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Verification and Demonstration of Low-Cost and Appropriate Micro-Irrigation System for Crop Production under Small Holder Farmers Condition in Raya Valley, Northern Ethiopia

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Abstract: *Irrigated agriculture plays a major role in food security, producing nearly 40 percent (%) of food and agricultural commodities. It uses more than 80% of the water withdrawn from the earth's rivers. This increased pressure to water as a valuable resource in agricultural food production which remains finite due to the competition of current and future events namely; rapid increase in world population, climatic change, agricultural and industrial sector activities. In order to conserve and able to produce food continuously; an efficient water use and crop yield improving agricultural practices need to be adapted and implemented. Demonstration of low-cost and appropriate micro-irrigation system had been designed and carried out under soil and agro climatic condition of Raya valley at mehoni agricultural research center, on station for two non consecutive years to evaluate the feasibility of drip irrigation and to efficiently utilize the scarce water resources and maximize crop yield. Full drip irrigation kits with its all accessories have been installed on 500m2 plot of land for marcofana pepper variety and all agronomic and water management was undertaken as recommended. The result 180,800.1 EB ha-1 revenue with net benefit of 23,650.1EB ha-1 from green pepper was earned and WUE of pepper also obtained high result. Model farmers had been participated in the demonstration that they had shown their interest with the technology. So, for justification it needs to be undertaken at farmer's level.*

Keywords: *Drip irrigation, Marcofana, Pepper, Water Use Efficiency*

1. INTRODUCTION

Drip irrigation is an irrigation method whereby small quantities of water drip directly to the root zone of crops through a network of plastic pipes, valves, emitters or drippers, and Drip irrigation is an irrigation method whereby small quantities of water drip directly to the root zone of crops through a network of plastic pipes, valves, emitters or drippers, and ancillary devices (Venot et al., 2014). Drip irrigation technology is said to improve yields and irrigation efficiency (Goldberg et al., 1976; Keller & Bliesner, 1990; Postel, 1999), notably by maximizing irrigation uniformity and minimizing water deliveries (Keller & Roberts, 2004). Research and development efforts on drip irrigation have long been driven by a search to optimize and better adjust irrigation delivery to crop water demands and the notion of efficiency (van der Kooij et al., 2013; Venot et al., 2014). Irrigation scholars, professionals but also the wider public generally considers drip irrigation to be a more sophisticated form of irrigation as compared to surface irrigation for instance. Its use is associated with modernization and progress, and with large and wealthy farmers. Since the 1960s when the first modern drip irrigation systems started to appear in Israel and the United States, efforts have also started to focus on refining drip irrigation to make it useful and affordable to smallholders' farmers.

The first model of drip irrigation systems specifically designed for smallholders in the developing world was developed in the 1970s by a US based irrigation equipment company called Chapin Water matics Inc. (Postel et al., 2001), following a request of the NGO Catholic Relief Service who wanted to use them in Senegal (Keller, 2000) Over the last 20 years, several other organizations, such as the Non-Governmental Organization International Development Enterprises (iDE) as well as the two major manufacturers of drip irrigation equipment, NETAFIM and Jain irrigation Systems Ltd, also engaged in efforts to design and disseminate drip irrigation systems for smallholders. Even if the

technology demonstration was undertaking across the world including the adoption of it is still in seldom due to its high capital cost (Postel, 1996) — about $1,000 (U.S.) per acre for row crops like vegetables. This makes installation of drip systems prohibitive for the great majority of farmers in developing countries including Ethiopia who cultivate less than five acres. Fortunately, Industrial manufacturers have "scaled down" and simplified large commercial drip irrigation systems (Huang, 2012). On the other hand, NGOs, such as iDE, claim to have designed a new spectrum of drip irrigation systems for the "poorest of the poor" in South Asia and sub-Saharan Africa (Polak, 2008; Postel et al., 2001). Both systems promoted by NGOs and large irrigation equipment companies have come to be known under the generic name of "drip irrigation kits" as they are compatible with small plots (from a few to one thousand square meters). These kits are also called 'low cost' or 'low pressure' drip irrigation systems. They are mostly used to grow vegetables and, in some instances, fruit trees on small plots. To meet the need for a low cost system, International Development Enterprises, a non-profit organization specializing in small scale irrigation, has developed and field tested a simplified drip system that is divisible, and costs $250 a hectare ($50 for a one-half acre unit).

