Agricultural Water Management

Testing Low-cost Gravity Drip Irrigation Technology Suitable to the Current Water Harvesting Structures

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Abstract

Currently, high attention is given for efficient utilization of the labor power and land for improved productivity. Constructing water harvesting structures and collecting runoff water on individual farmers' field for additional agricultural productivity purpose is one part of the strategy. Though a number of water harvesting structures are constructed at the different corners of the country, the adoption rate and return of these structures is not as expected. Lack of low cost, simple and efficient irrigation technologies for appropriate utilization of harvested water is the major reason for the above problems. Therefore this study was conducted with the objective of demonstrating, testing and evaluating low cost smallholder drip irrigation practices relative to can /manual water application for better utilization of harvested water. From the study smallholder drip systems gave better yield with lower irrigation water. In addition, drip irrigation was found more efficient, less laborious and with better economical return. From the practical training and field demonstration, the attitude of farmers about better utilization of harvested water with small holder drip irrigation system is changed and farmers have confessed as they will adopt water harvesting structures.

Key words: Irrigation water, tomato, onion, water use efficiency, yield

Introduction

Out of 113 Woredas of Amhara Region, 52 are food insecure at both community and household level (Ewnetu Gedif, presentation, 2005). Population pressure will further increase food insecure areas of the region if the agricultural activity continues dependant on this risky rain-fed staple-food production condition (Sijali, 2001).

Therefore, irrigation can and should play an important role in raising and stabilizing food production. Hence, a well-managed irrigation system is crucial. The vital task of increasing and stabilizing food production in drought prone regions must therefore include a concentrated effort to improve on-farm water management.

Realizing this situation, the region is undertaking different activities to intensify irrigation at small householder farmers' level. Lots of water harvesting structures have been constructed and ground water ponds developed widely in the dry land areas through different approaches.

Regardless of the heavy investment incurred to construct water-harvesting structures, most of them could not provide the desired results because of the high water demanding traditional surface irrigation methods. Because the only familiar technology for farmers is flood or manual irrigation, most of them are not convinced of the sufficiency of stored water for supplemental or full irrigation. Therefore, the adoption rate of water harvesting structures is low and even those constructed before are mostly idle. As a result, there is need of introducing and evaluating efficient, easily affordable and water saving irrigation systems that could help to utilize the limited water collected by water harvesting structures.

The time is ripe for new approach, an approach extending water-harvesting structures as package with appropriate drip irrigation method. Household drip irrigation systems are given attention in different parts of the world for such small stored waters.

The system is cost effective in that it uses gravitational force and most materials are locally available. The daily operation of the system should not require knowledge and abilities beyond those of the smallholder farmer. So that this experiment was conducted to demonstrate, test and evaluate low cost family drip irrigation system's suitability for the utilization of water harvested by conventional water harvesting structures relative to can /manual water application.

Materials and Methods

Three representative farm households having harvested water using hemispherical water harvesting structures were selected at Aliyu Amba, Ankober. Onion and tomato were grown side by side on selected farms and were irrigated using smallholder drip irrigation and traditional can irrigation methods. The two irrigation systems, drip irrigation system and traditional can (manual) irrigation were the two treatments compared.

Water storage, either barrel or plastic bucket in this case, was placed at about one meter height from the ground surface. Water used for irrigation was fetched manually from water harvesting structures and filled in water storage devices. Water from one storage barrel or bucket irrigates one onion and one tomato beds using one drip line. What is purchased from the drip system was the drip line and few accessories which are low cost (about 50 Birr, 5 USD each drip line with accessories). In one experimental area, two onion beds and two tomato beds were irrigated using each system, drip and can.

The amount of irrigation for drip case was determined by checking the moisture status of the soil using fill method, which is calibrated through continuous sampling. The experiment was conducted for two years (irrigation seasons) and data on total amount of water applied, time and labor required, yield and farmers view were taken for both systems.

