J. Sci. Technol. Environ. Inform. 04(01): 251-259 | Riza et al. (2016)
EISSN: 2409-7632, www.journalbinet.com
DOI: 10.18801/jstei.040116.28

JSTEI ONLINE JOURNAL Journal of Science, Technology & Environment Informatics

Journal BiNET Scientific Publication

Volume 04, Issue 01, pp. 251-259 Available online: 14 October 2016
http://www.journalbinet.com/jstei-volume-04.html
Original Research Paper

Evaluation and improvement of a low-head drip irrigation system to be used by small scale farmers in Bangladesh

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Article info.

Key Words:
Low-head, Drip Irrigation, Farmer's and ARFA

Received: 16.04.2016
Published: 14.10.2016

For Any Information:
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ABSTRACT

A study was undertaken to evaluate the low-head drip irrigation system introduced by ARFA Engineering in Bangladesh. The experiment was conducted at the Hydraulic Laboratory in the Department of Irrigation and Water Management, Bangladesh Agriculture University, Mymensingh. A timber framework (10.2 m long) experimental layout was assembled to support the drip lines at various land slopes (0 to 3.03%). Drip lines were positioned along the timber framework. A mini tank was used as water source and was placed at varying heads (0.5-1.0 m) from which water was allowed to flow through the rubber pipes at different emitters along the lateral lines. To collect the emitter water, catch cans were placed along the drip line directly below the emitters. Data were collected at varying water head, land slope, lateral length. Varying water head, land slope and lateral length affected the result. The experiment showed that for different heads and slopes, EU values are < 70% and FV values >20% and a CV value > 0.15 indicating that the performances of this (ARFA) drip irrigation system is very poor and not acceptable to irrigate crops in the field.

Citation: Riza, A. N., Akhter, T., Akhter, F. & Khair, M. A. (2016). Evaluation and improvement of a low-head drip irrigation system to be used by small scale farmers in Bangladesh. *Journal of Science, Technology and Environment Informatics*, 04(01), 251-259.

I. Introduction

Water is one of the most important inputs for crop production. Best seeds, fertilizer and plant protection measures will not be appropriately fruitful if water is not available in sufficient quantity and at right time for the crops. In Bangladesh, crop irrigation is performed mainly by strip, furrow and flooding methods. All these methods suffer disadvantages that they release water at a great discharge causing substantial amount of water losses as seepage and evaporation. Sprinkler method is also not suitable because high temperature and wind velocity cause high evaporation losses. Experiments at different places showed that uniform application of water at or near field capacity of the soil should be applied all over the field for a higher yield. This condition can be achieved by drip method of irrigation. Drip irrigation method is the only method which appears to be promising for dry land horticultural crops in Bangladesh. A low head drip technology through IWMI research has been evaluated through Unreliable rainfall causes periodic droughts in Kenya (Ngigi *et al.* 2000). Low-head drip technology was introduced to combat this problem and alleviate food security of thousands of people. IWMI research evaluated the low-head drip systems. Two common problems experienced by farmers by using low head drip systems are uneven water distribution, especially on slopping land which can drastically affect yields due to under-irrigation of some plants and over-irrigation of others and tendency of emitters to clog (Ngigi *et al.* 2005). Regarding water saving, water use efficiency, water distribution efficiency, and commercial cane sugar production, inline drip irrigation system showed good results in comparison to pressure compensation drip system.

