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Research Paper

The Effect of Emitter Discharge and Irrigation Volume on the Wet Barrier Advance in the Drip Irrigation: (A Case study of Gaem Abad Plain of Kerman)

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Abstract: The plan of soil profile wetting by a source point, emitter, which is called wet bulb, has an important role in the designing of drip irrigation, and it has effect on the amount of irrigation water. In fact, the first step for guarantying the irrigation performance is the determination of advance ratio of wet barrier in the horizontal and vertical directions. The experiment was conducted in the Ghaem Abad region of Kerman which has a sandy loam texture in order to evaluate the amount of emitter discharge and irrigation water volume on the wet barrier advances in the vertical and horizontal directions. Three amount of discharge amounts of 4, 8, and 24 Lit.hr^{-1} instead of amounts of irrigation water volume selected, and the measurements of movement ratio and moisture advances was done in the vertical and horizontal directions. The results of this study show that the amount of wetted diameter and depth of soil instead of certain volume of irrigation water will be increased and decreased respectively with increasing the emitter discharge ratio. These amounts and the volume of wetted soil, wet barrier volume will be gone up with increasing the period of irrigation instead of different amounts of emitter discharge. Also, the amount of wetted soil volume, wet bulb volume has an increasing ratio with going up the discharge and applied water volume. The evaluation of amount instead of different amounts of irrigation water volume shows that if the volume of applied water is more than 36 lit, the effect of discharge amount of emitter on the water distribution is significant, and with increasing the discharge, the amount of advances will be increased and decreased in the horizontal and vertical directions.

Key words: Discharge emitter, Wet barrier, Drip irrigation, Irrigation volume

Introduction

The agriculture has intended to the pressurized irrigation systems for saving the water use, increasing irrigation efficiency, and destroying the losses of water which is caused by penetration and evaporation. According to the climate conditions of Iran, increasing population, low efficiency of irrigation in the conventional and surface irrigation, using pressurized irrigation methods is one of the effective ways of using water resources. In the drip irrigation, water losses depend on the soil kind. If the soil, sand and clay, has not the ability to keep high moisture, the whole of water which is provided for the plant, will be not available for the root by the gravity, and the plant will feel stress. Accordingly, the plant can be irrigated well with decreasing the cycle and period of irrigation with the same proportion (Najafipoor and Zarrgani, 2007).

The drip irrigation can be used in the per kind of climate of dry, semi dry, semi humid , and even greenhouse position under the plastic cover. In the drip irrigation method, some parts of soil usually become wetted. This amount of wetting depends on miscellaneous factors which include discharge of emitter, the distance among the emitters, the distance of laterals from each other, kind of soil, and the slope of land and period of irrigation or volume of water which is left from emitter in per irrigation. The wetted parts which are around per emitter are usually small and it is extended like an upside down bulb in the depth of soil as if under per emitter the volume of soil which is called wet bulb becomes wet. Accordingly, it is necessary that the wetting pattern of soil profile or the volume of wet bulb will be predetermined for per land which should be irrigated with drip method (Alizadeh, 2003).

The water volume of irrigation have effect on wet bulb which is one of the most important and effective parameters in selection of emitter. The distance among the emitters is determined on the basis of form of wet pattern and area which is occupied with per emitter. The period of irrigation depends on when wet barrier arrives to root of a plan after beginning of irrigation. The distance of out lets, the flow intensity and period of irrigation should be designed as though the volume of wetted soil close to the volume of root plant. Thus, the observation of form and volume of wetted soil under emitters in order to supplying the demand of plant water, optimistic management and increasing of irrigation efficiency is necessary. For finding whether the case emitter can soak the favorable area or not, the concluded wet pattern is needed so the distance among the emitters can be determined on the basis of the patterns. (Najafi, 2006)

The suitable designing of drip irrigation network needs the adequate information of distribution way of water flow in the soil as vertical and horizontal and the information have effect on the election of emitter discharge. Finding the wet barrier advance ratio is very important in the regions in which the drip irrigation is used for planting crops, and it helps designing of irrigation network. Soil texture is one of the most important factors, or sometimes it can be said the most important factor which has effect

on the wet bulb shape in the designing of drip irrigation. The wet bulb has many differences from a soil to another soil. Moreover, the formation of wet bulb depended on the amount of clay or sand in the soil texture so that it is long and thin in a sandy soil, and small and wide in a clay soil (Najafi, 2006).

