Assefa et al., Irrigat Drainage Sys Eng 2017, 6:1
DOI: 10.4172/2168-9768.1000179

Irrigation & Drainage Systems Engineering

Research Article

OMICS International

Effects of Slopes, Furrow Lengths and Inflow Rates on Irrigation Performances and Yield of Sugarcane Plantation at Metehara, Ethiopia

Assefa S[1], Kedir Y[2]* and Alamirew T[3]

[1]Sugar Corporation, Research and Training, Wonji, Ethiopia
[2]Addis Ababa University, Ethiopia
[3]Water and Resource Centre, Addis Ababa University, Ethiopia

Abstract

A field study was conducted with the aim of evaluating effects of slope, furrow length and flow rate on irrigation performances, cane and sugar yield at Metehara sugar estate. The field experiment was arranged in a split-split plot design with 0.05, 0.08 and 0.1% slopes; 100, 150 and 200 m furrow length and 4, 5 and 6 L flow rate.

The analysis of performance indices indicated that the effect of slope was not statistically significant except distribution uniformity and uniformity coefficient; furrow length and flow rate were highly significant on all performance indicators. All indices except deep percolation ratio and storage efficiency have shown an increasing trend as flow rate increases. The range of cane and sugar yield found was from 9.54 to 13.33 t/ha/month and from 1.12 to 1.23 t/ha/month, respectively. Flow rate had significant variation on both cane and sugar yield. The interaction of 200 m furrow length of and 6 lit/s flow rate gave better distribution uniformity and cane yield with slope of 0.08% was recommended for Metehara Sugarcane Plantation.

Keywords: Furrow dimensions, Blocked-end furrow, Metehara, Irrigation performances, Sugarcane, Ethiopia

Introduction

For long term sustainability of an irrigation system, improvements in the performance of current water application and on-farm water management practices seem to be more necessary than any other practice [1]. An important aspect that has been considered in several studies is to design efficient irrigation systems at the farm-level (Feyen and Zerihun [2]; Zerihun et al. [3]; Khan et al. [5]; Hsiao et al. [6]). Pereira and Luis [7] reported that to improve the irrigation systems requires the consideration of factors influencing the hydraulic processes, the water infiltration and the uniformity of water application to the entire field (Figure 1).

Efficient application and distribution of water by furrow irrigation is dependent on furrow parameters such as inflow, soil texture, field slope, soil infiltration, plant coverage, roughness coefficient, field shape, irrigation management and etc. It is essential to understand the role and inter-dependence of these factors, which determine the prescribed amount of water to apply and ensure uniform application down the full furrow length. Improved efficiency in irrigation system design can help reduce the amount of irrigation water applied there by reducing water-logging and salinity problems while at the same time maintaining crop water needs [8].

Mekonen [9] investigated 0.3, 0.4 and 0.5 lit/s flow rates against 24, 35 and 50 m furrow length in split plot design at Batu Degaga and found that average application efficiency of 28.9, 33.6 and 40.46% for furrow lengths of 24, 35 and 50 m, respectively. Regarding flow rates, the average values of application efficiency became 32.9, 32.8 and 36.9% for the flow rates of 0.3, 0.4 and 0.5 lit/s, respectively. As to the irrigation adequacy 93.35, 86.9 and 99.2% were attained for the 24, 35 and 50 m furrow lengths, respectively.

Another study, conducted by Eshetu [10] at Yilmana Densa woreda, West Gojam Zone of Ethiopia, to evaluate effects of flow rates (0.4, 0.6, 0.8 lit/s) and furrow lengths (10, 25 and 40 m) on water use efficiencies found higher application efficiencies on longest furrow (40 m) as well as lowest flow rate (0.4 lit/s).

Eldeiry et al. [11] found on clay soil that furrow length and application discharge are the main factor affecting application efficiency. In addition, application efficiency depends on the soil water deficit at the time of irrigation (Pereira [7] Pereira and Trout [8]). Raine and Bakker [12] identified a range of methods to improve water application efficiencies in the sugar industry including the use of appropriate furrow lengths, irrigation cut off times and water application rates.

