EVALUATION OF PARAMETERS AFFECTING EMITTER DISCHARGE OF SOME LOW-HEAD DRIP IRRIGATION TECHNOLOGIES IN KENYA

***G. M. Ndegwa* [1] *and M. Lesukat*[2]**
[1]*Biomechanical and Environmental Engineering Department, Jomo Kenyatta University of Agriculture and Technology, Nairobi, Kenya*
[2]*African Institute for Capacity Development (AICAD), Nairobi, Kenya*

ABSTRACT

The use of low-head drip irrigation technology is a new development in Kenya due to the need to save water as a resource, among other advantages. However, during its adoption, high variations in emitter discharge occur on various drip tapes when water supply head of about 1.0 m is adopted. The objective of this study was therefore to determine the effect of slope, lateral length and water supply head on emitter discharge of the most commonly used low head drip irrigation tapes under field conditions. Four tapes, sold as Chapin, Dream, T-tape and Typhoon 25 were evaluated. Slopes were varied from 0% to 4%, lateral lengths varied from 5.0 m to 20.0 m, and water supply heads varied from 0.5 m to 2.0 m. The results showed that emitter discharges for Chapin were between 0.43 and 0.51 l/hr for 0-2% slopes with standard deviation of 0.05. Higher slopes resulted in increased flow variations as indicated by an emitter discharge of 0.53 l/hr at a standard deviation of 0.12 for the 4% slope. This would lead to low water distribution uniformity at higher slopes. Dream kit was also sensitive to change in slope. However, discharges from T-Tape and Typhoon 25 were less sensitive to change in slope and were suitable even for the 4% slope for 15 m laterals at a head of 1.0 m. Typhoon 25 system could also be adopted for longer laterals without affecting emitter discharges. Emitter discharge characteristic equations were also developed in which emitter discharge varied as the square root of water supply head for T-tape (R^2 of 97%) and Typhoon 25 (R^2 of 98%) for 0% slope, indicating turbulent flow and less sensitivity to slopes. However, relationships for Chapin and Dream kit systems were nearly linear at R^2 of 96% and 97%, respectively. This indicated that emitter discharge tended towards laminar flow; the tapes were therefore quite sensitive to pressure differences within the respective systems.

Key words: Coefficient of variation, data points, emitter discharge characteristics, field conditions, low head drip irrigation technologies.

1.0 INTRODUCTION

The benefits of drip irrigation systems include high water-use efficiency, minimised deep percolation and run-off, efficient use of low quality water, efficient delivery of fertilizers (fertigation) and other chemicals (chemigation) through the system. Other benefits are increased crop quality and yields and ability to irrigate land too steep for irrigation by other methods. Drip irrigation can therefore be helpful in situations where water is scarce or expensive. However, the high capital cost of conventional high - pressure drip systems, including complicated filtration, and the experience required to operate them, has restricted their use in developing countries (Rydzewski *et al.*, 1989).

The development of low-head emitters and simple filtration to reduce clogging of emitters has reduced much of the initial capital investments necessary, making drip irrigation systems affordable to small scale farmers. Low-head (LHD) systems operate under pressures of 0.5 - 2 m water head compared to the 10 -15 m water head needed for standard drip irrigation systems (Gilead, 1985). Small reservoirs such as simple buckets, oil drums or other storage facility can be filled manually and used as water tanks. These are raised on wooden supports to create a low operating head. An alternative is to use the output from a treadle pump to fill the bucket or drum. Pressure so created conveys water through flexible plastic tubes to emitters, which discharge it as droplets to root zone of plants.

Research and experience is providing tailor-made low head drip irrigation systems to suit different field and water conditions (Sijali, 2001). However, during adoption and experimentation of this technology, technical shortcomings such as low emission uniformity caused by emitter clogging, lack of skills in installation, operation, supply and viability have emerged. Other shortcomings include vulnerability of the tapes to attack by rodents in the field and in storage (Winrock, 2000). These shortcomings have the potential to undermine adoption and up-scaling of this technology if not addressed. Since clogging of emitters is a problem to most drip systems, low cost systems use simple cloth or wire mesh filters to prevent large particles from entering laterals. Systems using simple holes and baffles also rely on the farmer to use a pin or fine wire to clear any emitter that becomes blocked.

Low-head drip technology is a new development in Kenya, especially in the dry and hot climate of arid and semi-arid lands (ASAL). It is hence necessary to evaluate the performance of these systems under field conditions so as to increase their adoption and up-scaling. As pointed out by IPTRID (2000), tests on performance of available systems should continue in the field and merits of such systems published. These can also provide guidelines on application of the various tapes being supplied to stakeholders. The main objective of this study was therefore to evaluate the technical performance of the commonly available low-head drip irrigation technologies in Kenya. The specific objective was to determine effects of slope, lateral length and water supply head on emitter discharge of four low-head drip irrigation systems used in Kenya.