Result and Discussion

Amount of Irrigation Water Applied and Required Labor

In this study, using low cost family drip irrigation was found to reduce the total amount of irrigation water applied by 24.23 m^3/ha and 22.51 m^3/ha for tomato and onion respectively compared to manual can irrigation method (table 1). This much water difference per hectare base may not seem much, but compared to the total amount of water utilized for irrigation, saving this much water will help a lot to irrigate additional area. Irregular small application of can irrigation water by farmers and the rainfall condition of the area in mid irrigation seasons may have contributed for the decrement of the difference.

Regardless of farmers' suspicion of the adequacy of the harvested water for vegetable production, we were able to demonstrate it on their farm as they can produce vegetables with harvested water. Irrigation for drip system was applied each time until the soil reaches its field capacity. The irrigator used feel method, which was calibrated to field capacity by continuous sampling of moist soil and measuring the moisture content by gravimetric method, to determine the amount of irrigation requirement before each application. However, average irrigated soil depth usually didn't exceed 5 cm for can application method and roughly speaking it could be said that, farmers were showering the crop with water rather than irrigating it. Therefore, regardless of the same irrigation frequency for both methods, the amount of irrigation depth was quite different between the two systems.

Labor for drip case was calculated by recording the whole time spend from adjusting drip lines to end of irrigating fields with out considering different additional activities individuals can do once they adjust the drip system. For this reason, the labor used for drip was exaggerated add goes against the advantages and principles of drip irrigation. This under estimates the benefits of drip irrigation. Therefore, by considering the addition al activities farmers were doing side by side to irrigating their fields after adjusting the drip system, the total time was divided by two. This was done to have better cost benefit analysis information. But it is still over estimated and the labor for drip is higher for two onion plots (Abera and Dejene onion plots).

Time saving advantage of drip was assured by farmers who were participants of the demonstration based training we provided for the Woreda and Kebele Agricultural experts and farmers of the experimental area.

Table 1. Amount of applied water and labor required for drip and can method of application

Farm owner	Crop type	Volume of Water Applied(m^3/ha)			Labour (man-day/ha)		
		Drip	Can	Difference (Drip - Can)	Drip	Can	Difference (Drip - Can)
Abera Wessenie	Tomato	53.33	70.41	17.07	82.38	98.85	16.48
	Onion	142.55	177.86	35.31	255.21	245.54	-9.67
Dejene Tadesse	Tomato	77.58	113.27	35.69	108.95	181.76	72.81
	Onion	256.25	267.86	11.61	368.31	358.63	-9.68
Weldie Atlaw	Tomato	83.64	103.57	19.93	100.45	247.66	147.22
	Onion	244.37	265.00	20.63	293.90	602.68	308.78
Overall Mean	Tomato	71.52	95.75	24.23	97.26	176.09	78.83
	Onion	214.39	236.90	22.51	305.81	402.28	96.48

Yield and Water Use Efficiency

Considerable yield advantage was also obtained from the drip compared to can irrigation applications except low yield of onion from Abera's plot because of grazing problem of animals. The over all additional mean yield advantages of using drip irrigation were 62.92 qt/ha and 14.29qt/ha tomato and onion respectively (table 2)**.** Though the local price of tomato and onion was low during the harvesting period, farmers have found better income or benefit using family drip system. The rainfall, which is much higher than the previous years during the cropping season, may have an impact on yield difference between the two methods. The yield obtained from can application would have decreased by far if it would have not been for this unusual much rainfall condition.

Table 2. Yield of tomato, onion, and water use efficiency for both irrigation systems.

Farm owner	Crop type	Yield, qt/ha			Water Use efficiency(kg/lt)	
		Drip	Can	Diff	Drip	can
Abera Wessenie	Tomato	234.95	171.94	63.01	0.44	0.24
	Onion	80.36	100.00	-19.64	0.06	0.06
Dejene Tadesse	Tomato	160.46	103.06	57.40	0.21	0.09
	Onion	357.14	296.43	60.71	0.14	0.11
Weldie Atlaw	Tomato	409.18	340.82	68.36	0.49	0.33
	Onion	158.93	157.14	1.79	0.07	0.06
Overall Mean	Tomato	268.20	205.27	62.92	0.38	0.21
	Onion	198.81	184.52	14.29	0.09	0.08

The two irrigation methods can be also compared in terms of water use efficiency. In the study, drip has shown better water use efficiency than the can method. From table 2, the over all mean water use efficiency of tomato is 0.38 and 0.21 and that of onion is 0.09 and 0.08 for drip and can applications respectively. Water use efficiencies for onion in Abera's plot were the same for both systems because of the previously mentioned problem on yield. Still tomato has saved much water than onion irrespective of the application methods.