In Ethiopia sugarcane is fully irrigated and furrow irrigation is the most common method. Booker Tate [13] reported that furrow irrigation of Metehara sugarcane plantation is facing problems regarding water management: reduced systems (canals and night storages) capacity due to siltation, water shortage due to expansion and new development in the upper basin of Awash River and due to decreasing capacity of Koka Dam, soil salinity and sodality, water-logging in some fields and expansion of Lake Beseka.

To alleviate these problems improving water management becomes the first priority. However, there is little quantitative information about the field performance of irrigation systems in the estate.

The aim of this study was to generate information on furrow variables specifically slope, inflow rate, and furrow length and their relation with irrigation performance parameters.

Materials and Methods

Description of study fields

Metehara sugar estate is located in Oromiya region of Ethiopia

***Corresponding author:** Kedir Y, M. Sc Irrigation Engineer and Researcher, Addis Ababa University, Ethiopia, Tel: +251911628489; E-mail: yuskedd@gmail.com

Received February 15, 2017; **Accepted** March 15, 2017; **Published** March 21, 2017

Citation: Assefa S, Kedir Y, Alamirew T (2017) Effects of Slopes, Furrow Lengths and Inflow Rates on Irrigation Performances and Yield of Sugarcane Plantation at Metehara, Ethiopia. Irrigat Drainage Sys Eng 6: 179. doi: 10.4172/2168-9768.1000179

Citation: Assefa S, Kedir Y, Alamirew T (2017) Effects of Slopes, Furrow Lengths and Inflow Rates on Irrigation Performances and Yield of Sugarcane Plantation at Metehara, Ethiopia. Irrigat Drainage Sys Eng 6: 179. doi: 10.4172/2168-9768.1000179

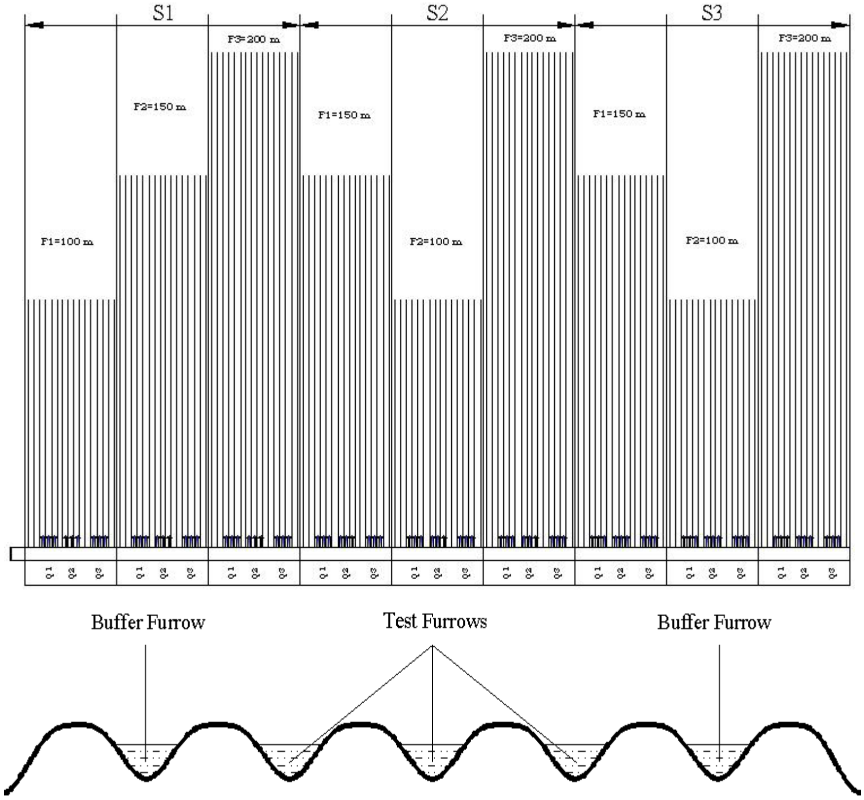

Figure 1: Schematic diagram of experimental layout.

(8°50'N and 39°55'E) at 950 m above sea level, has a semi-arid climatic with a bimodal annual rain of 610 mm.

