural development office(irrigating capacity of family drip irrigation system using singe drum is 500 m^2), one family drip irrigation was first installed at the experimental field and evaluations was made on emitter discharges at different operating head (2 meter, 1.5 meter, and 1 meter) during the high temperature months that indicates high crop water needs (March, April, may) during 2011/2012 by collecting cans or systematically selected 60 emitters.

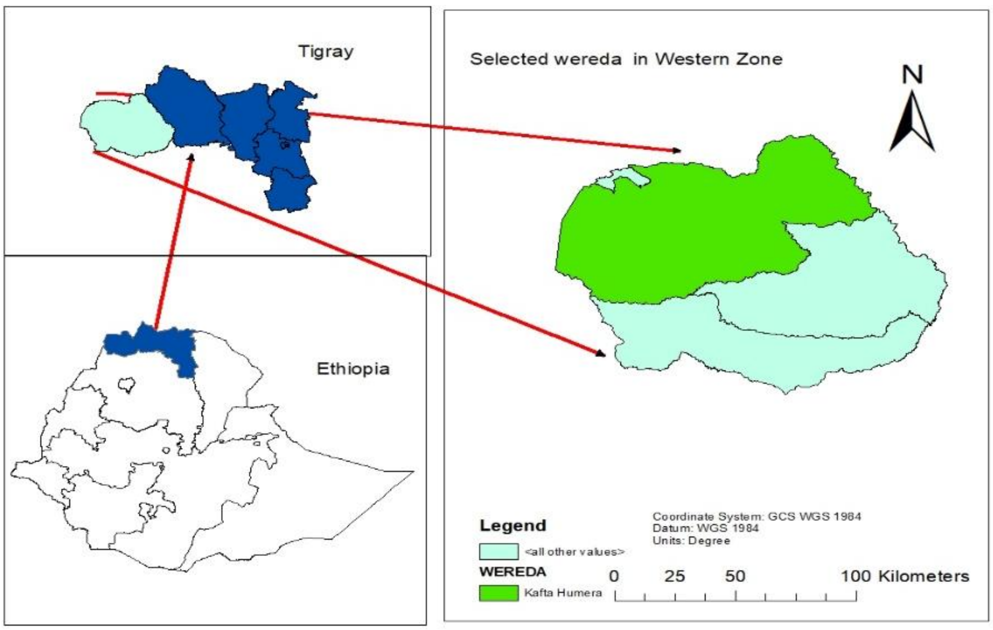

Fig. 1. Study area map (Prepared by Kasa M.)

Fig. 2. Sesame (setit1) under drip irrigation during the maturity stage

Table 1. Irrigation schedule for onion on-site evaluation of family drip irrigation

Onion (Bombay red) under furrow irrigation					Onion (Bombay red) under drip irrigation				
Date	**Day**	**Stage**	**Net Irr. mm**	**Gr. Irr.mm**	**Date**	**Day**	**Stage**	**Net Irr.mm**	**Gr. Irr.mm**
30-Dec	3	Init	40.8	68.1	30-Dec	3	Init	40.8	45.4
2-Jan	6	Init	11.4	18.9	2-Jan	6	Init	11.4	12.6
5-Jan	9	Init	11.3	18.9	5-Jan	9	Init	11.3	12.6
8-Jan	12	Init	11.3	18.9	8-Jan	12	Init	11.3	12.6
11-Jan	15	Init	11.4	19.0	11-Jan	15	Init	11.4	12.7
14-Jan	18	Init	11.5	19.2	14-Jan	18	Init	11.5	12.8
19-Jan	23	Dev	19.2	32.1	19-Jan	23	Dev	19.2	21.4
24-Jan	28	Dev	23.2	38.7	24-Jan	28	Dev	23.2	25.8
29-Jan	33	Dev	24.2	40.4	29-Jan	33	Dev	24.2	26.9
3-Feb	38	Dev	28.1	46.8	3-Feb	38	Dev	28.1	31.2
8-Feb	43	Dev	30.6	51.1	8-Feb	43	Dev	30.6	34.0
13-Feb	48	Dev	34.6	57.6	13-Feb	48	Dev	34.6	38.4
18-Feb	53	Dev	37.2	62.0	18-Feb	53	Dev	37.2	41.3
23-Feb	58	Mid	33.9	56.6	23-Feb	58	Mid	33.9	37.7
28-Feb	63	Mid	34.0	56.6	28-Feb	63	Mid	34.0	37.7
5-Mar	68	Mid	34.9	58.2	5-Mar	68	Mid	34.9	38.8
10-Mar	73	Mid	34.9	58.2	10-Mar	73	Mid	34.9	38.8
15-Mar	78	Mid	35.9	59.8	15-Mar	78	Mid	35.9	39.9
20-Mar	83	Mid	35.9	59.8	20-Mar	83	Mid	35.9	39.9
25-Mar	88	Mid	37.4	62.4	25-Mar	88	Mid	37.4	41.6
30-Mar	93	Mid	37.4	62.4	30-Mar	93	Mid	37.4	41.6
6-Apr	100	End	50	83.3	6-Apr	100	End	50.0	55.5
13-Apr	107	End	45.5	75.8	13-Apr	107	End	45.5	50.5
20-Apr	114	End	40.0	66.6	20-Apr	114	End	40.0	44.4
26-Apr	End	End			26-Apr	End	End		
Total			714.6	1191.4				714.6	794.1