2.0 MATERIALS AND METHODS

2.1 Study Area

The field experimental site was at Jomo Kenyatta University of Agriculture and Technology farm, Juja. This is situated in a semi-arid area, about 30 km North-East of Nairobi City, along the Nairobi-Thika highway in Kenya. The test field had clay soils. The field was disc ploughed, rotavated and then fenced to prevent interference of the site during the course of the trials.

2.2 Experimental Set-up

Three test blocks measuring 22 m by 10 m were demarcated within the test field with 3 m wide paths between them. Ground slopes of 0, 2 and 4% were made in the respective test blocks. Since ground on the site was generally flat, the 2 and 4% slopes were formed by cut and fill method. A wooden platform, see Figure 1, was then erected at the upper end of each of the three test blocks. Each stand was 2.5 m high and a bucket support placed at 0.25 m intervals.

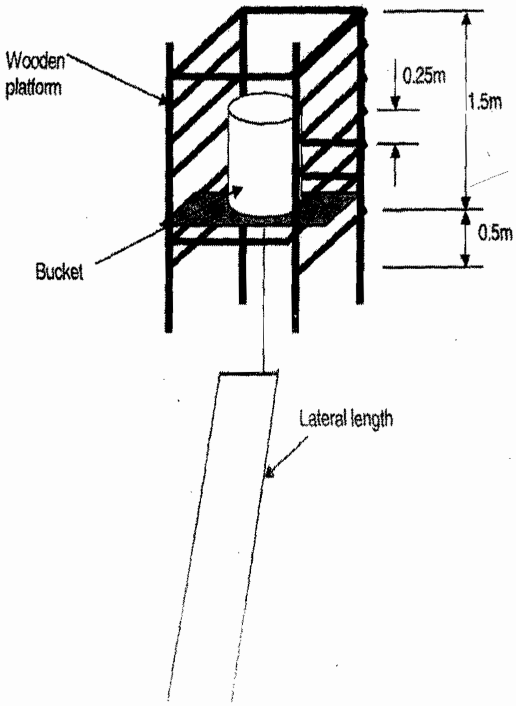


Figure 1: Experimental set - up of the drip tape trials

Four commonly available low-head drip irrigation tapes, shown in Figure 2, selling as Chapin, Dream Drip Kit, T-Tape 520 TSX and Typhoon 25, were selected for evaluation. The Chapin drip kit system consists of a 0.75 inch (19 mm) screen filter fixed at the bottom of the bucket, two rubber washers, male and female adapters, and two drip tapes. The tapes or laterals have a wall thickness of 0.25 mm, a tape diameter of 16 mm, and simple orifice emitters spaced at 30 cm. The tape is designed to have a flow ranging from 0.9 to 2.5 m^3/hr at water supply heads of 0.5 – 2 m. The bucket is mostly placed at 1 m above ground level. The driplines are supplied in lengths of 15 m, and are laid about 1 m apart on level ground (or raised bed), with emitters facing upwards to reduce the problem of sediments settling on the emitters.

The Dream drip kit is adapted from the Chapin kit in which the complicated filter-cork connection has been replaced by a simple elbow connection. This elbow is fitted with a filter that can be plugged in and out easily from a bucket (Ngigi *et al.*, 2000). The filter cork has a problem of breakage and cracking in the field.

The T-Tape 520 TSX series has a wall thickness of 0.5 mm, a tape diameter of 16 mm and an emitter spacing of 20 cm. Water in the supply tube passes into a turbulent flow regulating channel that is part of a flow emitter integrated into the drip line. The emitters have a slit opening that helps to reduce insect damage, impede root penetration, and eliminate clogging and external contaminants.

Typhoon 25 is a thin-walled drip line with a discharge rate range of 1.1 – 2.8 l/hr. It has a wall thickness of 0.63 mm, tape diameter of 15.4 mm, and an emitter spacing of 40 cm. The tape emitters have a water flow path cross-section of 0.63 by 15.4 mm; the wider cross-section allows large particles to pass through hence offering a high resistance to clogging. Pressure reduction in the emitters is accomplished by a turbulent flow path comprising of tooth pattern and a bath-like orifice.

All the four tapes are constructed from low-density polyethylene material. However, Typhoon 25 tape had the thickest wall followed by T-Tape and lastly the Chapin and Dream kit systems. This may have implications on sensitivity of the tapes to high temperatures in an arid and semi-arid environment due to material fatigue that might affect performance of emitters. Most emitters are somewhat sensitive to water temperature because of dimensional changes in the flow passages.