1.1. Statement of Problem

Water scarcity and expensiveness of initial investment, operation and maintenance cost of the system is a challenge to use different irrigation system for crop production at small holder's farmer's level in Raya valley, Ethiopia. To overcome this problem low cost drip irrigation need to be adopted by smallholder farmers.

1.2. Scope of the Study

This paper describe only the result of cost benefit of low cost family drip irrigation system including full drip irrigation cost, fertilizer cost, and labor cost of the installation and operation of system and Water use efficiency for Marcofana pepper variety, at Mehoni agricultural research center, Ethiopia.

1.3. Objectives

- To evaluate the feasibility of drip irrigation system at the Research center level
- To efficiently utilize the scarce water resources and maximize crop yield

2. Materials and Methods

2.1. Description of the Demonstration Site

The study was conducted at the research station of Mehoni Agricultural Research center (MeARC) in the Raya Valley, Northern Ethiopia, located 668 Km from the capital Addis Ababa and about 120 Km south of Mekelle, the capital city of Tigray regional state. Geographically the experimental site is located at 12° 41'50" North Latitude and 39° 42'08" East Longitude with an altitude of 1578 m.a.s.l. The site receives a mean annual rainfall of 300 mm with an average minimum and maximum temperature of 22 and 32°C, respectively. The soil textural class of the experimental area is clay loam with pH of 7.9-8.1(MeARC, 2015).

2.2. Methods

The trial was carrying out for two non consecutive years to evaluate feasibility of drip irrigation system on Marcofana pepper crop variety at Mehoni RC, Facagama site. A single drip system/family drip was used, which consist of water source (Tanker), control valve, filter, water pipe lines (mainline and sub-mainline), lateral lines and emitters and connected to each other as listed the parts respectively to operate the system. The system had been installed on well prepared fields of 25m length, and 20m width or 500 m^2 areas and the spacing between lateral and emitter were 0.6m and 0.4m respectively to grow Pepper.

To be honest ET by irrigation was estimated by taking the average daily used water during the trial period for each year. In average for 500m^2 area of land the water used daily were 3.5 and 4 time 400 litre of water filled tanker for the first and the second year respectively. IWUE was calculated as ratio of green pepper yield (Kg) per unit volume of Irrigation Water ($m^{3)}$ and was expressed as kg of green pepper per m^3 of consumed (evapotranspired) water.

To assess the economic viability of the drip irrigation system, both fixed and operating costs were calculated (çetin et al. 2004). Total cost, gross return or revenue, and net return or profit was estimated. The fixed cost includes material affording cost and fertilizer cost while operating cost was labor cost.

Marginal revenue (Gross return) = Yield*10 Birr, where 10 birr is the minimum return from 1kg of green pepper.

Profit (net return) = (Marginal revenue)- (Total cost)

Total cost = Fixed cost + Operating cost

WUE = (Yield)/(Total ETc), while

IWUE = (Yield)/(IW or ET by Irrigation)

All cultural practices were done accordance to the recommendation of the crop.

3. RESULTS OF THE STUDY

Quantitative data on Transplanting & Flowering date, Plant height, Primary branches, Number of flowers per plant, pod length & diameter, Pod number per plant, Weight of (Marketable & unmarketable) Yield and weight of Straw per plant has been collected. And important data has been analyzed in 2014 and 2016 respectively as shown in table below.

Table1. *Drip Irrigation use costs per production period at Mehoni Research site*

Year	Drip Irrigation Costs per 500 m^2 (EBirr)				Drip Irrigation Costs per ha (EBirr)			
	Material cost	**Fertilizer cost**	**Wage cost**	**Total cost**	**Material cost**	**Fertilizer cost**	**Wage cost**	**Total cost**
2014	1500	145	5960	7605	30000	2900	119200	152100
2016	2000	150	5960	8110	40000	3000	119200	162200
Mean	1750	147.5	5960	5960	35000	2950	119200	157150

Material cost includes cost of full drip irrigation equipment and fertilizer cost includes UREA and DAP affording cost and Wage cost includes labor cost to carry out all works throughout production period and Total cost is the cost of the three type's costs.