In drip method, irrigation water can be applied very efficiently to small trees and row crops such as tomatoes, corn, potatoes, melon, radish, cauliflower, beet root, sugarcane, tobacco, banana etc. In comparison to surface irrigation method and sprinkler method, drip irrigation can achieve 90 percent or more application efficiency which can hardly be achieved by the other methods (Islam, 2006). The drip irrigation equipment is considered to be main limitation for large scale adoption. In this circumstance affordable small-scale low-head drip technology is developed in a few countries of the world (Michael, 1978). A study was conducted to design agricultural irrigation system in Florida. They stated that data must be obtained from the emitter manufacturer or by testing a representative sample of emitters. Manufacturing variation, CV, between individual micro irrigation emitter must also be considered in design. The type of emitter used in a pressurized irrigation system affects the system design. Emitter hydraulic properties affect the allowable pressure losses in subunits and manufacture's variation and friction losses associated with emitter connections must be considered when micro irrigation systems are designed (Smajstrla *et al.* 1994). In crops favoring drip system water can be applied at a single point through device, called emitter or as line source from either closely spaced openings that discharge water a drop at a time. But due to higher installation cost and being import dependent farmers often feel very discouraged. Moreover, imported drip systems are delicate to handle and require special maintenance (Hansen *et al.* 1962). Drip irrigation is one of the latest method of irrigation which becoming increasingly popular in areas with water scarcity and salt problems. In Drip Irrigation System, Insect, disease and fungus problems are reduced by minimizing the wetting of the soil surface. During watering close to the plant base, deep percolation, runoff and soil water evaporation can be minimized using small diameter plastic line laterally connected with dripper. The system gives higher yield of crops and is about more by about 15 to 30 percent than other irrigation method. A low cost drip irrigation system has been introduced recently by BARI, which is manufactured and supplied by ARFA engineering in some places of Bangladesh without any technical and economic evaluation. According to an unpublished project report at the department of Irrigation and Water Management, BAU, the system has low emission uniformity and flow variation along the drip distribution lines. Low emission uniformity leads to either over irrigation or under irrigation along different section of a drip line and results in low irrigation efficiency. Most of the system operate with high heads (>10m) water pressure requiring a pump to force water into the distribution lines. Under the circumstances as discussed above, it is worthwhile to undertake a research work to evaluate the existing drip irrigation system (developed by ARFA Engg.) and to improve its performance. The objective of the study was to evaluate the technical performances of the existing BARI drip irrigation system. Specific objectives were to construct an experimental framework in laboratory for evaluating

EISSN: 2409-7632, www.journalbinet.com
DOI: 10.18801/jstei.040116.28

the performance of the ARFA drip irrigation system; to determine the effect of water supply head, land slope and lateral length on emitter discharge along the drip line; and to identify the technical defects of existing ARFA drip systems.

II. Materials and Methods

The experiment was carried out at the Hydraulic laboratory in the Department of Irrigation and Water Management at Bangladesh Agricultural University Mymensingh, Bangladesh during the month of November, 2011. For this purpose, a timber framework (10.2m long) experimental layout was assembled to support the drip lines at various land slopes (0 to 3.03%) as shown in Figure 01. The drip lines were positioned along the timber framework. A mini tank showing in the Figure 01 was used as water source and was placed at varying heads (0.5-1.0 m) from which water was allowed to flow through the rubber pipes at different emitters along the lateral lines. The tank was placed on a wooden stand, the height of which was changed to achieve varying supply head. To collect the emitter water catch cans was placed along the drip line directly below the emitters. The combined effects of water supply head, lateral slope and lateral length on water distribution along the drip line were evaluated.