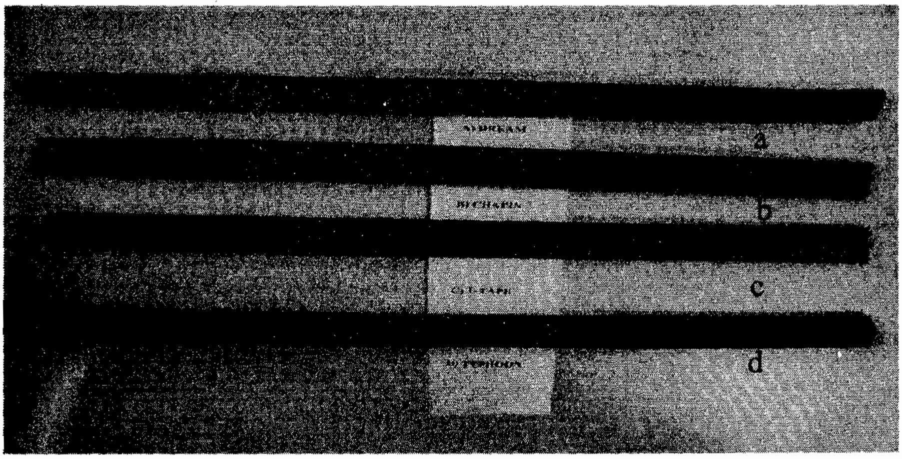


Figure 2: Evaluated drip tapes (a) Chapin, (b) Dream kit, (c) T-Tape 520 TSX, and (d) Typhoon 25

2.3 Data Collection

To evaluate a low-head drip system, two driplines of a given kit were first set up at a given water supply head and lateral length for the three slopes of 0, 2 and 4%. Water was allowed to run through the system to flush out any sediment in the driplines and then their ends were tied. Trial runs were first carried out to locate the exact positions for placement of 500 ml catch cans used to collect emitter discharges along two lateral lines in a test block. Each catch can was then placed beneath a point on the ground surface where an emitter discharged water. Any emitter in-between two emission points was sealed with a tape to enable 'point source' water applications to be obtained from closely spaced emitters, which would otherwise provide 'line source' applications.

For a given drip tape, lateral length and a test water supply head, a catch can was placed beneath an emission point to collect total emitter discharge in an irrigation session before the bucket water source was refilled. This was obtained by use of a stopwatch to record emitter-emptying time, T_e (min). Water volumes collected were then measured using a cylinder with 5 mm graduations. Three replicates of emitter discharge were then collected at a given emission point of a drip line. A mean emitter discharge, q_i, was then calculated for every two parallel emission points. Ground position of this mean emitter discharge was referred to as a 'data point'. Emitter discharges were measured at twelve data points in a test block, for a given slope and water supply head. Performance characteristics for each of the four drip tapes could hence be evaluated.

Effect of slope on emitter discharge for a 1 m water supply head and 15 m lateral length was first evaluated for the four drip tapes since these were recommended by other researchers such as Ngigi *et al.* (2000). Lateral lengths were then varied from 5 – 20 m, at a fixed water supply head, e.g., 1 m, and respective data point discharges recorded for the four drip tapes. Water supply head was then varied from 0.5 – 2.0 m so as to evaluate its effect on emitter discharge for a given lateral length of drip tape.

2.4 Data Analysis

Overall mean emitter discharge, q_a, for each drip tape, their standard deviation, Sd, and coefficient of variation of emitter discharge, Cv, were determined as expressed in equations 1 to 3 below:

$q_a = 1/n\, q_i$ ....(1)
$Sd = [1/(n-1).\ \Sigma(q_i - q_a)^2]^{1/2}$ ....(2)
$Cv = Sd / q_a$ ....(3)

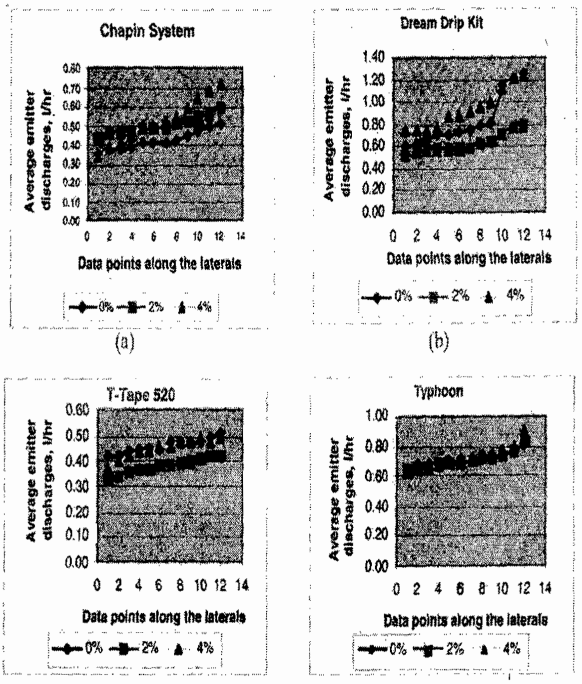
where q_i is data point average emitter discharge (l/hr), q_a the overall average of all the measured emitter discharge rates (l/hr), n the number of data points in a block (12 in this case), Sd the standard deviation of emitter discharge rates, and Cv the field tested discharge coefficient of variation of the set of emitters in which $q_1, q_2, \ldots, q_n$ are individual emitter discharge rates (l/hr). Since no two emitters can be identically manufactured, some variation in flow will exist from emitter to emitter, in addition to variation in flow due to pressure.

