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Economic Evaluation of Gravity Fed Drip Irrigation System For Vegetable Crop.

Nitin M Changade[1*] RK Sahu[2] Raj Kumar[1]

[1]*School of Agriculture, Lovely Professional University Punjab*
[2]*Faculty of Agriculture Engineering, IGKV Raipur (CG)*
**Correspondence author: nitin.18316@lup.co.in Contact : 9518987718*

Abstract

The micro drip irrigation system was fabricated using local and market available materials. Attempt was made to grow vegetable three crops (bottle gourd, bitter gourd and cucumber) under three irrigation methods (drip, pitcher and basin irrigation) which was replicated eight times at village Upperwara (Raipur district (C.G)) in order to boost the economy of the farmers. The FAO-CROPWAT model was used to estimate the ET of vegetable crop for irrigation scheduling with the help of meteorological data and soil characteristics. The economic evaluation per hector was done to determine the cost benefits ratio. On an average the use of gravity fed MDIS results higher yield (25.7%) with the reduction of labor cost (48.8), fertilizer cost (8.8 %) as compared to basin irrigation. The gravity fed drip irrigation gives higher B/C ratio (3.68)higher than pitcher (3.62) and basin irrigation.

Key wards : Gravity, drip irrigation, basin irrigation, yield , cost analysis,

Introduction

The waste land suffering from various problems such as water and wind erosion, water logging, salinity, alkalinity, water scarcity, and gully formation are now necessary to put under cultivation due to increased population pressure. In the state of Chhattisgarh, also the situation is not quite different. The waste land locally known as bhata land is a coarse-textured, red sandy gravelly soil, found on upland tops is deficient in minerals and other productivity enhancing nutrients(Tigga et al.). These soils are deficient in organic matter content and also poor water holding capacity. Chemical and physical characterizes of these waste land from protected and non protected sites of Raipur showed that the upper layer of soil is generallyloamy sand, while gravelly sand loam occurred below it (Verma and Sharma, 1989).Soil organic carbon, cation exchange capacity and plant diversity were higher in soils under tree canopies than in open areas(Mugunga& Mugumo, 2013).To facilitate the organic matter content in this soil, survival and growth of tree species is required. Micro drip irrigation system is one of the best options for use of limited water and fertilizer under degraded bhata land. Low cost micro irrigation system such as drip and pitcher irrigation technique for growing vegetable can save water upto 45% (Sahu 1984., Stein 1997). Sivanappan (1987) attempt successfully to fabricate the small drip irrigation set by locally available PVC pipes, tank and gate valve etc to irrigate banana and vegetable crops. In Chhattisgarh also drip irrigation set was designed and developed and used for growing vegetables in farmer's field (Rao & Sahu 2000, Patel & Sahu 2004). Looking the success of this technique, the study was proposed to economic evaluation of gravity fed drip irrigation along with basin irrigation methods for growing vegetables under tree plantation being developed in the bhata land.

Materials and Methods.

The study area was situated at village Upperwara in Abhonpur block of Raipur district (C.G) at 210^{o}15' N latitude and 81^{o}36' longitude with an altitude of 300.6 MSL. The average annual rainfall in the study area was about 1422 mm with 64 annual number of rainy days, dry moist and sub humid climate. The soils belongs to Lakholi series, reddish to dark brown in color, water holding capacity is very low (2.12cm), infiltration rate was remarkable high and field capacity ranged 12-20%.

The research was carried out with three irrigation method (drip irrigation, pitcher irrigation and basin irrigation) and three vegetables crop (bottle gourd, bitter gourd and cucumber) replicated 8 times with factorial RBD. The pitcher is the earthen pot of 1 liter capacity irrigate four crops simultaneously with siphon method. Siphon tube of 2 mm saline tube with regulator provided and operated at required discharge whereas gravity fed drip irrigation was designed as per the scientific formulae.

Gravity fed drip irrigation system.

The manifold and its lateral were designed and operated at a single manifold system, the micro drip irrigation system which was controlled by a single valve. The material used for design of the gravity fed drip irrigation was locally available

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material i.e water tank, lateral, emitter, filter etc. The friction head of drip irrigation laterals, the Darcy-Weishbach equation for smooth pipes combine with the Blasius equation water determined as follows.

$$H_f = \frac{KLQ^{1.75}}{D} \qquad (1)$$

Where, H_f = Frictional head (m), Q = Rate of discharge (lps), L = Length of pipe (m), D = Internal diameter of pipe (mm), K =constant (7.89 x 10^5)

In field layouts the actual emitter discharge varied considerably and depends on design characteristics of emitter, variability in manufacturing andageing of emitters, frictional head losses throughout the distribution network, elevation differences throughout the field, the numbers of clogged emittersin the system, the numbers of partially clogged emitters in the system(Solomon & Keller 1978).