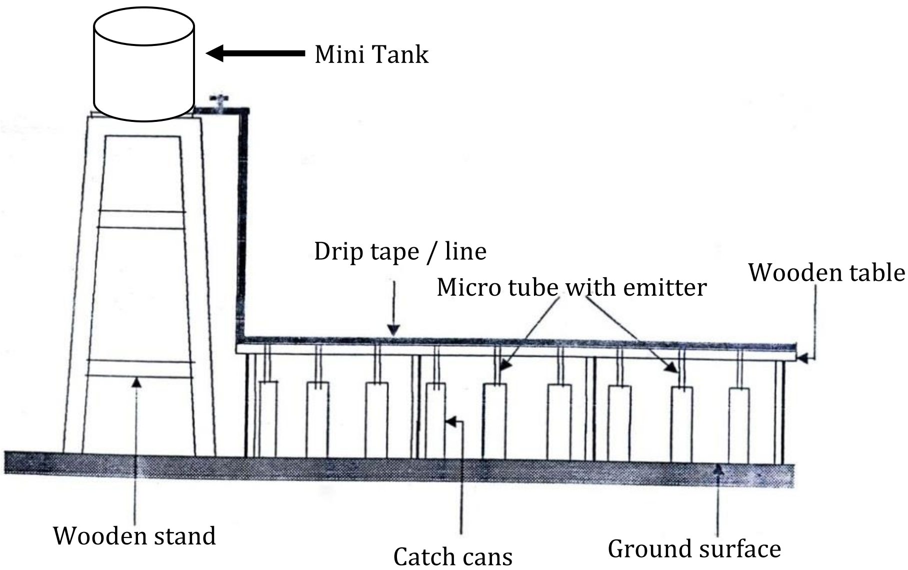

Figure 01. Side view of experimental layout used for evaluating the performance of the drip system.

Coefficient of variation (CV): The manufacture's coefficient of variation is determined from flow rate measurements for several identical emission devices and is computed with the following equation:

$$CV= \frac{(q_1^2 + q_2^2 + \cdots\cdots\cdots + q_n^2 - n\bar{q}^2)^{\frac{1}{2}}}{\bar{q}(n-1)^{\frac{1}{2}}}$$

Where,

CV= manufacture's coefficient of variation

$q_{1,} q_2, q_3, \ldots\ldots\ldots q_n$ = discharges of emission devices (l/h)

$\bar{q}$ =average discharge of emission devices tested (l/h)

n =number of emission devices tested

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Emission uniformity (EU): A general criterion which depends on water temperature and manufacture's coefficient of variation is called Emission uniformity (EU). The emission uniformity will be

$$EU = \frac{Q_{\min}}{Q_{mean}}(1-1\cdot 27CV)*100$$

Where,

EU = the design emission uniformity in percent
Cv = manufacture's coefficient of variation of used emitter's
Q_{mean} =average emitter discharge rate (l/h)
Q_{min} =the lowest emitter discharge rate in system (l/h)

Flow variation (FV): Flow variation is also a design parameter to evaluate a trickle lateral design. The defining equation for flow variation is

$$FV = \frac{(Q_{\max} - Q_{\min})}{Q_{\max}} \quad \text{or} \quad FV = 1-(\frac{Q_{\min}}{Q_{\max}})$$

Where,

FV = Flow variation
Q_{max} =maximum emitter discharge rate in system (l/h)
Q_{min} =the lowest emitter discharge rate in system (l/h)
P =operating pressure

K, X =constants for specified emitter were determined in the laboratory. General performance of evaluation criteria for EU values greater than 90% (James, 1988) and FV values less than10% is considered as excellent and acceptable. Appropriate water supply head, land slope, lateral length, emitter opening sizes along the lateral was determined on the basis of the evaluation criteria.

III. Results and Discussion

The effect of water head, lateral slope and drip line length on water distribution among the emitter discharge and along the laterals. The variation of water distribution has been shown by emission uniformity (EU) and flow variation (FV) along drip laterals. The emitter discharges distribution pattern under different supply head and different land slope has been given in Table 01 and 02.

Table 01. Emitter discharge for different supply heads and lateral length

Emitter Position	Lateral length (m)	Emitter discharge (lit/hr)		
		At 0.5m head	At 0.75m head	At 1m head
1	0.75	17.23	18.35	19.47
2	1.20	7.78	8.44	9.10
3	1.65	14.90	15.52	16.14
4	2.10	12.89	14.00	15.10
5	2.55	12.85	12.93	13.01
6	3.00	12.89	12.46	12.04
7	3.45	16.22	17.69	19.16
8	3.90	14.36	16.41	18.46
9	4.35	11.73	12.48	12.77
10	4.80	7.24	7.61	8.44
11	5.25	7.90	10.08	12.27
12	5.70	4.88	5.24	5.61
13	6.15	8.09	8.69	9.33
14	6.60	5.50	5.96	6.43