In the drip irrigation systems, the simple farm experiment is the most reliable way for determining the ratio of wet barrier advance or wet bulb shape which depends on the different factors such as texture and layering of soil, the intensity of water distribution, applied water volume, the distance between the emitters, initial soil moisture and slip line. (Haghighati, 1995)

Many researchers have studied dimensions of wetted plan of soil in the drip irrigation, determination of moisture plan shape and the distance which is between the emitters.

Ekramnia (1995), his evaluation about different kinds of emitters shows that the movement is function of gravity force in the sandy soil, but the main factor of determination of wet bulb of soil is capillarity force in the clay soil. Furthermore the wet bulb is vertical and thin in the clay soil and it is a small or big semi sphere whose center is under the emitter.

Hachoom (1973), has studied the effect of the equal volume of water irrigation on the wet barrier which is issued from the source point ; and it was observed that increasing in intensity of flow causes increasing in the wetted area and decreasing in depth of wetted soil. Also, the plan of soil wetting looks semi ellipse form for per emitter in the every time.

Root(1974), according his studies moisture distribution from a point source, it has seen that if the used water volume for the sandy soil is less than 95lit, the wet barriers has nearly a sphere form, but the vertical movement of water is more than horizontal movement for more than 95 lit .Also, he mention that the total volume of wetted soil is more the function of applied water than the period of used water.

Rahimzadegan (1977) has studied the movement of water under a point source, and he concluded that the capillarity force controls the wetting plan when the irrigation begins. Also, the effect of gravity force will be increased with increasing the depth wetting. The wet barrier moves in the depth direction with low discharges, and it moves horizontally with more discharges. Moreover, the severity of horizontal movement is more than vertical movement for all of performed discharges when the flows begin, but the severity of two movement will decreased with passing the time. Furthermore, the wet barrier advance would not halt, and the vertical movement is more than horizontal one when the irrigation stops.

Clark et al (1993), according to his studies on the sandy soil concluded that the ratio of horizontal movement of water with the application of 1.5 to 1.9 lit.h^{-1} discharge varies from 15.5 to 20 cm in these kinds of soil.

Ali khan et al (1996), studied the distribution of water in profile soil under a drip point, and they concluded that the ratio of wet barrier advance changes with changing discharge of emitter and the water volume of irrigation as if in less discharges the depth of wet barrier became more wetted and in more discharges, the horizontal movement increase and the depth of penetration is reduced.

Alqinna and Abuawwad (2001) studied the effect of superficial crust on advance of moisture barrier instead of applied different amounts of water from a source in drip irrigation and they presented equations for horizontal and vertical advance of wet barrier. They saw that increasing in amount of discharge increase the ratio of horizontal movement of water, but vertical advance of water decrease significantly because of surface crest which contribute to decrease of amount of penetration. The distance of emitters in the soils which are faced to surface crest usually should be wider than distance of emitters in the soil without crest instead of one kind of soil and certain ratio of discharge.

Thorburn et al (2003), concluded that among the distance of drip irrigation, the ratio of flow, the wet characteristics of soil and period of irrigation should be a harmony in the drip irrigation for improvement of efficiency of consumption water and mineral material

Acer et al (2009), examined the effect of discharges: 2 and 4 lit per hour on amount of vertical and horizontal advance of wet barrier in the soil which have loamy- sand soil and they saw that different values of discharge of emitter have no significant impact on horizontal and vertical movement on the wet barrier ,but the application of different values of water has significant effect on vertical movement of wet barrier; also, increase of water irrigation volume cause the growth of vertical movement. Consequently, increase of applied water volume and discharge of emitter provide the maximum wetted volume of soil.

In this research, the effect of amount of emitter discharge and irrigation water volume on the horizontal movement of wet barrier inside of the soil profile which is sandy loam under the emitter was evaluated. Finally, the results were presented.

Material and Methods

The available research was done on July of 2010 on a soil which has sandy- loam texture around the city of Kerman and GHAEME ABAD region that has 57^0, 07' eastern longitude and 30°, 18' northern latitude. The climate of this region which has 140 mm average annual rainfall and the average of temperature on Jul is 28^0c, is dry. In order to achieving soil texture which has effect on developing of wetted pattern, making samples from soil in different depths was done. The conclusions of measurement of texture percent of soil and physical and chemical characteristics of soil which is under study are collected. (Table1)

Table1. The result of the measurement of soil particle percent and physical properties of the soil

The depths of making samples)cm(	Sand (%)	Clay (%)	Silt (%)	Soil texture	The ratio of sodium absorption (SAR)	$\rho b\ (gr/cm^3)$	PH	EC (ds/m)