The sugar estate is a state-owned agro industrial company, with total net sugarcane plantation area of 10,200 ha. Water is abstracted from Awash River using diversion weir.

A single tertiary sugarcane field has nominal size of 64 ha for which 200 lit/s of irrigation water is allocated. Longitudinal slopes of the fields are categorized as flat (0 to 0.5%), mild (0.5 to 0.8%) and steeply (0.8 to 1.5%). Almost all fields have 100 m furrow length with "Block-ended" method with spacing of 1.45 m. Since establishment rigid plastic siphons with 70 mm internal diameter have been used to deliver water for each furrow at a rate of 5 lit/s using 30 cm pressure head. Recently with the objective of improving infield water distribution efficiency, flexible gated pipe has been introduced and replacing siphons. Internal diameter of the pipe is 425 mm. When irrigating both sides, 20 outlets from each will be opened simultaneously while one side of a field is irrigated 40 outlets will be opened.

Experimental design and treatment setup

The treatments applied were slopes, furrow lengths and flow rates. Each treatment has three levels with two replications for the main plot factor (slope). The treatment levels were 0.05, 0.08, 0.1% furrow slopes (S), 100,150, 200 m furrow lengths (F) and 4, 5, 6 lit/s flow rates (Q) with split-split plot arrangement, where slopes constituted the main plot factor, furrow lengths constituted the sub-plot factors and flow rates constituted the sub-sub-plot factors. Each furrow set was also divided into three sub-sets consisting of five furrows each. Flow rates were assigned randomly. The middle three furrows were used for monitoring irrigation events and the outer furrows used as a buffer.

Composite soil samples were analysed for texture, field capacity, permanent wilting point and bulk density using standard procedures. Soil moisture samples before irrigation were taken at 25 m interval along the furrows from each plot at two depths, 0-30 cm and 30-60 cm, using soil auger (0-30 cm before hilling up irrigation events and at two depths for after hilling up irrigation events) and were determined using gravimetric method.

Amount of water to be applied during each event (Zreq) was determined based on soil moisture deficit level at root depth. Furrow cross sections were determined using profile-meter and the data were used to derive the relationship between depth of water in the furrow and corresponding top width. For this study calibrated Manning's roughness coefficients which are 0.1 and 0.04 were used for before and after hilling up irrigation events.

Furrow flow rates were measured using 3 inches Parshal-flumes which were placed at the upstream, centre and tail end of the furrows. Prior to the test, the flow rates were calibrated by fixing opening areas pipe outlets and the required pressure heads. During the test, flow rates were initially measured every 2 min until it became stable. After stabilization, measurements were taken every 10 min. The tail water (runoff loss) was collected at end of each furrow using plastic bucket then runoff volumes were determined using graduated cylinder.

Advance and recession times were measured for each treatment plots combination. Stakes were driven into the soil along the furrows at fixed interval of 25 m before irrigation events. Advance times were recorded at the time when water reach at each stakes while recession times (trec) were recorded at times when water fully infiltrated or disappeared from the furrow bed at observation sections.

After determining the depth of water retained in the soil profile, performance indicators were calculated.

Destructive cane sampling was carried out at the age of 11 months and the following cane and sugar yield parameters were determined. The data were analysed with ANOVA technique using Gen-STAT model, which is more popular and powerful statistical package for engineering experiment. The ANOVA will help to identify whether the means are equal or not. To determine which means are significantly different, Turkey's multiple comparison tests were used. It is the most common and more conservative procedure which is designed specifically for pairwise comparison. It also controls the maximum experiment-wise error rates under any complete or partial null hypothesis.

Result and Discussion

Soil has a clay texture with sand, silt and clay as 14.9, 23.27 and 61.83%, respectively with average moisture content of 40.75% at field capacity and 19.96% at permanent wilting point on weight basis. Average bulk density of the soil was 1.22 g/cm^3. Total available water holding capacity of the soil was 250.35 mm/m from which 162.73 mm/m (65%) is readily available water for sugarcane.

pH of the soil varies from 7.95 at 0-30 cm to 8.03 for 30-60 cm depth indicating the soil is slightly alkaline or nearly neutral, and hence, suitable for sugarcane. The soil has an EC value of 0.21 to 0.26 dS/m.

