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Verification and Demonstration of Low-Cost and Appropriate Micro-Irrigation System for Crop Production Under Smallholder Farmers Condition in Pawe District of Metekel Zone.

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Abstract

Low-cost family drip irrigation technologies have the capacity to minimize the frequency of irrigation but maximize duration of application. The work was conducted to evaluate the feasibility of low cost family drip irrigation and to efficiently utilize the scarce water resources and maximize crop yield for small holder farmer in Metekel zone. It was conducted on pawe agricultural research center station for one year (2012) for verification and on farm for two consecutive years (2013 up to 2014) for demonstration, adoption and to evaluate the feasibility of drip irrigation. The test crops was pepper (melkazala)Full drip irrigation kits with its all accessories have been installed on well prepared fields of 10m length, and 10m width that was 100m^2 areas. Irrigation water was harvested from wells. The spacing between laterals and emitters were 0.6mand 0.4m respectively. All agronomics and water management practices have been undertaken as recommended. Total costs and benefits were calculated for 2012 and 2013 to show the benefit and cost analysis and 1755 birr and 374.1birr profits were obtained in 2012 and 2013 cropping season respectively .But the demonstration was continued and field days were prepared during 2013 and during 2014 cropping season. The farmers appreciate the technology when they observe the field performance of the test crop and believed that they can produced crops for their diet in there garden by harvesting the available water from wells and using low cost family drip irrigation technology.

Keywords: Drip irrigation, pepper, and Metekel zone, profit.

Introduction

Low-cost family drip irrigation technologies can provide small-scale farmers with an affordable means to increase their agricultural production through more efficient water usage. Benefits of drip systems include increased crop output that can alleviate hunger and generate additional income, water savings, a reduction in labor-intensive hand-irrigation of crops, and flexible systems capable of accommodating a variety of plot sizes. Hence, the family drip irrigation has the capacity to minimize the frequency of irrigation but maximizes duration of application that is allowed by the soil and crop and the irrigation occurs less frequently but fully utilizes water stored in the crops' root zone.

Therefore; drip irrigation systems is being considered as one of the alternatives in the planning of irrigation in different area of the World. Drip irrigation is often promoted as a technology that can conserve water, increase crop production, and improve crop quality. To this end, efforts to improve irrigation efficiency through new technologies of using Drip have been undertaken in many areas of the country [9].

Drip irrigation, as defined by [16], is an irrigation technique in which small amounts of water are applied directly to the root zone of plants using a system of plastic pipes, valves, emitters, or drippers, and auxiliary equipment. Drip irrigation is familiarized primarily to save water and increase the water use efficiency in agriculture [5].

Drip irrigation increased output higher than other irrigation techniques, according to many research [8]. The study discovered average water savings of 55%, labor savings of 58 %, and a reduction in spending on pesticides and fertilizers of 16% when compared with flood irrigation systems [12]. In comparison to basin, furrow, and sprinkler irrigation methods, drip irrigation produced the highest mean potential dry yield of pepper with 1.58 t ha^{-1}[7].

According to [13]. Applications are made more frequently with drip irrigation water, which creates a highly beneficial high moisture level in the soil where plants can thrive. In order to only soak a portion of the soil where the roots grow, water is administered near to the plants. According to [11], drip irrigation scheduling is usually based on frequent replacement of the water consumed by the crop to maintain essentially steady level of moisture content in the root zone.

Hot pepper (Capsicum annuum L.) belongs to the genus Capsicum and family Solanaceae [14]. The world average yield of pepper is 3.75 t/ha [3]. The water requirements for hot pepper production were 775 mm at Alemaya, 602 mm at Awassa, 613 mm at Bako, 517 mm at Melkassa and 629 mm at Zeway [19].

CROPWAT (currently in version 8) is a Windows computer program for the calculation of crop water requirements and irrigation requirements based on soil, climate and crop data. CROPWAT 8.0 can also be used to evaluate farmers' irrigation practices and to estimate crop performance under both rainfed and irrigated conditions.

Water scarcity for crop production at small holder's farmer‟s level in pawe district, Ethiopia. To solve this problem low cost drip irrigation need to be adopted by smallholder farmers. This needs 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 pepper.