3.0 RESULTS AND DISCUSSION

3.1 Effect of Slope on Emitter Discharges

On undulating terrain, the design of a high-uniformity system is constrained by the pressure sensitivity of emitters (Keller and Bliesner, 1990). Figure 3 presents effect of slope on emitter discharges for a lateral length of 15 m at 1 m water supply head. It is observed that emitter discharges generally increase along the lateral lengths from the first data point to end of a lateral length for the four drip tapes and for the three slopes.

For Chapin system, Figure 3 (a), minimum discharge was 0.36 l/hr for the first data point and increased to 0.52 l/hr at the furthest data point for the 15 m lateral, 1 m head and 0% slope. Discharge trends for the 0 and 2% slopes were almost parallel, indicating that discharge between these two slopes had a similar trend, but varied only due to slope. However, discharge trend at 4% slope indicated a sharp variation from the start to end of lateral length, suggesting a high flow variation at slopes greater than 2%. Figure 3 (b) indicates characteristic curves for Dream drip kit system. Emitter discharge at the first data point was about 0.61 l/hr for the 0% slope and increased to about 1.24 l/hr at the furthest data point. All emitter discharges increased along the lateral for the three slopes.



(a) (b)

Figure 3: Effect of slope on emitter discharge for various drip tapes for 15 m l laterals at 1 head

Characteristic curves for the T-Tape system, Figure 3(c), indicated that discharge trends for the 0 and 2% slopes were almost parallel while the 4% discharge trend was between these two curves. Discharge varied from 0.43 to 0.51 l/hr between the first and last data points for the 0% slope. Trend for Typhoon 25, Figure 3(d), indicated that discharge increased along the lateral length for all slopes. Emitter discharge between the first and last data points varied between 0.63 and 0.82 l/hr for the 0% slope. However, the three curves merged closely, indicating that emitter discharges were independent of the slope evaluated.

Pressure variations in driplines are unavoidable. In conventional drip irrigation systems, emitter discharge would be expected to increase exponentially from the end emitter to the first one due to pressure losses in the 'leaking' lateral. However, these low head drip systems had short laterals of about 15 m long whose end was closed. As the bucket water source became empty, the emitter(s) closest to it drained water first. As water pressure decreased along the lateral, pressure that had built up from the closed end of the lateral continued to slowly sustain emitter discharge. This resulted with an emitter emptying time that increased towards the end of the lateral, hence showing increased discharges along the laterals even at 0% slope. This discharge trend was observed to increase at slopes of more than 2%, especially for the Chapin and Dream kit systems. It was also sensitive to the type of emitters used in the laterals.

Table 1 presents overall mean emitter discharge, q_a, for each drip tape as influenced by slope, their standard deviations, Sd, and coefficient of variation, Cv. For Chapin system, CC, q_a increased with slope, giving 0.43, 0.51 and 0.53 l/hr for 0, 2, and 4% slopes, respectively. The respective coef-ficients of variation, Cv, were 0.11, 0.09, and 0.23, implying less variation for 0 and 2% slopes, respectively, and a Cv value that was almost twice higher for the 4% slope. In addition, standard deviation, Sd, of the discharges were 0.05, 0.05, and 0.12 for 0, 2 and 4% slopes, respectively. Therefore, Sd values were highest for 4% slope while it was the same value for both 0 and 2% slopes. These results therefore indicated that the Chapin system can reasonably be used for slopes of 0 to about 2% since flow variations of emitter discharges were relatively low as indicated by values of Cv (about 0.10) and Sd (0.05) compared to those of the 4% slope. Slopes higher than 2% hence resulted in increased variation of flow between the first and last data points in a drip line. A possible cause for these observations was the type of emitters used by the Chapin system, i.e., simple orifice emitters, which are sensitive to pressure variations.

Table 1: Effects of slope on emitter discharge at 1 m head and 15 m laterals for various drip tapes

	Slope(%)											
	0				2				4			
Parameter	CC	DD	TT	T25	CC	DD	TT	T25	CC	DD	TT	T25
q_a	0.43	0.83	0.46	0.72	0.51	0.62	0.38	0.71	0.53	0.93	0.45	0.73
Sd	0.05	0.23	0.03	0.05	0.05	0.09	0.03	0.05	0.12	0.18	0.04	0.07
Cv	0.11	0.27	0.06	0.07	0.09	0.14	0.08	0.07	0.23	0.19	0.08	0.10

For Dream Kit, DD, q_a values were 0.83, 0.62, and 0.93 l/hr; for 0, 2, and 4% slopes, respectively. Cv values for Dream kit were 0.27, 0.09 and 0.19; and Sd values were 0.23, 0.09 and 0.18 for 0, 2, and 4% slopes, respectively. The higher Sd and Cv values at 0% were possibly due to an undetected emitter clogging at about ¾ of the lateral length that could have increased flow volumes down slope. This is suggested from the sudden change in emitter discharge of this slope in Figure 3 (b).