Irrigation Performances

Application efficiency

Application efficiency, E_a, obtained was in the order of 51.53% to 64.87% and the maximum value was for 100 m furrows length, 4 lit/s inflow rates and 1% furrow slope interaction. Statistically there was no significant ($p>0.05$) variation on application efficiency due to furrow slopes. This result showed that what matters the efficiency is, it is not the slope rather the unevenness of the slope along the furrow length.

Effect of furrow length on E_a was highly significant ($p<0.01$). The mean values of E_a were 61.22, 58.06 and 55.52% for 100, 150 and 200 m furrow lengths, respectively.

Similarly, effect of flow rate on E_a was highly significant ($P<0.01$) with mean values of 55.78, 59.23 and 59.8% for 4, 5 and 6 lit/s flow rates, respectively. E_a has shown increasing trend as flow rate increased.

Interaction effect between furrow length and flow rate on E_a was also highly significant ($p<0.01$) as summarized in Table 1. The highest value was obtained for treatment interaction of smallest furrow length (100 m) and relatively moderate flow rate (5 lit/s) with mean value of 63.68%. The least E_a was recorded for treatment interactions of longer furrow length (200 m) and smallest flow rate (4 lit/s) with mean value of 51.95%. Except 100 m furrow length, E_a has shown an increasing trend as flow rate increased.

	Mean application efficiency (%)			
	Flow rate (lit/s)			
Furrow length (m)	**4**	**5**	**6**	**Mean**
100	60.81	63.68	59.18	61.22
150	54.57	58.24	61.36	58.06
200	51.95	55.75	58.84	55.52
Mean	55.781	59.23	59.80	
	F	**Q**	**F x Q**	
SE	0.153	0.322	0.480	
LSD (0.05)	0.531	0.956	1.411	
CV%	0.6	2.3	2.3	

Table 1: The interaction effects of flow rate and furrow length on application efficiency (%).

For a given flow rate, E_a has a decreasing trend as furrow length increased after certain optimal level. This is in agreement with the result of Eldeiry et al. [11] who stated higher efficiencies achieved for small furrow lengths with relatively low discharges and larger flow rates are needed as furrow length increases to obtain high efficiencies.

Irrigation uniformity

Uniformity refers to the evenness of the infiltrated water throughout a field and depends on system design and maintenance [14]. A uniformity of 100% means the same amount of water infiltrates everywhere in a field. Among the common index describing uniformity is the distribution uniformity (DU).

Using the derived cumulative infiltration functions before and after hilling up:

$Z=0.04\ t^{0.26}+0.0000212t$ and

$Z=0.058\ t^{0.12}+0.0000212t$;

Depths of water infiltrated into the soil at different points along the furrows were determined.

Regarding infiltrated depth of furrow irrigation at 4, 5 and 6 lit/s flow rate for 100 m furrow length and 0.08% furrow slope, higher deep percolated loss was observed for 4 lit/s while the minimum was observed on 6 lit/s due to faster advance.

For furrow irrigation at 4, 5 and 6 lit/s flow rate for 200 m furrow length and 0.08% furrow slope, the maximum and minimum percolation was occurred for the flow rate of 6 and 4 lit/s, respectively. The reason for this is for smaller inflow rate on a longer furrows take long advance time that facilitates longer irrigation time that leads excessive deep percolation losses below the root depth. When inflow rate increased for particular furrow length, uniform longitudinal infiltrated depth is achieved but there exist deep percolation and runoff losses. Applied depths were non-uniformly distributed and the distribution had skewed towards inlet of the furrow due to differences in opportunity time along the length of each furrow.

When inflow rate increased for particular furrow length, uniform longitudinal infiltrated depth is achieved but there exist deep percolation and runoff losses. On the other hand, maximum percolated depth was observed for longer furrow for each flow rate.

Therefore, these infiltration characteristics of furrow irrigation show that for fixed flow system, appropriate combination of design parameters are needed to achieve uniform longitudinal profile of infiltrated depth along the furrows that have minimum deep percolation and runoff losses.

Distribution uniformity (DU)

It is defined as the ratio of the least amount of infiltrated water to the average infiltrated amount. It is a term that describes how uniformly water is applied in a field [15].