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15	7.05	7.70	7.97	8.25
16	7.50	7.24	7.53	7.82
17	7.95	7.05	7.72	8.40
18	8.40	5.92	6.23	6.54
19	8.85	5.84	6.19	6.58
20	9.30	6.23	6.66	7.08
21	9.75	5.46	5.17	5.23
22	10.20	6.39	7.55	8.71
	avg=	*9.38*	*10.04*	*10.72*

Table 02. Emitter discharges for different supply heads with varying land slope

Emitter Position	Lateral length (m)	Emitter discharge (lit/hr)		
		0.5m head with 3.03% slope	0.75m head with 3.03% slope	1m head with 1.51% slope
1	0.75	16.03	17.15	17.07
2	1.20	7.43	8.09	8.43
3	1.65	12.62	13.24	11.76
4	2.10	12.74	13.80	14.63
5	2.55	8.79	8.90	7.70
6	3.00	10.95	10.53	8.62
7	3.45	12.89	14.36	14.79
8	3.90	12.19	14.24	14.28
9	4.35	11.07	11.57	11.42
10	4.80	6.62	7.22	7.20
11	5.25	8.09	10.28	12.19
12	5.70	6.04	6.72	6.81
13	6.15	9.33	10.18	9.70
14	6.60	6.58	7.24	7.34
15	7.05	7.70	7.99	8.27
16	7.50	7.82	8.30	8.17
17	7.95	7.94	8.65	8.59
18	8.40	3.75	4.04	5.50
19	8.85	7.01	7.37	6.85
20	9.30	6.43	6.81	7.11
21	9.75	4.92	5.40	5.61
22	10.20	6.62	7.37	7.81
	avg=	*8.80*	*9.52*	*9.54*

Values of emission uniformity (EU), coefficient of variation (CV) and flow variation (FV) were computed using the data from Tables 01 and 02 and has been presented in Table 03.

Table 03. EU (%) and FV (%) for different supply water heads with different land slopes

Water supply head	Land slope (%)	CV	Q_{max} (lit/hr)	Q_{min} (lit/hr)	Q_{mean} (lit/hr)	FV(%)	EU(%)
0.5m	0%	0.5	14.74	5.52	8.20	62.5	29.4
	3.03%	0.348	12.54	5.66	8.18	57	39
0.75m	0%	0.41	15.82	5.76	8.84	64	31
	3.03%	0.348	13.62	6.15	8.82	55	39
1.0m	0%	0.42	16.89	6.08	9.47	64	29.95
	1.51%	0.342	13.37	6.42	8.87	52	38.1
	3.03%	0.356	14.69	6.65	9.46	57	38.81

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General performance evaluation criteria for EU values ≥ 90% excellent, 80-90%, good; 70-80%, fair; and <70%, poor. The general criteria FV values are ≤10%, desirable; 10-20%, acceptable; and > 20% is not acceptable and the value of CV is > 0.15 is unacceptable. The table 03 shows that for different heads and slopes, EU values are < 70%and FV values >20% and CV values > 0.15 indicating that the performances of this (ARPA) drip irrigation system is very poor and not acceptable to irrigate crops in the field (ASAE ,1999).

Effect of supply head on emitter discharge along the lateral length

Figure 02 shows the effect of water supply head on emitter discharge along the lateral length. From this figure, it is seen that emitter discharge increases with increase in supply head and gradually decreases with the increase of distance of lateral length.