Wu et al.(1979) adopted the Christiansen equation for estimating uniformity of water application in drip irrigation system,

$$Uniformity\ coefficient = \left[1 - \left(\frac{\sum X}{mn}\right)\right] x\ 100 \qquad (2)$$

Where X = Absolute numerical deviation of individual observation from the averagedischarge rate (lph), m = Average value of all observed values of discharge rate (lph), n = Total number of observation.

Keller and Karmeli (1975) defined the Emission uniformity (EU) as:

$$EU = \frac{Average\ \ of\ lowest\ \frac{1}{4}th\ flow\ \ (qn)}{Average\ \ of\ all\ emmiter\ \ flow\ \ (qn)}\ x\ 100 \qquad (3)$$

Daily water requirement of vegetable is determined by using FAO CROPWAT model, daily meteorological data were collected from Agro meteorological department. Required data was fed in model and reference evapotranspiration data was determined which was used for determination of volume of water (liter per day)

$$V = ET\ x\ \frac{A_t}{T_p} \qquad (4)$$

Where ET = Reference evapotranspiration, mm/day,A_t = Wetted area, $m^2$$T_p$ = total number of plants

Results and Discussion

Hydraulic performance of drip irrigation:

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Hydraulic characteristics revealed the efficiency and performance of gravity fed drip irrigation of system. Based on the design parameter formulated (from equation 1 to 4) by the various researcher were calculated to check the performance of system and depicted in table 1. As per the flow measurement characteristics, three flow regimes were identified in which the main and sub main pipes was found to be partially turbulent whereas the flow in laterals and emitters was found to be unstable and laminar flow respectively. As worked out and reported earlier the frictional head losses were 0.022, 0.039, 1.848, 6.995 and 67.73 cm in the main, sub main, laterals, fittings and emitters respectively. Coefficient of uniformity (CU) of the system was determined as suggested by Christiansenvaried from 98.67 to 99.69 per cent in laterals with an overall CU of the system as 99.2 per cent. Similarly the Emission Uniformity(EU) was also found to varyfrom97.93to99.22percentwithoverallsystem'sEUwasworkedouttobe 98.93 per cent. The hydraulic performance of the system is depend upon the uncertain pressure obtained in system due to various losses so system must be operated at appropriate pressure at the upstream end point of the system so that the average discharged flow and the uniformity can be matched (Chamba et al 2019). Similar results were obtained by Singh et al. (1989) with the maximum EU value of 88.5 per cent under different operating pressures varied from 0.5 to 1.5 kg cm^{-2}. The results indicated the better uniformity of emitter discharge through the system.

Table 1:Hydraulic characteristic of unit Gravity fed Drip irrigation system

Sr. No.	Characteristics	Main	Sub main	Lateral	Emitters
1.	Discharge, $m^3 h^{-1}$, $L h^{-1}$	0.700	0.696	0.09945	0.001165
2.	Nominal Diameter, mm	63	63	12	2
3.	Wall thickness of pipe, t, mm	2.8	2.8	1.0	1
4.	Inside Diameter, D, mm	57.4	57.4	10	1

5.	Reynolds number, Re	5506.8	5398.3	3462.5	324.6
6.	Type of flow	Partially turbulent	Partially turbulent	Unstable flow	Laminar
7.	Frictional head losses, cm	0.022	0.0380	1.848	67.73
8.	Coefficient of Uniformity (CU)			95.6 to 97.4 %	
9.	Overall system's CU			96.7%	
10.	Emission uniformity (EU)			89.9 to 93.5 %	
11.	Overall System's EU			90.1%	

Crop yields:

On an average the marketable vegetable yields under drip irrigation (194.4 q ha^{-1}) and pitcher irrigation (186.3 q ha^{-1}) were significantly higher by 25.73 and 21.24 per cent respectively as compared to those under basin method of irrigation (156.1 q ha^{-1}) as per shown in table 4. The result revealed that bottle gourd resulted in significantly higher yield by 26.9 and 20.4 per cent under drip and pitcher irrigation respectively over that under basin irrigation (229.2 q ha^{-1}). Drip irrigation increased yields of gourds by 20-25 per cent compared to furrow irrigation (Singh et al 1989). Higher yields of cucumber (32.5 per cent with saving of 52 per cent water) was recorded by Padmakumari and Sivanappan (1985) in Tamil Nadu. Sivanappan & Natarajan (1974) reported that the yield of bottle gourd at Jodhpur was found to be 46.8 per cent higher in drip irrigation (55.8 t ha^{-1}) as compared to furrow irrigation (38 t ha^{-1}). Devaranavadgi (2011) reported that drip irrigated bitter gourd shows maximum number of fruits per plant, average fruit weight, fruit length, fruit girth and 65.40 percent more yield per hectare compare to furrow irrigation. Rakesh & Deshmukh (2018) also concluded that drip irrigated bitter gourd yield increases about 50 percent with water saving 55 percent compared to furrow irrigation.

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Economic evaluation of drip and pitcher irrigation.

The component wise cost of drip irrigation and pitcher irrigation system for one hectare area as per the rate of year 2006 is shown in Table 2 and 3. The average labour cost per hectare was arrived at Rs. 7420 and Rs. 8830 per hectare for vegetables under drip and pitcher irrigation respectively whereas in basin irrigation method, it was Rs 13690 per ha. (Table 3). Field data revealed that 45.8 and 35.5 per cent saving in labour cost was observed for preparatory tillage under drip irrigation and pitcher irrigation respectively over conventional basin irrigation. Fertilizer cost is less in drip and pitcher irrigation. Drip and pitcher irrigation saved the 68.8and 71.9 per cent fertilizer cost respectively over the basin irrigation. The difference in total operating cost of drip and pitcher irrigation was not very much (Rs 29,059/- and Rs 28,428/- per ha respectively). On the other hand the total operating cost (Rs 31,490/- per ha) was found higher in basin irrigation as compared to drip and pitcher irrigation.

From the gross income received from different crops in three methods of irrigation, the B/C ratios were worked out (Table 4).The relative variation of B/C ratio of vegetables in different irrigation methods is shown in Figure 1. It revealed that B/C ratio of vegetables was highest in drip irrigation, followed by pitcher irrigation over the basin irrigation. Cucumber was found to result highest B/C ratio (4.08 in drip, 4.03 in pitcher, 3.04 in basin) among the three crops. The highest B/C ratio was found in vegetables irrigated by drip irrigation method (3.68), closely followed by pitcher (3.62). Traditional basin irrigation resulted in lowest B/C ratio (2.75).

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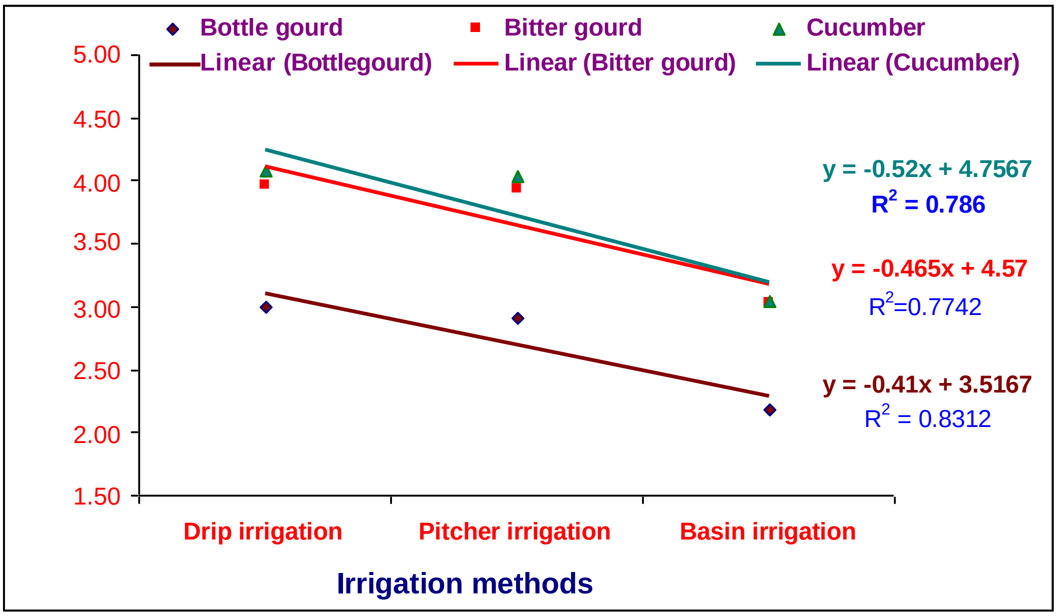