The analyses of variance showed that effect of slope on distribution uniformity (DU) was significant at $p<0.05$ and mean distribution uniformities were 85.9, 86.62 and 87.40% for 0.05, 0.08 and 0.1% slopes, respectively as shown in Table 2. The maximum DU was obtained for

0.1% slope. This value was in statistical parity with 0.8% slope. DU showed an increasing trend as slope increased and is influenced by the longitudinal slope of the furrow [7]. As the slope increases the advance rate become faster and the infiltration opportunity time (IOT) become uniform. This uniformity of IOT leads to improvement of DU.

Effect of furrow length and flow rate on distribution uniformity (DU) was highly significant. Mean DU with respect to furrow length were 88.15, 86.28, and 85.33%, for of 100, 150, and 200 m, respectively; that of flow rate were 84.03, 87.14 and 88.76% for 4, 5, and 6 lit/s, respectively (Table 3). Interaction effects of furrow length and flow rate on DU was also highly significant ($p<0.01$). The maximum value 89.32% was obtained for 200 m furrow length and 6 lit/s flow rate; whereas the minimum value 81.85% was obtained for flow rate of 4 lit/s flow rate of the same furrow length. The maximum value was in statistical parity with the interaction effects of 100 m furrow length with 5 and 6 lit/s flow rates.

The values of DU increases as the flow rate increased regardless of furrow lengths and decreases as the furrow length increases. This is similar to the reports of Feyen et al. [2] and Holzaphel et al. [16] which stated that uniformity is an increasing function of flow rate and a decreasing function furrow length. Increase in flow rates reduces the difference in wetting time between the head and tail of the furrow. The values of the indices were also much higher than the advanced furrow irrigation systems design, i.e., 70% [17].

Storage efficiency (E_s)

Results of storage efficiency indicated that there was no statistically significant ($p>0.05$) variation due to slopes. The effect of both furrow length and flow rate on E_s was statistically highly significant ($p<0.01$). Mean values of E_s were 98.69, 99.54, and 100% for furrow length of 100, 150, and 200 m, and 99.63, 99.51, and 99.1% for flow rates of 4, 5, and 6 lit/s, respectively (Table 4).

Interaction effects between furrow length and flow rate were highly significant ($p<0.01$) on difference of means of storage efficiencies. E_s has shown an increasing trend for increasing furrow length and for decreasing flow rate. This may be due to the fact that small discharge has slow advance time which gave longer IOT. The maximum E_s (100%) was achieved for 4 lit/s on 200 m long furrow and the minimum (98.06%) was obtained for 100 m furrow length 6 lit/s flow rate. The maximum ES was in statistical parity with the interaction effect of 200 m furrow length with the flow rate of 5 and 6 lit/s.

E_s values were in the range of 97.1 to 100% showing that the depth of water infiltrated satisfied soil moisture deficit which were measured prior to irrigation.

Deep percolation (DPR) and runoff (RR)

The statistical analyses on DPR indicated that there was no significant ($p>0.05$) variation in the main effect slope. The effect of furrow length and flow rate on DPR were highly significant at $p<0.01$. Mean value of for 100, 150 and 200 m were 19.39, 23.81 and 26.85% respectively and 25.65, 23.29, and 21.11% for 4, 5 and 6 lit/s flow rates, respectively (Table 5). This result is similar to Eshetu [10] in which the effect of furrow length and flow rate on DPR was significant ($p<0.05$).

The result depicted that for all flow rates, DPR increases as the furrow length increase. This is congruent to the general principle, which states DPR increase with the increase of furrow length [18].

The effect of slope on RR was found to be non-significant ($p>0.05$). On the other hand effects of furrow length and flow rate on the RR were statistically highly significant (Table 6) with mean indices of 20.53, 19.41 and 18.81% for furrow lengths of 100, 150 and 200 m respectively, which were normal trend for furrow irrigation [18]. It showed a decreasing trend with increasing furrow length. As the furrow length increases largest portion of water lost as deep percolation as it has better opportunity time. The mean of RR were 18.82, 18.14, and 21.79% for flow rates of 4, 5 and 6 lit/s, respectively [19].