Objectives:

- To evaluate the feasibility of drip irrigation system at the farmer's circumstances
- To efficiently utilize the scarce water resources and maximize crop yield at smallholder farmers conditions.

Materials and Methods

Description of the Study Area

The demonstration was conducted in Pawe district which is one of the seven districts in the Metekel administrative zone of Benshangul Gumuz Regional state. It is located geographically between 36°20'-36° 32' longitude and 11°12'-11°21' latitude with an altitude of 1120 m.a.s.l. The district has 20 kebeles and the climate of the area is hot humid and characterized by unimodal rainfall pattern with high and torrential rainfall that exceeds from May to October. The area experiences a temperature ranging from 19.4°C to 37.6°C with a mean annual rainfall of 1586.32 mm. The district covers a total area of 63,400 hectares. The farming system of the districts is characterized by a mixed crop-livestock farming system dominated by crop production. The major crops grown in the districts include; maize, finger millet, soybean, sesame, groundnut and rice [19]. Pawe is located 575 kilometers away from Addis Ababa. According to [15]. The area is characterized by its high rainfall with an extended period (April/May to September/October), high temperature, and black soil.

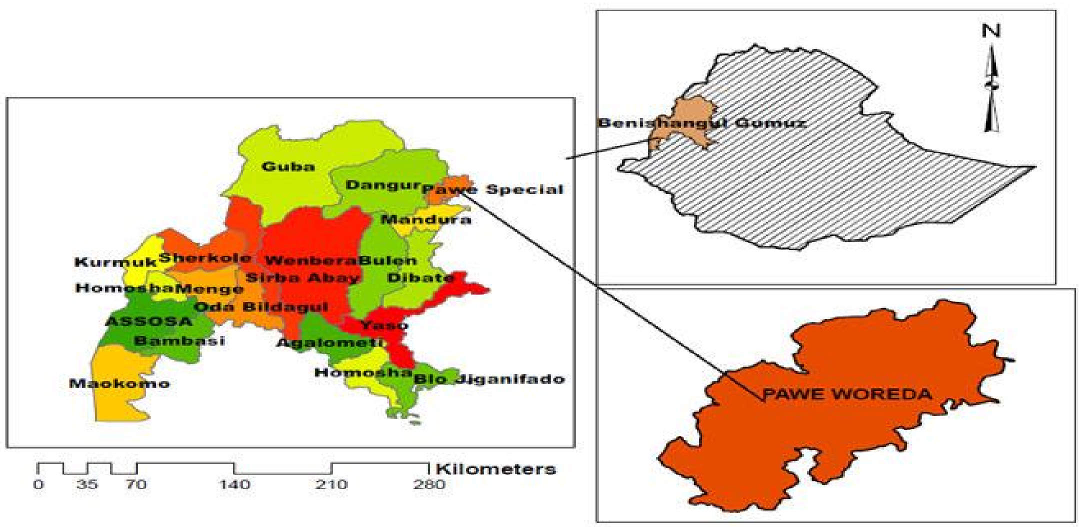

Figure 1: Location map of the study area

The trial was carrying out for five years to evaluate feasibility of drip irrigation system on pepper crop. The connection procedure of family drip is Water source, control valve, filter, mainline, sub-mainline, lateral lines and emitters and connected to each other. The system had been installed on well prepared fields of 10m length, and 10m width that was $100m^2$ areas and the spacing between lateral was 0.6 which is equal to spacing of pepper and spacing between emitters was 0.4m respectively. The water container rose 1.5 m above ground level to create sufficient pressure. Watering can used to fill the water container.

Both fixed and operating costs were calculated to assess the economic viability of the drip irrigation system, Total cost, gross return and net return or profit was estimated. The fixed cost includes material cost and fertilizer cost while operating cost was labor cost.

Crop water requirement computed using CropWat 8.0 and using monthly ETO values together rainfall, crop character and the required soil characteristics as inputs.

Marginal revenue (Gross return) = Yield*10 Birr (1)

Where, 10 birr is the minimum return from 1kg of marketable fruit yield.