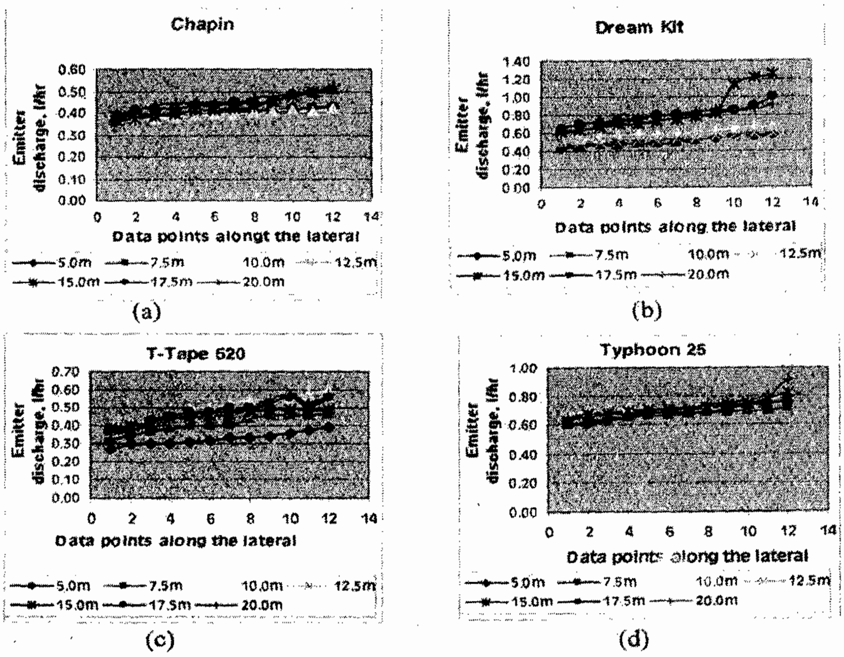
The q_a values for T-Tape 520, TT, were 0.46, 0.45 and 0.38 l/hr, respectively, i.e. similar for lower slopes up to 2% but were slightly lower for 4% slope. On the other hand, Sd values were 0.03, 0.03, and 0.04 while Cv values were 0.06, 0.08, and 0.08 for 0, 2, and 4% slopes, respectively. From these observations, effect of slope was less significant on emitter discharge. Therefore, T-Tape could be used for all slopes tested without significantly affecting emitter discharge and hence water distribution in the irrigated fields.

For Typhoon 25 tape, T25, q_a values were 0.72, 0.71 and 0.73 l/hr, for the 0, 2 and 4% slopes, respectively. The tapes therefore produced similar q_a values for the tested slopes. Sd values were 0.05, 0.05, and 0.07 while Cv values were 0.07, 0.7, 0.10 for 0%, 2% and 4% slopes, respectively. This implied that slope had almost no effect on emitter discharges. The tape could hence be adopted for all tested slopes without affecting emitter discharge.

3.2 Effect of Lateral Length on Emitter Discharges for Various Drip Tapes

The lateral length, even on smooth fields, must be kept reasonably short to avoid excessive differences in pressure. Factors that affect maximum recommended length are discharge per unit length, desired emission uniformity, flow characteristics of the emitter selected, lateral layout pattern, terrain, and lateral pipe diameter. In most installations, field dimensions and cultural practices are deciding factors for determining the length (Keller and Bliesner, 1990). Figure 4 presents variation of emitter discharge as influenced by lateral length for 0% slope and supply head of 1 m for the drip tapes.

The Chapin system, Figure 4a, had mean emitter discharges that were almost uniform for all lateral lengths at the tested conditions. These observations show that best results could be realised by adopting laterals of up to 12.5 m by virtue of small differences of 0.12 l/hr in mean emitter discharges between them. For the Dream kit, Figure 4b, lateral lengths indicated two clusters of emitter discharges; one for lateral lengths of 5 – 12.5 m, with emitter discharges, q_a, of about 0.5 l/hr. The other one has lateral lengths longer than 12.5m, i.e., 15 – 20 m, that show large discharge changes between the first and last data points along the laterals, i.e. between 0.6 – 1.0 l/hr. For emitter discharges of about 0.50 l/hr to be realised, 12.5 m laterals could be adopted.