Figure 1. Benefits cost ratio of vegetable under different irrigation method

It seems that the capital cost of drip and pitcher irrigation would be recouped in the first season. After one season onwardsthesavingindripwouldmeantheadditionalincometothecultivator.Jha (2017) conducted economic evaluation of crop yield of all crops and BC ratio was statistically analyzed using analysis of variance (ANOVA) at 5% level of significance in which result revealed that the average benefit cost ratio of drip irrigated crops was about 33% higher over furrow method of water application.Similar results were obtained by Kadam & Magar (1992) for growing tomato with drip and furrow irrigation. They found that two seasons (one year) were required to cover the additional cost of drip irrigation set from the savings in labor cost alone.

Table 2. Component used and cost in unit gravity fed micro drip irrigation system

Sr. No	Component specification	Cost in Rs
1	Water tank, 750 lit	1200
2	Main/ sub-main-63 mm, 29.5 m, @ Rs.20/- per m	590
3	Lateral-12 mm, 182 m @ Rs.5/- per m	910

4	End plug,: 2 Nos. in sub-main, @ Rs.10/- 7 Nos. in lateral @ Rs.3/-	41
5	Filter- 1 No. @ Rs.40/-	40
6	Tee – 1 No. @ Rs.25/-	25
7	Reducer tee-1 No. @ Rs.25/-	25
8	Micro tubes- 252 m, @ Rs.3/- per m	756
9	Control valve – 1 No. @ Rs. 40/-	40
10	Total unit MDIS cost	3627
	Number of units required per hectare	14
	Per hector cost of MDIS	50,778

Table 3: Details of the Component used and cost in pitcher irrigation.

Sr. No	Particular	Item no	Cost per item	Total cost
1	Pitcher (Earthen Pot) with lid 20 lit capacity.	42	10	420
2	Siphon tube, 2mm	168	Rs 3 / m	504
3	Bamboo strip (0.5 m height, 2 cm thick.)	84	Rs 0.50	42
4	Other material such as nozzle, clips, straw etc.	42 sets	Rs 1.	42
5	Installation cost	42	Rs 1	42
6	Total capital cost			1050
7	Total unit per ha			14
8	**Total cost per ha**			**14700**
9.	Salvage value after 7 years			1470
10	Depreciation per year			1890
11	Interest on investment @ 10 %			808.5
12	**Yearly fixed cost**			**2698.5**

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13	Operating cost of pitcher	80 man days	50	4000
14	**Total cost of pitcher Irrigation per ha.**			**6698.5**

Table4. Economics of vegetable production under threeirrigation methods (Rs. per ha)

	Names of the items	**Drip**	**Pitcher**	**Basin**
A)	**Fixed cost**			
1	Rental value of land	1000	1000	1000
2	Seasonal fixed cost	8380	6698	00.00
3	Total fixed cost	9380	7398	1000
B)	**Variable cost**			
1	Labour cost	7420	8830	13690
2	Fertilizer cost	1000	900	3200
3	Seeds	8000	8000	8000
4	Plant protection	1000	1000	1000
5	Water cost	2259	2300	4600
6	Total variable cost	19679	21030	30490
C)	**Total cost (A+B)**	**29059**	**28428**	**31490**
D)	Bottle gourd			
	Yield, q ha^{-1}	290.9	276.0	229.2
	Income @ Rs 300 /- per q	87270	82800	68760
	B/C ratio	3.00	2.91	2.18
E)	Bitter gourd			
	Yield, q ha^{-1}	144	139.63	119.25
	Income @ Rs 800/- per q	1,15,200	111704	95600
	B/C ratio	3.96	3.93	3.03
F)	Cucumber			
	Yield, q ha^{-1}	148.1	143.2	119.75

	Income @ Rs.800/-per q	118480	114560	95800
	B/C ratio	4.08	4.03	3.04
G)	Average – Vegetables			
	Yield, q ha^{-1}	194.3	186.3	156.1
	Income @ Rs 633/- per q	106983	103021	86653
	B/C ratio	3.68	3.62	2.75

Conclusion and future study

In order to promote vegetables, gravity fed drip irrigation can best be used advantageously over basin irrigation due to higher benefit cost ratio and yield. As per the income and investment of drip irrigation system it seems that the initial cost of investment can be recouped in one season. There is future scope in this research to study the various fertigation levels along with the saline water under gravity fed drip irrigation.

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