Slope (%)	Mean distribution uniformity (%)
0.05	85.90
0.08	86.62
0.1	87.4
SEm+	0.11
LSD (0.05)	0.667
CV%	0.2

Table 2: Effects of slope on distribution uniformity.

Furrow length (m)	Mean of distribution efficiency (%)			
	Flow rate (lit/s)			
	4	5	6	Mean
100	86.31	88.81	88.84	87.99
150	83.92	86.78	88.14	86.28
200	81.85	85.79	89.32	85.65
Mean	84.03	87.14	88.76	
	F	Q	F x Q	
SEm±	0.2	0.151	0.291	
LSD (0.05)	0.685	0.449	0.861	
CV%	0.6	0.70	0.70	

Table 3: The interaction effects of flow rate and furrow length on distribution uniformity.

	Means requirement efficiencies (%)*			
	Flow rate (lit/s)			
Furrow length (m)	4	5	6	Mean
100	99.15	98.90	98.06	98.69
150	99.74	99.63	99.26	99.54
200	100	99.99	99.98	100
Mean	99.63	99.51	99.1	
	F	Q	F x Q	
SEm±	0.048	0.047	0.082	
LSD (0.05)	0.167	0.14	0.24	
CV%	0.1	0.2	0.2	

*Means followed by the same superscripts in the same column or row are not statistically different

Table 4: The interaction effects of flow rate and furrow length on storage efficiency (%).

	Mean Deep Percolation Ratio (%)			
	Flow rate (lit/s)			
Furrow length (m)	4	5	6	Mean
100	22.07	19.51	16.58	19.39
150	26.47	23.69	21.28	23.81
200	28.41	26.68	25.46	26.85
Mean	25.65	23.29	21.11	
	F	Q	F x Q	
SEm±	0.241	0.22	0.394	
LSD (0.05)	0.835	0.655	1.155	
CV%	2.5	4.0	4.0	

*Means followed by the same superscripts in the same column or row are not statistically different

Table 5: The interaction effects of flow rate and furrow length on deep percolation ratio (%).

The interaction effect of flow rate and furrow length on RR was also significant at p<0.05. RR showed an increasing trend as flow rate increase.

Cane and sugar yield

Mean cane yields obtained were 10.96, 11.14, and 11.46 t/ha/month for 0.05, 0.08 and 0.1% slopes; 10.47, 11.21, and 11.88 t/ha/month for 100, 150, and 200 m furrow length and 10.75, 11.16, and 11.65 t/ha/month for 4, 5, and 6 lit/s flow rates, respectively (Table 7).

Mean values due to the effect of treatments slope and furrow length on cane yield were not significant (p>0.05), whereas that of flow rates were highly significant (P<0.01). Better cane yield was obtained at higher flow rates and increases as the flow rate increase. This happens due to the fact that better irrigation uniformity was attained in higher flow rates [20]. The result showed that slope and furrow length have no effect on yield of sugarcane.

The effect of interaction between slope, furrow length and flow rate on cane yield was found to be significant (p<0.05).

Mean sugar yields obtained were 1.13, 1.15, and 1.22 t/ha/month for 0.05, 0.08, and 0.1% slope, 1.06, 1.18, and 1.22 t/ha/month for 100, 150, and 200 m furrow length and 1.12, 1.16, and 1.23 t/ha/month for 4, 5, and 6 lit/s flow rates, respectively. It showed non-significant (P>0.05) difference for slope, furrow length and their interaction. However, the effect of flow rate showed significant difference (P<0.05).

There was an increase in yield as all slopes, furrow length and flow rate increases [21]. But the increment of sugar yield at each level of treatments doesn't have significance difference except flow rate. The maximum yield was observed at the flow rate of 6 lit/s. Since there is no difference between levels of slope and furrow length, the higher levels of the two treatments with 6 lit/s flow rate have good yielding potential (Table 8).

Furrow length (m)	Means of Runoff Ratio (%)*			
	Flow rate (lit/s)			
	4	5	6	Mean
100	18.43	17.88	25.27	20.53
150	18.84	18.88	20.51	19.41
200	19.18	17.66	19.58	18.81
Mean	18.82	18.14	21.79	
	F	Q	F x Q	
SEm±	0.249	0.469	0.709	
LSD (0.05)	0.862	1.394	2.078	
CV%	3.1	10.2	10.2	

*Means followed by the same superscripts in the same column or row are not statistically different.