(a) (b)

(c) (d)

Figure 4: Effect of lateral length on emitter discharge for 1m head and 0% slope for various drip tapes

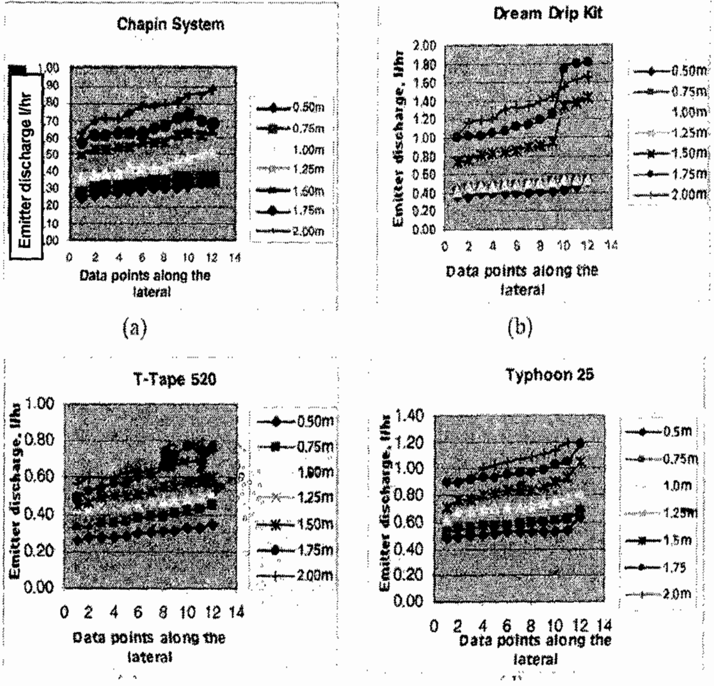
T-Tape, Figure 4c, had mean emitter discharge, q_a, of about 0.5 l/hr for lengths of up to 15 m. However, discharge variations increase when lateral length exceeds 15 m. Thus, high emission uniformity and low flow variation could be realised by adopting laterals of up to 15 m. Typhoon 25 tape, Figure 4d, had mean emitter discharge, q_a, of about 0.7 l/hr for all lengths tested. It was also observed that there was less difference in discharge at the beginning and end of each lateral for this water supply head. This indicated a lower flow variation and higher water distribution uniformity for this tape for laterals tested.

3.3 Effect of Water Supply Head on Emitter Discharges

Figure 5 shows the trend of emitter discharges for various water supply heads for 15 m lateral lengths at 0% slope for the four drip tapes. It can be observed that emitter discharges generally increase with water supply head for 15 m lateral lengths for all evaluated drip tapes. The laterals were closed at the end, which was responsible for pressure build up from the lateral ends.

For Chapin system, Figure 5a, water supply heads of 0.5 – 0.75 m had discharges of 0.25 – 3.5 l/hr between the first and last data points in a lateral while those of 1.25 – 1.5 m head had between 0.45 and 0.6 l/hr. However, water supply heads higher than 1.5 m showed variation in emitter discharge trends, e.g., at about ¾ lateral length for 1.75 m head of water. For better results to be realised, water supply heads of 0.5 – 1.0 m could be adopted for 15 m tape lengths.

For Dream kit, Figue 5b, emitter discharge curves down the lateral length overlapped each other for water supply heads between 0.5 - 1.0 m, hence indicating similar discharge trend. The discharges had a range of 0.40 to 0.55 l/hr between the first and last data points. However, higher water supply heads gave a totally different trend, with discharge variations as high as 0.7-1.4 l/hr for 1.25 to 1.5 m head and higher. This peculiar behaviour could not readily be explained, but possible reasons may include an unnoticed clogging at about ¾ lateral lengths during data collection for the 1.25, 1.5 and 1.75 m water supply heads. Water supply heads of 0.5 – 1.0 m head could hence be suggested for Dream kit for 15 m laterals, since higher heads produced large changes in emitter discharges and may need to be avoided for better water distribution.



(a) (b)

(c) (d)

Figure 5: Effects of water supply head on emitter discharge for various drip tapes for 15 m laterals at 0% slope

For T-Tape, Figure 5c, emitter discharge increased uniformly from beginning to end of laterals for water heads of 0.5 – 1.5 m. However, higher heads indicated a higher rate of discharge variation between the first and last data points in a lateral. For high emission uniformity and low flow variation to be realised, supply head of about 1.0 m with q_a of about 0.46 l/hr was appropriate. For Typhoon 25 tape, Figure 5d, trend of emitter discharge characteristics indicated less variation for 0.5 – 1.75 m heads, e.g., between 0.6 – 0.8 l/hr between first and last data points for a head of 1 m. The 0.5 m and 1.75 m water supply head trends were almost parallel to each other, indicating similar discharge trends but higher emitter discharges at higher heads.

3.4 Effects of Slope and Water Supply Head on Emitter Flow Rate Regime

Micro-irrigation emitter flow rates have different responses to pressure variations. The response of a specific emitter depends on its design and construction. Figure 6 presents variation of emitter discharge with water supply head for 15 m laterals at 0% slope for four drip tapes.