0-30	65.6	8.60	25.80	Sandy-loam	8.07	1.73	8.09	1.92
30-60	54.00	17.40	28.60	Sandy-loam	8.76	1.70	7.88	5.30
60-90	50.00	11.00	39.00	loam	12.85	1.72	7.70	10.73
90-120	71.00	5.00	24.00	Sandy-loam	10.67	1.75	7.66	8.15

Firstly, three kinds of the emitters with the discharges of 4, 8, 24 Lit.hr^{-1} were chose, and they are located on the pipes with the certain distances in the case position after the preparation and leveling of soil surface and installation of pipes were conducted. Then, a suitable period with per discharge was selected, and the flounce of stream was done.

After finishing of period of irrigation of per series of emitters, the flounce of that bifurcation broke off. After passing 24 hours from interruption of flow that the gravity water was existed, the soil moisture arrived in the farming capacity (Fc) and the measurement of ratio of horizontal and vertical movement of wet barrier in the profile soil was done as thought with creating a vertical cut from the installation of the emitter to the end of wet bulb.

As the amount of initial moisture of soil is one of the factors which effect on the shape of wet bulb in the different depths of soil making sample was done before the beginning of experiment in the per step and the amount of primary moisture determined in the laboratory. If the amount of initial moisture became more as possible as, the movement of water in the soil becomes less, and the different between the initial moisture of soil and the moisture which is created by the irrigation in per step of experiment become difficult, so they are not spreadable. The result of measuring moisture showed that the moisture of the soil was significant and it can be avoided.

Finally, the amount of depth and maximum diameter of wet bulb instead of different performance were chose for the next steps of research.

Results and Discussions

Before the evaluation of emitter discharge effect on the water distribution in the vertical and horizontal directions, drawing of final limit and development of moisture plans instead of different periods of irrigation, it is necessary to evaluate the variation of vertical and horizontal movement of wet barrier instead of different periods for the emitter performance for the discharge of 4, 8, and 24 Lit.hr^{-1}. Then the linear equations which have the best fitting on the whole of data instead of per discharge were extracted, and in the next step, the equations were assessed.

The all of these steps were conducted in a separate research after the vertical and horizontal movements of moisture in the soil were measured and the required data were collected. Then the statically calculations were done, and the results of the research were used as required as in this research. The achieved parameters and equations are shown in Table 2.

The moisture plans will be determined as the movement of water into the depth of root and horizontally. In this study, the maximum horizontal advance of wet barrier and vertical movement of wet barrier under the point source were shown with D_f and Z_f respectively. After the equations instead of different period of irrigations for per amount of discharge were achieved, the impact of emitter discharge on the water distribution in the horizontal and vertical directions was assessed. First of all, the constant volume of water irrigation were chose, and the impact of increasing discharge from 4 to 8 and 24 lit.hr^{-1} was evaluated. The amount of elected period and irrigation water volume for the selected discharges were shown in Table3.

The variation of vertical and horizontal wet barrier water volume of 48, 72, and 96 lit were assessed, and the results are gathered in the Figure of 1,2and 3.

As it was shown in the Figure1, instead of applied water volume of 48 lit, maximum horizontal movements which is about 126 cm belongs to the emitter with the discharge of 24 Lit.hr^{-1}.

Also, maximum vertical movement which is about 42 cm under the emitter belongs to the emitter with the discharge of 4lit.hr^{-1}.

According to the Figure 2, instead of applied water volume of 72 lit the maximum horizontal and vertical movements which are 135 and 56 cm respectively; belongs to the emitters with discharges of 24 and 4lit.hr^{-1} respectively.

In the Figure 3, the trend has continued as instead of 96 lit applied water volumes, the maximum movement on the soil surface and vertical movement which are about 144 and 72 cm respectively belong to the emitters with discharges of 24 and 4lit.hr^{-1} respectively. On the basis of assessment of the equations instead of different volumes of water irrigation, it was seen that if the applied water volume was more than 36 lit, the impact of emitter discharge on the water distribution is significant, and whenever the discharge goes up, the movement ratio in the horizontal and vertical movement decrease. Accordingly, resulted equations were suitable instead of certain period of emitter performance so that the verification of the results will be proved. Hence, the period of irrigation for per kind of the emitter should be according to fourth row of Table 2.