Table2. *Pepper Yield and Water use Efficiency at Mehoni Research site*

Year	Ph (cm)	Marketable Yield (Kg)		ETc (mm)		WUE (Kg/m^3)	
		(Kg/500 m^2)	**(Kg/ha)**	**ET total**	**ET by Irrigation**	**CWUE**	**IWUE**
2014	54.86	899.3	17985.78	496.2	350	3.62	5.14
2016	72.7	908.7	18174.24	487.1	400	3.73	4.54
Mean	63.78	904	18080.01	491.65	375	3.675	4.84

ET total is Crop water requirement throughout the vegetating period unto harvesting, ET by Irrigation is ETc used by irrigation, CWUE is Crop water use efficiency and IWUE is Irrigation water use efficiency.

Table3. *Analyzed Cost benefit of pepper production with drip irrigation technology at Mehoni Research site*

Year	Marginal Revenue (Yield*10birr) in EBirr		Profit (Marginal Revenue-Total Cost) in EBirr	
	Revenue/500m^2	**Revenue/ha**	**Benefit/500m^2**	**Benefit/ha**
2014	8993	179857.8	1388	27757.8
2016	9087	181742.4	977	19542.4
Mean	9040	180800.1	1182.5	23650.1

Marginal Revenue is the minimum total income from pepper production under drip irrigation technology and Profit is the net income after covering the costs of production.

4. DISCUSSION

In both trial years the wage cost is the highest expense and it shows that the feasibility of drip irrigation highly affected by wage cost. Even though drip irrigation saves labor water accessibility

could limit this fact. In other word if the wage cost could be managed properly this technology would be most economical.

The two year's mean seasonal irrigation water depth applied for pepper was 375mm and the mean of marketable yield was 18080.01Kg ha^{-1} or 18.08 ton ha^{-1}. The mean minimum profit earned from green pepper yield was 23650.1EBirr ha^{-1}. This implies that the technology is profitable for small holder's farmers.

Data from CROPWAT Modeling

Long term climate data of the research site

Month	Min Temp °C	Max Temp °C	Humidity %	Wind km/day	Sun hours	Rad MJ/m²/day	ETo mm/day
January	11.5	27.2	73	69	7.9	18.4	3.35
February	12.8	27.1	70	86	9.4	22.0	4.03
March	13.5	29.5	68	86	8.7	22.4	4.45
April	13.8	29.7	67	95	8.7	22.9	4.66
May	15.3	32.5	58	52	9.1	23.3	4.69
June	15.8	35.0	60	43	8.6	22.2	4.70
August	15.0	29.7	95	43	6.5	19.3	3.89
September	14.3	30.8	74	52	6.6	19.2	3.96
October	13.1	29.8	69	86	9.2	22.0	4.37
November	12.1	28.6	67	69	9.0	20.2	3.78
December	11.3	27.1	69	69	8.8	19.1	3.41
Average	13.7	29.9	72	67	8.3	20.8	4.11

Indices

Fig1. *Biomass Demonstration (2014)*

Fig2. *When explanation on Drip Irrigation Demonstration for selected farmers undertaken (2016)*

Fig3. *When Demonstration and Training on Drip Irrigation for selected farmers in (2016)*

Fig4. *When Demonstration and Training on Drip Irrigation for selected farmers in (2016)*

5. Conclusion and Recommendation

The result shows that drip irrigation system is economical for smallholder farmers if wage cost of accessing and operating of water is managed. The yield per capita of the production was economical and WUE also high. This may be due to water management problem. To avoid this confusion Irrigation water and effective rainfall amount data need to be accurately collected and their effect must be studied at the same trial period.

Demonstration had been appreciated by selected farmers and they have shown their interest to use this technology though they have question on water accessibility. So that pre-extension demonstration trial of the technology at farmer's level is necessary.

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