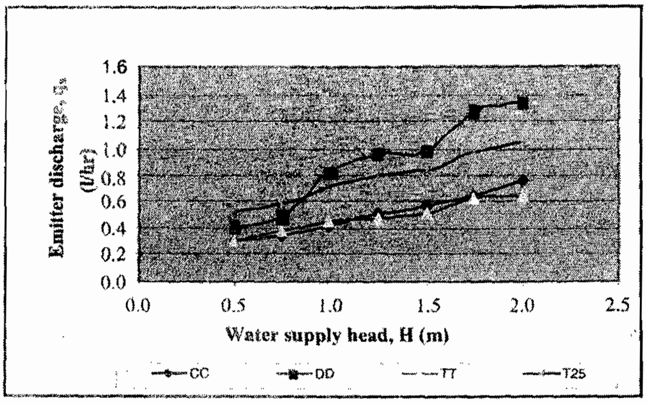
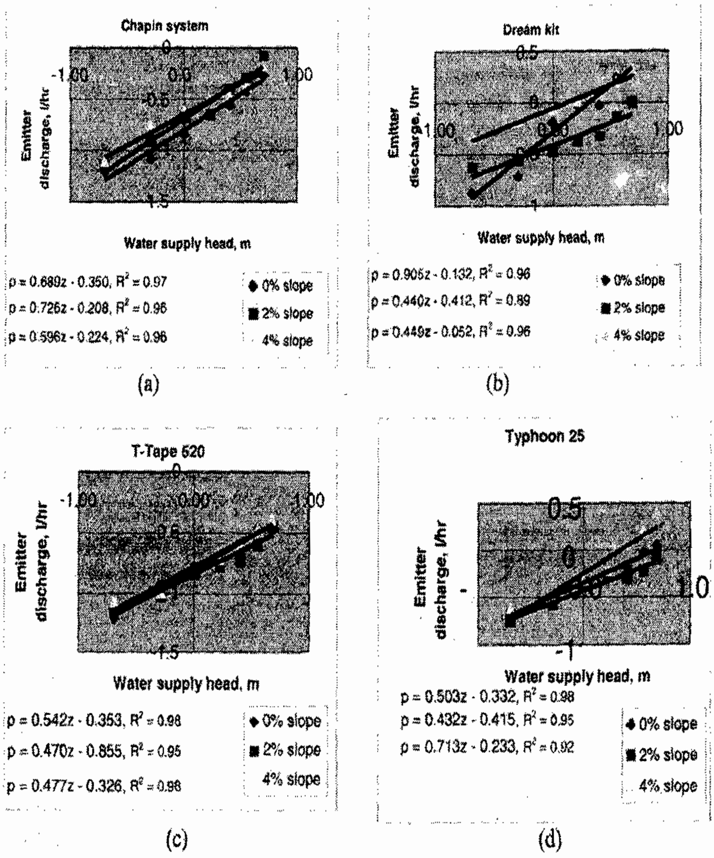


Figure 6: Effect of water supply head on emitter discharge for the four drip tapes at 0% slope

The Dream Kit tape (DD) had the largest variation of overall average emitter discharge with water supply head, i.e. 0.4 – 1.3 l/hr for heads of 0.5 – 2.0 m. However, T-Tape (TT) and Chapin (CC) varied at almost the same rate with emitter discharge range of 0.3 – 0.7 l/hr for water supply heads of 0.5 – 2.0 m. Typhoon 25 (T25) indicated a smooth trend of emitter discharges of 0.5 – 1.1 l/hr for water supply heads of 0.5 – 2.0 m; however, the trend was almost parallel to that of the T-Tape. The discharge from most drip irrigation emitters with fixed or flexible cross-sections is expressed by Keller and Bliesner (1990) as:

$$q = K_d H^x \qquad (4)$$

where q is emitter discharge (l/hr), H is working pressure head at the emitter (m), K_d a constant of proportionality that characterises each emitter (discharge coefficient), and x a measure of how sensitive the flow is to pressure changes (emitter discharge exponent). The value of x measures the flatness of the discharge – pressure curve. It is somewhat between 0 and 1, the lower the value of x the less discharge will be affected by pressure variations and vice versus. It clearly demonstrates the desirability of an emitter that has a discharge – pressure curve with a low x value. Figure 7 shows a plot of log-log of emitter discharge, q_a versus water supply head, H, for the four drip tapes tested. Log q_a is denoted as p while log H is denoted as z in Figure 7. The x value can be obtained as the slope of a plot of log q versus log H, while K_d is obtained from the intercept to the plot.



(a) (b) (c) (d)

Figure 7: Effect of slope and water supply head on flow regime for the four drip tapes

For Chapin system, Figure 7a, x values for 0, 2 and 4% slopes were 0.70 (R^2 of 97%), 0.73 and 0.60 (both at R^2 of 96%), respectively. For laminar flow emitters, the relation between discharge and operating pressure is nearly linear, implying an x value close to 1. This indicates that emitter discharge was towards laminar flow for the Chapin system; discharge was therefore quite sensitive to pressure differences within the system. Dream kit, Figure 7b, also produced a high x value of 0.9 (R^2 of 96%) at 0% slope, while other values were 0.44, and 0.45 for 2 and 4% slopes, respectively. However, due to excessive variation of this value for the slopes tested, emitter discharge variation for this system was assumed to be similar to that of Chapin kit since the two tapes use similar orifice emitters.