Table2. The vertical and horizontal advance equations of wet barrier instead of different periods

q (lit/hr)	Vertical advance Equation of wet barrier	Horizontal advance Equation of wet barrier	t≥ (hr)

4	$Z_f = ۲۱.۶۷e^{-۰.۰۲۲۶t} r = ۰.۹۹۰$	$D_f = ۱۸.۱۲e^{-۰.۰۳۸۶t} r = ۰.۹۹۷$	t≥9
8	$Z_f = ۲۲.۶۹e^{-۰.۰۸۳۶t} r = ۰.۹۷۹$	$D_f = ۵۶.۸۶e^{-۰.۰۷۱۶t} r = ۰.۹۹۵$	t≥4.5
24	$Z_f = ۲۸.۰۷e^{-۰.۱۳۱۶t} r = ۰.۹۹۵$	$D_f = ۱۱۰.۶e^{-۰.۰۶۶۶t} r = ۰.۹۹۶$	t≥1.5

On the basis of the case Figs, the moisture plan being stretched in the upper half in the comparison with horizon in the comparison with lower half as the maximum horizontal movement was done in the depth of 10 to 30 cm.
The cause of this issue comes back to the soil texture.
According to the results of sampling from the sail up to the depth of 120 cm, the soil texture was sandy-loom, and on the basis of Table 1, if the depth of the soil increases, the percent of clay will be decreased, and the percent of sand will be increased so, firstly the shape of the wet bulb has a more wetted width, and if the depth goes up, the ratio of the width has decreased, and the depth of movement will be increased.
Li et al (2004), Al-qinna and Abu-Awwad (2001), got the same results with the application of water volume of irrigation 6 and 24 lit respectively.

Table3. The irrigation volume instead of different periods of per emitter performance

q (lit/hr)	t (hr)	V_w (lit)
4	4	16
4	8	32
4	12	48
4	16	64
4	20	80
4	24	96
8	2	16
8	4	32
8	6	48
8	8	64
8	10	80
8	12	96
24	1/5	36
24	3	72
24	4/5	108
24	6	144
24	7/5	180
24	9	216

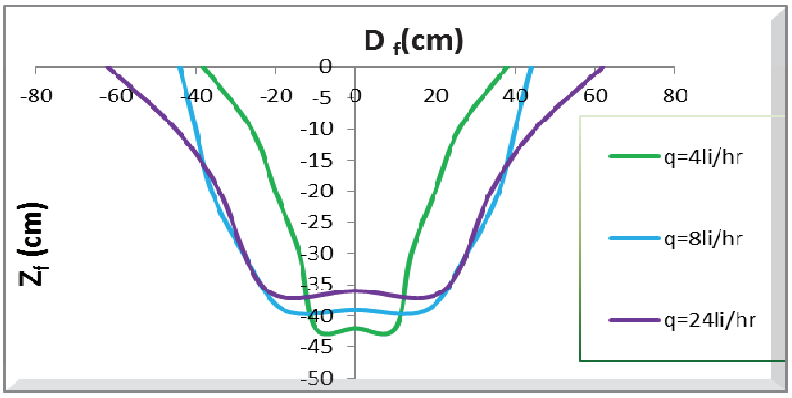

Figure1. The comparison of profile variation of moisture plan, the applied water volume of 48lit

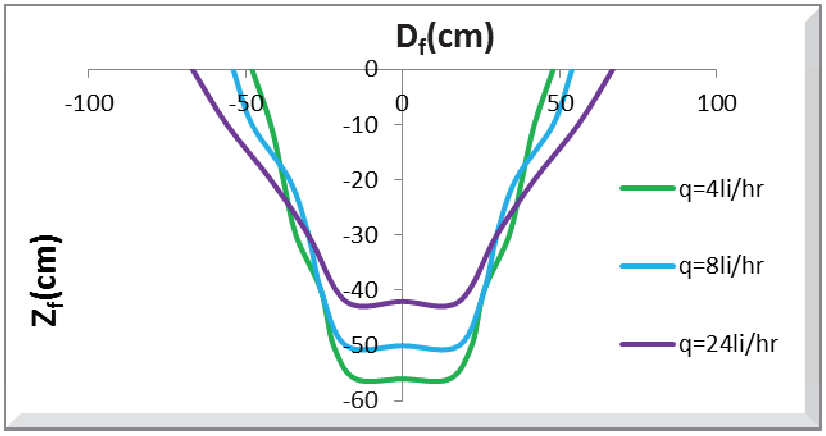

Figure2. The comparison of profile variation of moisture plan, the applied water volume of 72lit.