Profit (net return) = (Marginal revenue)- (Total cost) (2)

Total cost = Fixed cost + Operating cost (3)

WUE = (Yield)/(Total ETc), (4)

While, IWUE = (Yield)/(IW or ET by Irrigation) (5)

Table 1: Estimated ETo from long term climatic data records

Month	Min.T. (^{0}C)	Max.T. (^{0}C)	R.H. (%)	W.S. (km/day)	Sun (h)	S.R. (MJ/M^2/d)	ETo (mm/day)	TR (mm)	ER (mm)
January	15.3	33.0	33	156	8.1	19.0	5.09	0.7	0.7
February	18.5	34.9	33	164	7.0	18.7	5.56	0.6	0.6
March	19.8	36.5	24	181	7.6	20.8	6.60	7.8	7.7
April	21.3	35.7	34	164	6.9	20.2	6.18	27.8	26.6
May	20.4	31.5	61	138	6.5	19.2	4.85	93.2	79.3
June	19.0	27.7	78	112	7.0	19.7	4.12	289.8	154
July	18.1	24.7	87	121	6.0	18.3	3.49	361.4	161.1
August	17.7	24.2	88	121	4.9	16.9	3.17	396.3	164.6
September	18.2	26.5	84	104	6.3	18.8	3.64	261.1	151.1
October	18.1	27.7	77	95	6.5	18.2	3.67	132.5	104.5
November	16.5	28.4	66	95	7.7	18.7	3.76	14.4	14.1
December	15.5	30.3	54	104	7.9	18.2	3.91	0.7	0.7
Average	18.2	30.1	60	130	6.9	18.9	4.50	132.2	72

Results and Discussion

Long term climatic data of study area were collected from Pawe Agricultural Research Center. Monthly reference Evapo-transpiration (ETo) of the study area was estimated by CROPWAT8 software model

Note:Max. temp. (°C) =maximum temperature in degree Celsius, Min. temp. (0^C) =minimum temperature in degree Celsius, RH (%) = relative humidity in percent. WS (km/day) =wind speed in kilometer per day, SH(h)=sunshinhour in hour, SR (MJ/M^2/d)= Solar radiation in MegaJoule Per Square meter per day, TR(mm)=total rain fall in millimeter, ER=effective rain fall in millimeter, ETo (mm/day)=reference evapotranspiration in millimeter per day

As shown in Figure 1, the maximum value of ET_O was found to be 6.60 mm/day in March and the minimum ET_O was 3.17mm/day in August.The average ET_O value simulated using CropWat in *Pawe* district was found to be 4.50 mm/day.

Table-2: Characteristics of pepper used as input for CropWat

Crop characteristics	Growing stages				Total
	Initial	Development	Mid	Late	
Kc	0.6		1.05	0.98	
Stages	30	40	45	35	150
Rooting depth	0.25		0.8		
Critical depletion (fraction)	0.2	0.3		0.5	
Yield response factor	1.4	0.6	1.2	0.6	1.11
Crop height		0.7 (optional)			

As shown in Table 2, since there was no determined crop coefficient, growing stages, rooting depth, critical depletion, and yield response factor, for this area, the FAO recommended values for the pepper characteristics used to simulate crop water requirement and to make irrigation scheduling. The transplanting date for both years was the local transplanting date what was considered December first.

Table 3: Drip Irrigation use costs per production period at pawe district.

Years	Drip Irrigation Costs/100 m^2 (Ethiopian birr)				Drip Irrigation Costs/ ha (Ethiopian birr)			
	Material cost	Fertilizer cost	Wage cost	Total cost	Material cost	Fertilizer cost	wage cost	Total cost
2012	600	25	700	1325	60000	2500	70000	132500
2013	650	27	800	1477	65000	2700	80000	147700
Mean	495	14.05	650	1159.05	49500	1405	65000	115905

Material cost includes cost of full drip irrigation equipment and fertilizer cost includes UREA and DAP Wage cost includes labor cost to carry out all works throughout production period and Total cost is the cost of the material cost, fertilizer cost and labor costs.