T-Tape 520 had x values of 0.54 (R^2 of 98%), 0.47, and 0.51, Figure 7c, while values for Typhoon 25, Figure 7d, were 0.50 (R^2 of 98%), 0.43 (R^2 of 95%), and 0.71 (R^2 of 92%), for 0, 2 and 4% slopes, respectively. This implied that for these emitters, change in discharge varies with the square - root of pressure head at 0% slope since $x \cong 0.5$; hence they are turbulent–flow emitters. The pressure must hence be increased four times to double the flow. They are hence less sensitive to pressure changes in their systems. Other emitters have an x value close to zero. These are the pressure-compensated emitters; they are constructed to yield a nearly constant discharge over a wide range of pressures. For complete flow regulation, x is zero. However, considerable regulation is achieved when x is between 0.2 and 0.35 (Keller and Bliesner, 1990).

The emitter discharge characteristic equations developed for the various tapes for 0% slope can therefore be summarised as follows:

Chapin:	$q = 0.45\ H^{0.7}$,	$R^2 = 97\%$	(Towards laminar flow)	5(a)
Dream kit:	$q = 0.74\ H^{0.9}$,	$R^2 = 96\%$	(Laminar flow)	5(b)
T-Tape:	$q = 0.45\ H^{0.5}$,	$R^2 = 97\%$	(Turbulent flow)	5(c)
Typhoon 25:	$q = 0.45\ H^{0.5}$,	$R^2 = 98\%$	(Turbulent flow)	5(d)

(ii) Lateral lengths of about 12.5 m gave least discharge variations for Chapin and Dream kits while 15 m laterals could be adopted for the T-tape system. Typhoon

These equations can then be used to predict emitter discharge, q (l/hr) for a given water supply head, H (m), for a 0% ground slope.

CONCLUSIONS

This study aimed to investigate effects of slope, lateral length and water supply head on emitter discharge of four commonly used low head drip irrigation technologies under field conditions. The following conclusions were drawn:

(i) Total emitter discharges along a lateral generally increased with slope due to pressure build-up from the closed lateral ends. Chapin and Dream kit systems were more sensitive to pressure differences within the respective systems and could be adopted for 0 - 2 % slopes. However, T-tape and Typhoon 25 systems were more independent of slope and could hence be utilised for higher slopes of even 4%.

(ii) Lateral lengths of about 12.5 m gave least discharge variations for Chapin and Dream kits while 15 m laterals could be adopted for the T-tape system. Typhoon 25 systems could be adopted for longer laterals without affecting emitter discharges.

(iii) Higher water supply heads resulted in higher emitter discharges. However, water supply heads of 0.5 – 1.0 m could be adopted for 15 m lateral tapes for the Chapin and Dream kits since higher heads produced high emitter discharge variations. T-tape systems had low flow variations for water supply heads of 0.5 – 1.5 m while Typhoon 25 tapes had better water distribution even at water heads of 1.75 m.

(iv) Emitter discharge characteristic equations were developed for the various tapes for 0% slope. Relationship between emitter discharge and operating pressure for Chapin and Dream kit systems showed high sensitivity to pressure differences within the respective systems; relationship was nearly linear at R^2 of 96% and 97%, respectively. T-tape and Typhoon 25 systems were less sensitive; emitter discharge varied as the square -root of water supply head for T-tape (R^2 of 97%) and Typhoon 25 (R^2 of 98%). They were therefore suitable for higher slopes compared to Chapin and Dream kits.

REFERENCES

1. Hanson, B. R., Fipps, G. and Martin, E. C. (2000). Drip Irrigation of Row Crops: What is the State of the Art? pp 11. Research and Extension, Kansas State University, Kansas.
2. IPTRID, 2000. Affordable Irrigation Technologies for Smallholders: Opportunities for Technology adaptation and Capacity Building. International Programme for Technology and Research in Irrigation and Drainage. Programme Formulation Reports No 6 – Dec 2000.
3. Keller, J. and Bliesner R.D. (1990). Sprinkler and Trickle Irrigation. Chapman and Hall, New York.
4. Lesukat, M. 2005. Field Evaluation of Low Head Drip Irrigation Technologies in Kenya (Msc. Thesis, JKUAT).
5. Ngigi, S.N., Thome, J. N., Waweru, D. W. and Blank, H. G. (2000). Technical Evaluation of Low Head Drip Irrigation Technologies in Kenya. Research Report, Nairobi University and IWMI, Nairobi, Kenya. pp 21.
6. Rydzewski, J.R. and Ward, C. F. (Eds) (1989). Irrigation Theory and Practice. Proceedings of the International Conference, University of Southampton, pp 616-629.
7. Sijali, V.I. (2001). Drip Irrigation: Options for Smallholder Farmers in Eastern and Southern Africa, pp 60. TH No. 24. ISBN 9966 – 896–77- 5.
8. Winrock. 2000. Proceedings Of Low Head Drip Irrigation Review Workshop, Nairobi, Kenya. 17-18th February 2000.