Table 6: The interaction effects of furrow length and flow rate on runoff ratio (%).

Slope	Furrow length	Cane yield (t/ha/month)*			
		Flow rates			
		Q_1	Q_2	Q_3	Mean
S_1	F_1	9.92	10.86	11.04	10.61
	F_2	10.57	10.70	11.21	10.83
	F_3	11.25	11.38	11.71	11.45
	Mean	10.58	10.98	11.32	10.96
S_2	F_1	9.54	10.15	10.31	10.00
	F_2	10.55	11.02	11.44	11.00
	F_3	11.71	12.19	13.33	12.41
	Mean	10.60	11.12	11.69	11.14
S_3	F_1	10.66	10.73	11.05	10.81
	F_2	11.23	11.70	12.47	11.80
	F_3	11.36	11.70	12.27	11.77
	F_3	11.68	11.38	11.93	11.46
	Mean	10.75	11.16	11.93	11.65
		S	F	Q	S x F x Q
	SEm±	0.069	0.35	0.05	0.52
	LSD (0.05)	0.42	1.22	0.16	1.74
	CV%	1.4	7.7	2.0	2.0

Table 7: The interaction effect of slope, furrow length and flow rate on cane yield (t\ha\month).

Summary

It was observed that after hilling up treatments had better application efficiencies than that of before hilling up treatments. Mean values were 54.2% and 62.34% for before hilling up and after hilling up irrigation events respectively. This is due to high crop resistance in former case which increases deep percolation.

In relation to distribution uniformity, the highest and the lowest values obtained were 96% and 74.22% for before and after hilling-up treatments, respectively. Almost all treatments had distribution uniformity of greater than 80%. Only nine before hilling up irrigation activities few events had distribution uniformity values in ranges between 74-80%. All irrigation events of the study are within acceptable limit.

In case of storage efficiency, before hilling up treatments were performing well compared to after hilling up treatments. The highest storage efficiency was observed for both treatments with mean value of 100% and the lowest was for after hilling up treatments with mean value of 95.6%. This might be because of before hilling up treatments had received much water due to flow resistance of the crop. Water losses (deep percolation and tail water runoff losses) were found to be highest for before hilling up irrigation events than after hilling up treatments. A lot of water was applied in before than after hilling up irrigation event as the advance is delayed by the crop resistance. Slow advance increases the infiltrated volume, increases deep percolation. This contributes to the lower value of application efficiency in before hilling up irrigation events.

Conclusion and Recommendation

Surface irrigation is not only the primary consumer of water but it is also the most inefficient user.

Results of performance indicators showed that the interaction effects of furrow lengths and flow rates were significantly (p<0.05) different in influencing application efficiency.

Distribution efficiency was affected by slope with the values of 85.90%, 86.62% and 87.4% for 0.05%, 0.08% and 0.1% slopes, respectively. Also it was significantly affected (P<0.01) by interaction of furrow length and flow rate with highest value of 89.32% for 200 m

	Sugar Yield (t/ha/month)		
	S	F	Q
1	1.13	1.06	1.12
2	1.15	1.18	1.16
3	1.22	1.22	1.23
SEm±			0.02
LSD (0.05)			0.07
CV%			8.4

Table 8: The effect of flow rates on sugar yield.

and 6 lit/s; and lowest value of 81.85% for combination of 200 m furrow length and 6 lit/s.

Storage efficiency was significantly affected (P>0.01) by the interaction effect of furrow length and flow rate with highest value of 100% for treatment combination of 200 m furrow length and 4 lit/s; lowest value of 99.06% for 100 m and 6 lit/s.

Interaction effect of slope, furrow length and flow rate on cane yield was found to be significant (p<0.05). Highest cane yield 13.33 t/ha/month was obtained from combination of 0.08% slope, 200 m furrow length and 6 lit/s flow rate. The least yield 9.54 t/ha/month was obtained from combination of 0.08% furrow slope; 100 m furrow length and 4 lit/s flow rate.