Table 4: Marketable Pepper Yield and Water use Efficiency at pawe district

Year	Marketable yield (kg)		Water requirements(mm)		WUE (Kg/m^3)	
Year	(Kg/100 m^2)	(Kg/ha)	ETc(mm)	NIR(mm)	CWUE	IWUE
2012	30,8kg	30, 800kg	762.4	725.6	4.04	4.2
2013	185.11 kg	18,511 kg	762.4	725.6	2.4	2.6
Mean	246.6kg	9255.5kg	762.4	725.6	3.22	3.4

ETc total is Crop water requirement, NIR is ETc used by irrigation, CWUE is Crop water use efficiency and IWUE is Irrigation water use efficiency.

Table 5: Analyzed Cost benefit of pepper production with drip irrigation technology pawe district.

Years	Marginal Revenue (Yield*10birr) in Ethiopian birr		Profit (Marginal Revenue-Total Cost) in Ethiopian birr	
	Revenue/100m^2	Revenue/ha	Benefit/100m^2	Benefit/ha
2012	3080	308000	1755	175,500
2013	1851.1	185110	374.1	37,410
Mean	2465.55	246555	1064.55	106,455

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. The farmer benefited 1755 birr covering the total cost in 2012 cropping season. And the was the benefit of 374.1 birr in 2013 cropping season. The yield gap between the two years was large due to fertility difference between the two locations. Fertility status in pawe agricultural research was very fertile.

The average yields of green pepper in Ethiopian in 2006 and 2007 were about 64.20 and 54.50 q/ha, respectively [4]. World average green pepper productivity is 14.05 tons per hectares [6].

Onion yield and water use efficiency are increased in Amhara's lowland region when it is drip-irrigated with mulch [17]. Both irrigation level and mulching rate had a significant impact on the total marketable onion.

Experiences from Arba Minch demonstrate that a single, inexpensive drip irrigation system may provide a household with fresh vegetables for domestic consumption for an initial expenditure of 60 to 70$ [17].

Ethiopia's Mid-Rift Valley, Adami Tulu Jido Kombolcha District, evaluation of Low Cost Drip Irrigation Technology through Tomato Production revealed that low cost drip irrigation system has demonstrated superior performance on tomato production and other yield-related parameters as compared to conventional furrow irrigation system. Drip irrigation had substantially greater water use efficiency since it utilized far less water than surface irrigation systems did [1].

Farmers far from river may accessible to hand dug wells, but its amount may low as compared to river water. Therefore, this low quantity of water requires effective utilization [10].

The average yields of green pepper in Ethiopian in research condition was and 15 - 20 t/ha (lema et al., 2008).[10].

Figure 2: Installation of family drip irrigation for verification on pawe agricultural research center station.

Figure 3: Performance of pepper during monitoring and evaluation

Figure 4: Performance of pepper during mid-stage

Figure 5: Participants during field day

Participants during the training observed and viewed the implemented family drip technologies, increase their awareness and finally promised to use the technology when the accessed it.

According to [10]. Thus, from the economic point of view drip irrigation which have greater marginal rate of return than furrow irrigation and, hence more profitable than furrow irrigations. Thus, the treatment which was non-dominated and having a marginal rate of return of greater or equal to 50% with the highest net benefit was taken to be economically profitable [2].

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 [20].

Conclusion and Recommendation

The result shows that drip irrigation system is economical for smallholder farmers. Cost of accessing and operating of water should be managed. Demonstration had been appreciated by selected farmers and they show their interest to use this technology though they have question on family drip irrigation marketing accessibility and operational skills. Understanding of drip irrigation technology usage and administration, as well as monitoring and implementation techniques should be increase through Extension services. Economic feasibility analyzes of the drip irrigation system should be prioritized widely. Drip irrigation is simple to design and install, and it lessens disease issues brought on by excessive wetness on some plants. It is the method of irrigation that is most effective. In drip irrigation each plant receives the precise amount of water and nutrients it requires at the precise time for optimum growth by being delivered straight to the root zone of the plants. The farmer who can use family drip irrigation benefited with the average of 106,455Ethiopiopan birr.

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