Table 2. Irrigation schedule for sesame on-site evaluation of family drip irrigation

Sesame (setit1)) under furrow irrigation					Sesame (setit1)) under drip irrigation				
Date	**Day**	**Stage**	**Net Irr. mm**	**Gr. Irr. mm**	**Date**	**Day**	**Stage**	**Net Irr. mm**	**Gr. Irr. mm**
27-Feb	3	Init	32.9	54.8	27-Feb	3	Init	32.9	36.5
2-Mar	6	Init	11.1	18.5	2-Mar	6	Init	11.1	12.4
5-Mar	9	Init	11.2	18.6	5-Mar	9	Init	11.2	12.4
8-Mar	12	Init	11.2	18.6	8-Mar	12	Init	11.2	12.4
11-Mar	15	Init	12.2	20.4	11-Mar	15	Init	12.2	13.6
16-Mar	20	Dev	23.8	39.7	16-Mar	20	Dev	23.8	26.5
21-Mar	25	Dev	26.3	43.9	21-Mar	25	Dev	26.3	29.2
26-Mar	30	Dev	36.3	60.6	26-Mar	30	Dev	36.3	40.4
31-Mar	35	Dev	36.3	60.6	31-Mar	35	Dev	36.3	40.4
5-Apr	40	Dev	46.8	77.9	5-Apr	40	Dev	46.8	51.9
10-Apr	45	Mid	41.4	68.9	10-Apr	45	Mid	41.4	46.0
15-Apr	50	Mid	44.2	73.7	15-Apr	50	Mid	44.2	49.2
20-Apr	55	Mid	44.2	73.7	20-Apr	55	Mid	44.2	49.2
25-Apr	60	Mid	44.6	74.4	25-Apr	60	Mid	44.6	49.6
30-Apr	65	Mid	44.6	74.4	30-Apr	65	Mid	44.6	49.6
5-May	70	Mid	45.0	75.0	5-May	70	Mid	45.0	50.0
10-May	75	Mid	45.0	75.0	10-May	75	Mid	45.0	50.0
17-May	82	End	56.5	94.2	17-May	82	End	56.5	62.8
24-May	89	End	49.1	81.9	24-May	89	End	49.1	54.6
30-May	End	End			30-May	End	End		
Total			662.7	1104.8				662.7	736.7

Table 3. Water productivity of onion

Irrigation method used	Applied water m^3/ha-season	Yield(kg/ha)	WP(Kg/m^3)	Amount of water saved (%)
Drip	7941	7166.8	0.90	33.34
Furrow	11914	6531.04	0.55	_

Table 4. Water productivity of sesame

Irrigation method used	Applied water m^3/ha-season	Yield(kg/ha)	Wp (Kg/m^3)	Amount of water saved (%)
Drip	7367	1002.1	0.14	33.31
Furrow	11048	502.53	0.045	_

The irrigation schedule was prepared for both commodities onion and sesame for furrow and drip irrigation system as shown in Table 1 and Table 2.

3. RESULTS AND DISCUSSION

3.1 Irrigation Water Productivity for Onion and Sesame

The pre-experiment evaluation of emitter discharge at different operating head had shown that operating the family drip irrigation at a stand height of 2-meter, 1.5 meter, and 1 meter for 3.03, 3.46 and 4.04 hours daily respectively can provide enough amount of water for irrigation. This revealed good solutions that the threat of farmers and development agents on the possibility of family drip irrigation to provide enough water for crop production at Humera condition. According to [3] emission uniformity of family drip irrigation was more than 93%.

The water productivity (WP) of onion and sesame under furrow and drip irrigation described in Table 3 and Table 4 respectively. The irrigation water productivity estimated by using a ratio of the yield obtained in kg/ha and the amount of water applied to the irrigation field per season in m^3.

Yield and water productivity of onion was better in drip irrigation as compared with furrow irrigation. There is a 10 % yield increment using drip irrigation for onion production compared with furrow irrigation method. Likewise, it is possible to produce 0.9 kg of onion using unit volume of water using drip irrigation and 0.55 kg of onion for unit volume of water using furrow irrigation (Table 3). So using drip irrigation can create a chance of an additional 33% irrigable land. This result is in line with [7] for 100% crop water requirement of onion crop under drip irrigation there is 44.6% of water saved over furrow irrigation.

Yield and water productivity of sesame was also best in drip irrigation as compared with furrow irrigation. There is a 99% yield increment using drip irrigation for sesame production than furrow irrigation. Likewise, it is possible to produce 0.14 kg of sesame using unit volume of water using drip irrigation and 0.045 kg of sesame for unit volume of water using furrow irrigation (Table 4). [8] Got a water productivity of 0.109 kg/m^3 for sesame crop. Using drip irrigation therefore can create a chance of an additional 33% irrigable land. The highest yield of Sesame seed was recorded using drip irrigation because there was no water drop contact with the blooms whose pressure impact could have dropped some of the blooms [9].

Using the latest irrigation technique can decrease the total cost of the agriculture due to the education in operation period which in turn decrease the expenses of the operation and the fuel consumption and increase the life time of the pumps and pipelines [10].

4. CONCLUSIONS AND RECOMMENDATION

High yield and water productivity were observed under drip irrigation over furrow irrigation. For sesame production both the yield and water productivity were doubled. Using drip irrigation can provide enough amount of water for irrigation if proper scheduling is made.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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