All irrigation performance indicators were highly affected by interaction effect of furrow length and flow rate. Irrigation uniformities and cane yield also affected by the main plot factor slope. The higher slope has maximum uniformity and cane yield. Sugar yield was affected only by flow rate. There is no significance sugar yield difference between slope, furrow length and their interaction effect.

Considering this and other economic advantages, it can be conclude that higher slope with longer furrow length and highest flow rate is better for sugar production.

References

1. Sarwar A, Bastiaanssen WGM, Feddes RA (2001) Irrigation water distribution and long-term effects on crop and environment. Agricultural Water Management 50: 125-140.
2. Feyen J, Zerihun D (1999) Assessment of the performance of border and furrow irrigation systems and the relationship between performance indicators and system variables. Agricultural Water Management 40: 353-365.
3. Zerihun D, Sanchez A, Farrell-Poe KL (2001) Analysis and design of furrow irrigation systems. Journal of Irrigation and Drainage Engineering, p: 127.
4. Hillel D, Vlek P (2005) The sustainability of irrigation. Advances in Agronomy, p: 87.
5. Khan S, Rana T, Yuanlai C (2006) Can irrigation be sustainable? Agricultural Water Management 80: 87-99.
6. Hsiao T, Steduto P, Fereres E (2007) A systematic and quantitative approach to improve water use efficiency in agriculture. Irrig Sci 25: 209-231.
7. Pereira LS, Luis S (1999) Higher Performance through Combined Improvements in Irrigation Methods and Scheduling: a Discussion. Agricultural Water Management 40: 140-169.
8. Pereira LS, Trout TJ (1999) Irrigation methods. In: van Lier HN, Pereira LS, Steiner FR (eds.), CIGR Handbook of Agricultural Engineering 1: 297-379.
9. Mekonen M (2006) Performance evaluation of Bato Degaga surface irrigation system. Alemaya University.
10. Eshetu S (2007) Evaluation of the Effect of Flow Rate and Furrow Length on Irrigation Efficiencies and Water Use. Haramaya University.
11. Eldeiry A, Garcia LA, El-Zaher AS, Kiwan ME (2005) Furrow irrigation system design for clay soils in arid regions. Appl Eng Agric 21: 411-420.
12. Raine SR, Bakker DM (1996) Increased furrow irrigation efficiency through better design and management of cane fields. Society of Sugarcane Technologists, pp: 119-124.
13. Booker Tate Limited (2009) Re-evaluation of Plantation Soil at Metahara Sugar Factory. Addis Ababa.
14. Jurreins M, Zerihum D, Boonasta J, Feyen J (2001) SURDEV: Surface Irrigation Software. ILRI Publication 59. Wageningen, the Netherlands.
15. Jensen ME (1980) Design and Operation of Farm Irrigation Systems. ASAE P: 829.
16. Holzapfel EA, Carlos L, Miguel AM, Jerónimo P, Jose LA et al. (2009) Furrow irrigation management and design criteria using efficiency parameters and simulation models. Chilean Journal of Agriculture Research 70: 287-296.
17. Ranghuwanshi NS, Wa11ender WW (1998) Optimal furrow irrigation scheduling under heterogeneous conditions. Agricultural Systems 56: 39-35.
18. Zerihun D, Feyen J, Reddy JM, Wang Z (1999) Minimum cost design of furrow irrigation systems. Trans ASAE 42: 945-955.
19. Cuenca RH (1989) Irrigation System Design: An Engineering approach. Prentice Hall, New Jersey P: 552.
20. FAO (Food and Agricultural Organization) (2010) Water development and management unit crop water information: sugarcane.
21. Hassan SA (1998) Engineering studies for increasing water distribution uniformity of perforated pipes for surface irrigation system. Agric Eng Dept. Cairo University.

Citation: Assefa S, Kedir Y, Alamirew T (2017) Effects of Slopes, Furrow Lengths and Inflow Rates on Irrigation Performances and Yield of Sugarcane Plantation at Metehara, Ethiopia. Irrigat Drainage Sys Eng 6: 179. doi: 10.4172/2168-9768.1000179