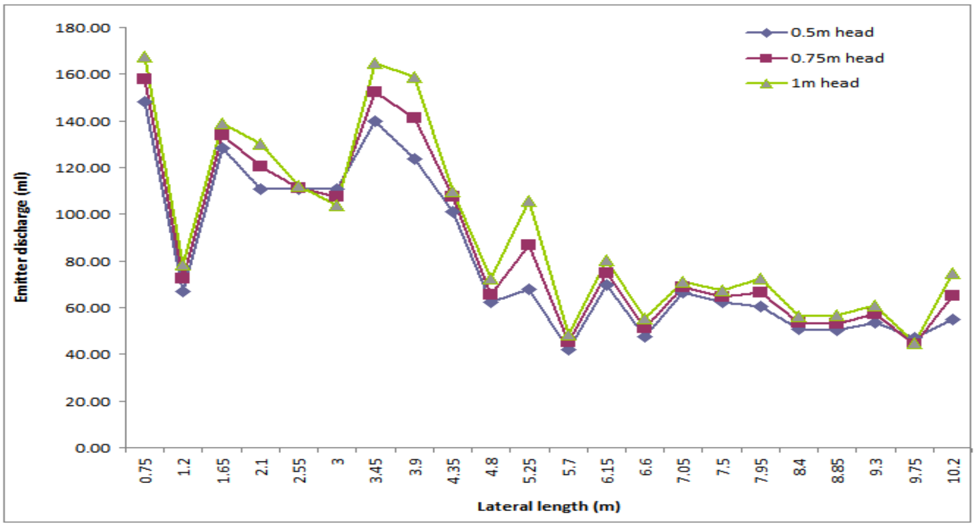

Figure 02. Emitter discharge along the lateral length under different supply head.

Effect of land slope on water discharge along the lateral length

Due to defecting construction and uncontrolled outlet of the emitter tapes, emitter discharges were not uniform and varied significantly from tap to tap. Moreover, air clogging was a common phenomenon. As a result the effect of land slope could not be ascertained properly from the figure 03 as depicted below.

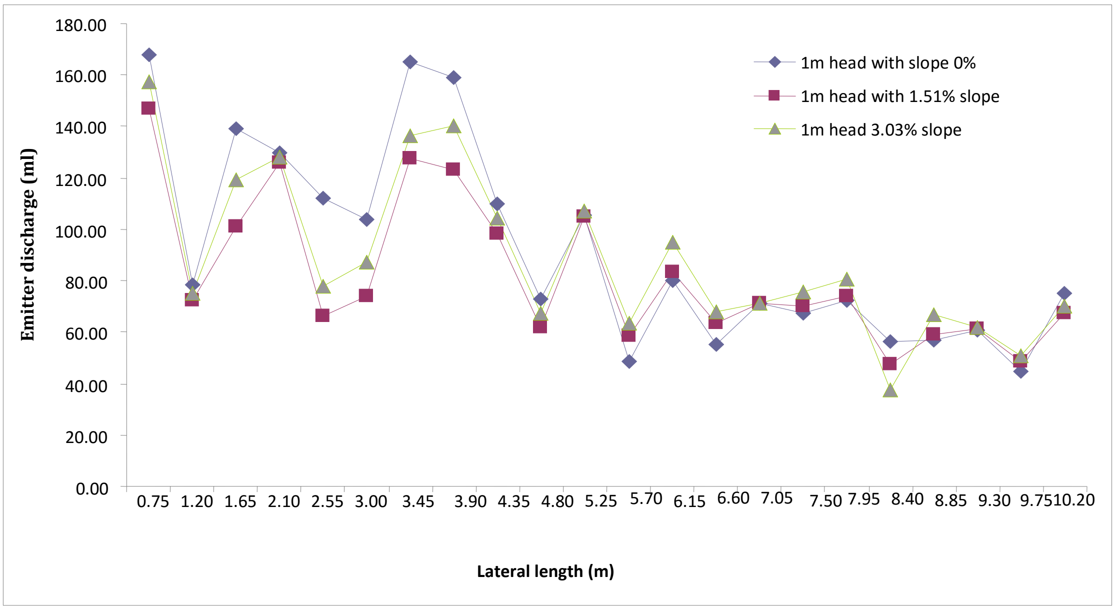

Figure 03. Effect of lateral slope on emitter discharge under the head of 1m and length 10.2.

Effect of supply head on water distribution uniformity

Figure 04 shows that EU improves with increase in supply head from 0.5 to 0.75m. After that the values of EU decrease with head. From Figure 05 it is observed that FV decreases with decreasing head. The effect of water supply head on water distribution uniformity for this drip system is not prominent.