Cost Benefit Analysis

The cost of labor was estimated based on labor cost during the study time, 8 Birr/man/day. One full set of drip line, which can give service for at least four irrigation seasons and two vegetable producing beds (one onion and one tomato), was purchased 50 Birr. The cost of drip lines per hectare basis was calculated by considering the above realities. The partial cost and benefit analysis indicated that the benefit obtained from drip system is much better than the farmers' method of water application (table 3). In spite of the low price of onion (1.50 Birr/kg) and tomato (1.00 Birr/kg) taken from the local market during harvesting season, drip rate of return which is 451.18% for tomato and 138.27% for onion is higher. From the partial budget analysis, one can easily identify and choose that tomato can give much higher return than onion. This is due to the high labor demand for shifting of smallholder drip lines to irrigate densely populated (15 cm between plants) onion than tomato (60 cm spacing between plants)

Table 3. Partial budget analysis and water use efficiency for drip irrigation technology compared with farmer method at Aliyu Amba

	Tomato		Onion	
Variables	Drip	Can	Drip	Can
Labor cost (Birr/ha)	778.05	1408.72	2446.44	3218.27
drip material cost	1860.20		1860.20	
Total cost (Birr/ha)	2638.25	1408.72	4306.64	3218.27
Benefit, yield(Birr/ha)	26819.67	20527.33	29821.50	27678.50
Benefit, water(Birr/ha)	484.62		450.29	
Total Benefit (Birr/ha)	27304.29	20527.33	30271.79	27678.50
Net Benefit (Birr/ha)	24666.04	19118.61	25965.15	24460.23
Marginal Rate of Return (%)	451.18		138.27	
Water use efficiency (kg/lt)	0.38	0.21	0.09	0.08

Training and Field Day

Field day was prepared for about thirty male and 10 female a total of farmers and development agents of the peasant association in order to make aware of the farmers about drip irrigation methods. Demonstration based training about drip irrigation was also given for 15 farmers, 2 development agents of the peasant association and 1 expert of the Woreda's Bureau of Agriculture and Rural Development. This training was undertaken for motivating the farmers to practice drip irrigation in the future.

During the training, most farmers were highly astonished of family drip technology. They have convinced that, it could be possible to produce different vegetables using rain-harvested water. Besides the technology's water saving importance farmers indicated that its simplicity and the possibility to do other activities side by side to irrigating crops will enable everybody at home to handle the practice at any time. Trainees expressed that it was because of their lack of awareness they refused to construct their own water harvesting structures in-group. Almost all express their regression fore not having and as they need to construct and practice drip irrigation.

Those farmers owning farms with water harvesting structures where the experiment has conducted started to use their land and harvested water intensively after we started to work with them.

Conclusions and Recommendations

In the demonstration based evaluation and comparison study, drip irrigation gave better yield advantage with relatively less water than farmers manual can application. Water Use efficiency of vegetables was also higher in the drip case. As result, the economical return of drip irrigation, which is expressed in terms of marginal rate of return, was relatively better.

During the field demonstration and training, local growers were happy for the simplicity, low cost, water saving, better yielding properties of small holder drip technology. Farmers witnessed as it saves much water, does not require any outside power for water pressure, increases the quantity and quality of yield, reduces labor requirement and reduces weed.

Therefore, Scaling-up smallholder drip irrigation technology in the area by establishing Farmers Research Extension Group (FREG) or in other means will improve productivity and utilization of harvested water. This will in turn facilitate the adoption rate of water harvesting structures.

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