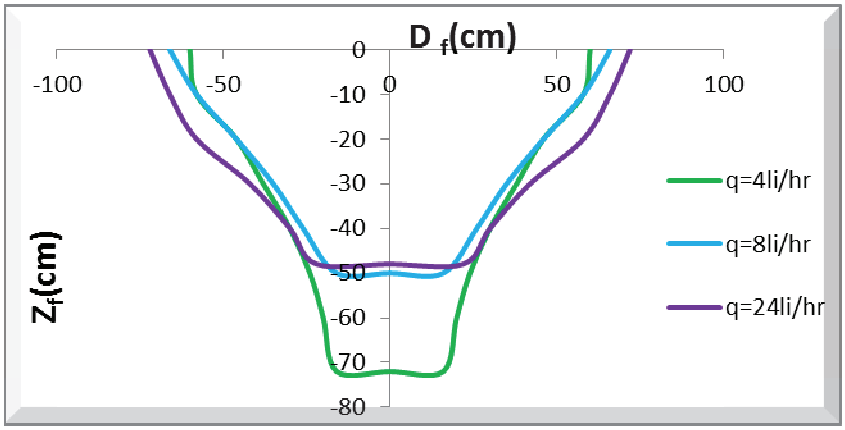

Figure3. The comparison of profile variation of moisture plan, the applied water volume of 96lit.

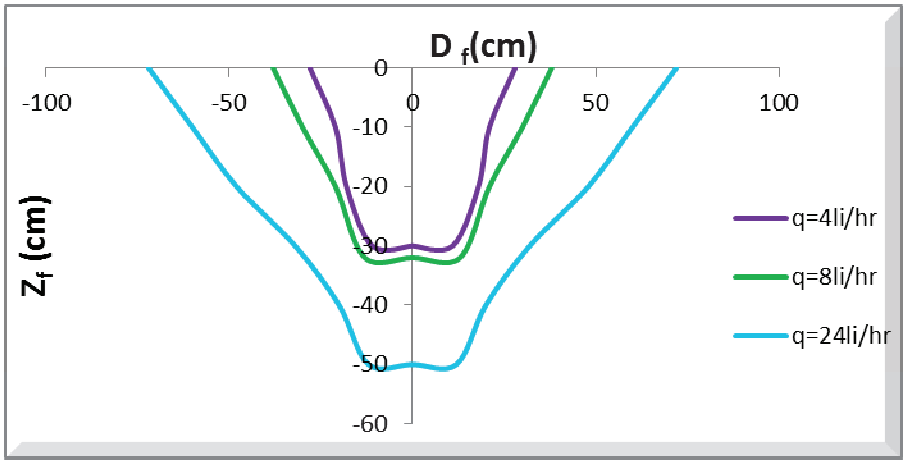

Figure4. The comparison of profile variation of moisture plan in the different emitters (The period performance of 4hr)

In order to evaluate the effect of discharge and applied water volume on the distribution of wetting plan of the emitters in the horizontal and vertical directions, three period of performance of 4, 8, and 12 hour were selected for the emitters. Also, the variation of moisture advance in the horizontal and vertical direction was assessed Figure 4, 5, and 6.

According to the Figs 4,5and6, it is seen that the wetting plan of soil was the same nearly for three amounts of emitter discharge and the expansion of wet bulb is more in the emitters with higher amount of discharge and applied volume. On the basis of the Figs4, 5 and 6 the different of advance is insignificant in the horizontal and vertical directions with the emitters of 4 and 8 lit.hr^{-1}, but the difference becomes more with the emitters of24 lit.hr^{-1}.
It is noticeable that the trend has continued with increasing the period of emitter performance. According to the Figs 4, 5, and 6 which include the drawing of lines of co-moisture for different discharges in the different periods, it is seen that with increasing period, the plan of lines of co-moisture is expanded. Moreover, with passing the time from the beginning of irrigation, the plan of moisture advance which belong to the discharges of 4, 8 lit.hr^{-1}, are closer to the each other's.
Alikhan et al (1996) and Rahimzadegan (1997), achieved the same result in this field.

Conclusion

According to this study which is on the basis of field trials, the advance ratio of wet barrier is really important, and it helps designing of irrigation network. If the dimensions of wet bulb are determined, the maximum diameter of wetting with considering the applied discharge amount instead of different periods of irrigation can be determined.