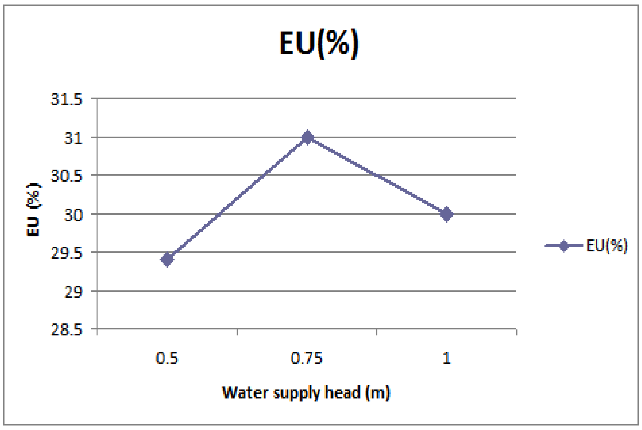

Figure 04. Variation of EU with variable supply head at 0% slope.

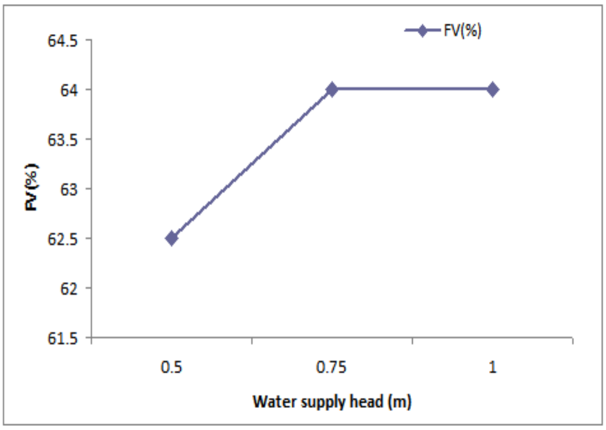

Figure 05. Variation of FV with varying heads at 0% slope.

Effect of land slope on water distribution

Figure 06 shows emission uniformity increase with increasing land slope from 0 to 1.51% and there was no significant increase or change in EU between slopes 1.51% to 3.03%. Similarly FV decreases with increasing of slope o to 1.51% and there was no significant change in flow variation from 1.51% to 3.03%.

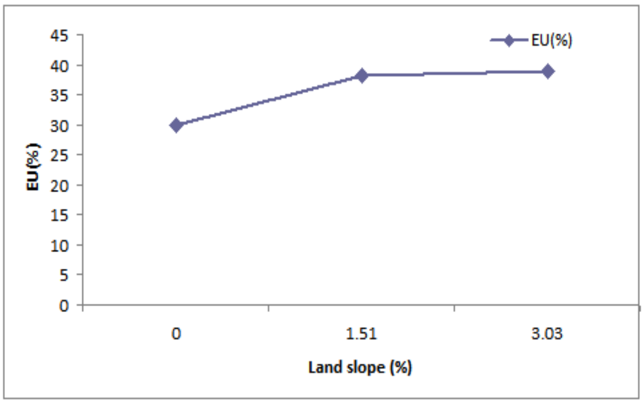

Figure 06. EU (%) for various lateral slopes at 1.0m head.

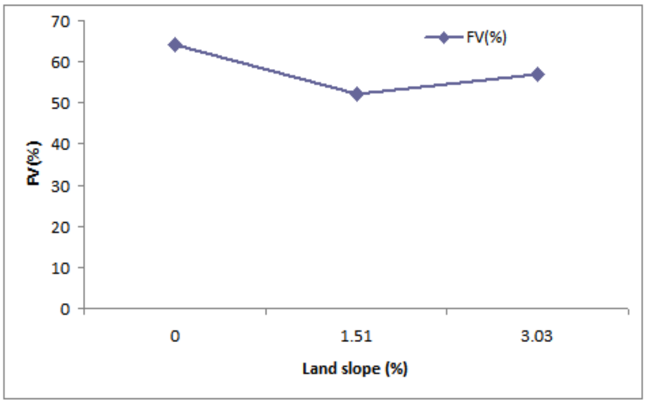

Figure 07. FV (%) for various land slopes at 1.0 m head.