Finally on the basis of the area which is wetted by the emitter with the certain discharge, the best distance between the emitters can be determined and the amount of wetted depth of wet bulb instead of different amounts of discharge which are under the experiment can be achieved instead of different periods of irrigation. It was concluded that instead of a constant volume of water irrigation, if the amount of discharge increase from the 4 to 8 and 24lit.hr^{-1}, the wetted diameter and depth of soil will be increased and decreased respectively.

Also, if the period of irrigation instead of different amounts of discharge is gone up, the dimensions of wet bulb and in conclusion the volume of wetted soil become increased.
Moreover, if the discharge and applied volume of water increase, the ratio of wetted volume of soil wet bulb volume has an increasing ratio and the case water volume distribute in the less time in proportion to the emitter with less discharge.

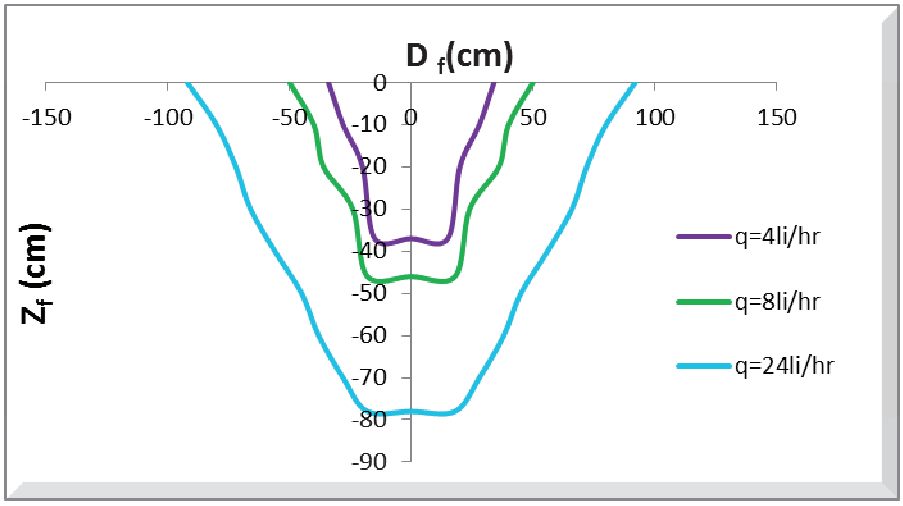

Figure5. The comparison of profile variation of moisture plan in the different emitters (The period performance of8hr)

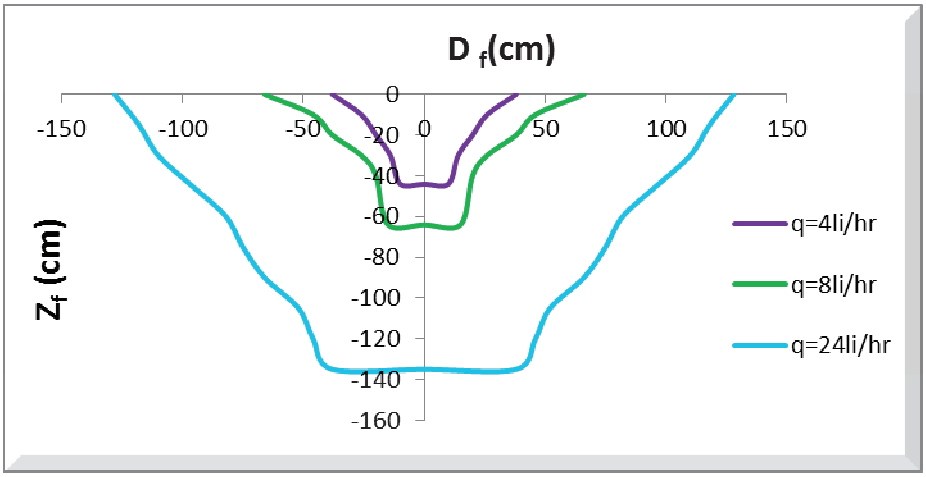

Figure6. The comparison of profile variation of moisture plan in the different emitters (The period performance of12hr)

The evaluation of amount instead of different amounts of irrigation water volume shows that if the volume of applied water is more than 36 lit, the effect of discharge amount of emitter on the water distribution is significant, and with increasing the discharge, the amount of advances will be increased and decreased in the horizontal and vertical directions.

Soil texture is one of the most important factors, or sometimes it can be said the most important factor which has effect on the wet bulb shape in the designing of drip irrigation. The wet bulb has many differences from a soil to another soil. Moreover, the formation of wet bulb depended on the amount of clay or sand in the soil texture so that it is long and thin in a sandy soil, and small and wide in a clay soil.

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