EISSN: 2409-7632, www.journalbinet.com
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Figure 08. Data collection with improve mechanisms.

IV. Conclusion

Technical evaluation of the ARFA drip irrigation system has revealed the under varying supply heads and slopes, according to the general performance evaluation criteria (EU, FV and CV), the ARFA drip irrigation system is very inefficient and unacceptable. Due to uncontrolled outlet of the emitter tapes, the emission uniformity is very low causing either over irrigation or under irrigation along different section of drip lines. But the drip kit was found durable and drip laterals were strong enough to withstand rough handling and can only be used with modified emitter tapes. Based on laboratory experiments and ergonomics (the work, an average person can perform conveniently without much physical stress), a water supply source (100 litre drum/mini tank) placed at a head of about 1.0m will be suitable for row crops planted along the laterals at specified emitter spacing for 200-250 m^2 plot area. A 200 litre tank may be used for larger plot area of about 500m^2 depending on crop water requirement; the plot area could further be adjusted by changing the size of water tank and water head. A study may be undertaken to develop or fabricate emitter tape with controlled outlets so that water can be applied to crops according to their need to make the drip irrigation efficient and economic.

V. References

[1]. American society of Agricultural Engineers (ASAE). (1999). Engineering Practice Standard EP 458. Field Evaluation of Micro Irrigation Systems. American society of Agricultural Engineers (ASAE). St Joseph, Mich., USA.
[2]. Hansen, E. V., Israelsen, O. W. & Sringhom, E. G. (1962). Irrigation Principles and Practices. John Wiley and Sons, New York.
[3]. Islam, M. N. (2006). Effect of Drip Irrigation over Conventional Methods on the Growth and Yield of Tomato. MS thesis, Department of Irrigation and Water Management, Bangladesh Agricultural University, Mymensingh.
[4]. James, L. G. (1988). Principles of Farm Irrigation System Design. John Wiley & Sons, Canada.
[5]. Michael, A. M. (1978). Irrigation Theory and Practices. Vikas Publisher House Pvt. Ltd. New Delhi 110014, India.
[6]. Ngigi, S. N., Savenije, H. H. G., Thome, J. N, Rockstrom J. N. & de Vries, F. W. T. P. (2005). Agro-hydrological Evaluation of On-Farm Rainwater Storage Systems for Supplemental Irrigation in

EISSN: 2409-7632, www.journalbinet.com
DOI: 10.18801/jstei.040116.28

Laikipia district, Kenya. Agricultural Water Management. 73(1), 21-41. http://dx.doi.org/10.1016/j.agwat.2004.09.021

[7]. Ngigi, S. N., Thome J. N., Waweru D, W. & Blank, H. G. (2000). An evaluation of Low-Head drip Irrigation Technologies in Kenya, International Water Management Institute (IWMI).

[8]. Smajstrla, A. G., Clark, G. A. Haman D. Z. and Zazuela, F. S. (1994). Design of Agricultural Irrigation Systems in Florida. Florida Cooperative Extension Service, University of Florida.

How to cite this article?

APA (American Psychological Association)

Riza, A. N., Akhter, T., Akhter, F. & Khair, M. A. (2016). Evaluation and improvement of a low-head drip irrigation system to be used by small scale farmers in Bangladesh. *Journal of Science, Technology and Environment Informatics*, 04(01), 251-259.

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Riza, A. N., Akhter, T., Akhter, F. and Khair, M. A. Evaluation and improvement of a low-head drip irrigation system to be used by small scale farmers in Bangladesh. *Journal of Science, Technology and Environment Informatics*, 04 no. 01(2016): 251-259.