MODEL OF THE SOIL WETTING SHAPE UNDER DRIP IRRIGATION ON SLOPING LANDS BY USING DIMENSIONAL ANALYSIS TECHNIQUE

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ABSTRACT

A little number of studies has been done concerning slope effect in wetted onion-shaped. And no relation has been presented to estimate it. In the present research, a series of farm experiments in treatment and necessary and enough repetitions conducted and collecting experimental data, and analyzing them and using dimensional analysis technique, an equation presented to estimate distribution of water in the soil diameter which is function of dropper discharge, infiltration rate of water in soil, volume of irrigation water and slope of lands. The performance Evaluation of the model was carried out with statistical parameters, by maximum error (MXE) mean error (ME) and root mean square error (RMSE). Optimal quantity of error mean square error is zero and it is when all of predicted quantities and measurement are equal to each other. Quantity of this index is 0.043.And this is representative of well adaptation between measured quantities and simulated quantities. Also, maximum error which its optimal quantity is zero and its high quantity is representative of the worst state of model performance and quantity of this index is 0.027 therefore; it is a good representative of model work. The minimum quantities of error is 0.063 and its quantity is in relatively good area. Statistical comparison indicated that the model can express the wetted soil shape well. Thus, in brief, we can say that presented equation is able to satisfy for soil with a specific texture, emitter with specific discharge and required water volume for irrigation and land with different slopes, wetted soil diameter and consequently its wetted area with high accuracy.

Introduction

World irrigate lands area is about 17 percent of all agriculture lands. About 34 percent of world's food provide in this section. Most of lands irrigate in surface method. Surface irrigation efficiency average and its traditional type does not exceed 35 percent. Lowering surface efficiency is the most effective factor of farmer's dismiss from surface irrigation method and their turning to under pressure irrigation method. Trickle irrigation has received high welcome in the recent years.

The partial soil wetting pattern by micro irrigation requires assessment of the percentage of soil volume that is wetted (Sne. Moshe. 2006). Designing and planning trickle irrigation without enough information from moisture distribution information from moisture distribution in the soil do not result in the correct result. Distance between emitter on lateral pipe and distance of lateral pipes from each other should be determined based on adequacy degree of wetted soil diameter by emitters. Duration of irrigation also is depends on the fact that at what time after

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commencement of irrigation, the wetting front reaches depth of plant's root or a multiple of it. Distance of outlets, discharge rate, and time of irrigation in drip irrigation have to determine so that volume of wetted soil is close to volume of plant's root as much as possible. There is not one practical and suitable method for calculating wetted area. And it will be satisfied by presented table by Jack Keller (1984) and it happens concerning sloped lands of water movement in soil profile in the direction of slope and roots above section of dropper receive a little water and roots of the below section of soil profile receive more than water which considers as
wasted water. Volume and wetted soil surface and moisture onion shape
depends on different factors including soil texture and layering, soil homogeneity, dripper flow rate, primary moisture of soil, consumption water, and land slope. Keller and et al have presented a table for estimate areas wetted in level lands for dripper by 4 – L/hr but concerning sloped lands, table or and practical relation has not been presented to satisfy areas wetted, but several studies have been conducted.

Ali khan and et al (2006) studied water distribution in soil profile under point source and concluded that in low dripper flow rate with increase dripper flow rate and volume of irrigation water, areas wetted and vertical depth increases but in more dripper flow rate horizontal forwarding increased more than vertical depth.

In starting irrigation, wetted front move in horizontal forwarding has been more than vertical forwarding for all discharge, But gradually, movement of forwarding along with time has decreased and in the meantime of stopping water giving, wet front movement do not stop and vertical forwarding speed is more than horizontal forwarding.

Hachum A.Y (1973) evaluated effect of irrigation water volume on wetting front in one point source, and observed that moisture pattern can be in one half ellipsoid shape. According to researches that Hoover.j (1985) one about way of distributing moisture in the sloped lands understood that in sloped ranges in the meantime of irrigation, current horizontal component exists either in surface or under surface. It is effective and vertical component decrease with increase in slope and with decrease in vertical component. Philip, J.R.,J.R., Knight (1977) studied Steady infiltration flow with sloping boundaries, they presented analytic relations for pointed feed source in the soil surface, and assumed that moisture development take place in the gravity direction or vertical direction. Sharifbian hagh and et al (1999), in research on 4 soil texture with zero, 5 and 10 percent slopes and 3 treatment 4, 8 and 12 liter per hour dropper ,measured wet section due to slope and also wet soil diameter in the above and bottom of laying dropper and they were compared.

Mirzaei and et al (2006) presented relations to estimate diameter and wet soil depth for two pointed, linear feed source state and three different texture of soil. In the presented relations, diameter and wet soil depth are function of dropper discharge, irrigation time, hydraulic conductivity of soil. Keller and karmeli (1974) presented and experimental relation to satisfy or estimate wet soil diameter. Healy and Warrick (1988) Presented an experimental relation to estimate wet soil diameter which is function of factor time dimensionless. B. Zur (1995) assumed that the volume and geometry of the wetted soil under a point source is best represented by a truncated ellipsoid. Shu Qiaosheng and et al (2007) presented a relation for surface trickle irrigation in wetting front simulation around porous pipe in sub-surface irrigation by using dimensional analysis. Considering previous studies, it is observed that there is not an appropriate and practical relation for calculating dropper wet area in the sloped lands and the objective of this study is simulation of wet front pattern in trickle irrigation in sloped lands and it development one simple analytic model from soil moisture front shape.

Material and Methods

To study dropper discharge on moisture front three treatment of 2, 4 an 8 liter/ hour were choose and In this research, automatically variable orifice emitter were used. These emitters have constant discharge in range of pressure 0.4 to 5 atmosphere. Discharge in each one of emitter measured in volumetric analysis method and to

ensure from nonclogging of emitters, potable water also used.
To determine effect of consumption water volume on wetted soil area, 5 volume of water 2, 4, 8, 16 and32 liters were studied. To determine irrigation time on wetted soil area 3 duration time, 1, 2 and 4 hour were studied. All of the above treatment were experimented in 4 lands, level and slope, 0, 5, 15 and 20 percent.
Soil infiltration rate were measured by multiple cylinder method and also gulf permeability meter were measured, Basic infiltration rate or final infiltration rate to double ring infiltrometer method was 1.2 cm/hr and in gulf permeability meter method was 1.04cm/hr. Experiments 4 discharge of emitters, 3 irrigation duration time and 4 slope of lands were measured. Names of treatment tests were determined respectively slope, discharge and irrigation time in table number 1.

Table 1. Treatments tests in slope field (S=15%).

Discharge Q (L/hr)	Irrigation Times / durations(hr)		
	1	2	4
2	$S_{15}Q_2T_1$	$S_{15}Q_2T_2$	$S_{15}Q_2T_4$
4	$S_{15}Q_4T_1$	$S_{15}Q_4T_2$	$S_{15}Q_4T_4$
8	$S_{15}Q_8T_1$	$S_{15}Q_8T_2$	$S_{15}Q_8T_4$

For example $S_{15}Q_8T_2$ is representative of experiment in land slope of 15 percent by emitter discharge 8 L/ hr and time of irrigation is 2 hours.
After started experiment, in different times, wetting front in soil surface were measured in different points and total shape of wetted surface were determined then 24 hours after conducting experiment when wetting front forwarded totally in the soil by digging pit to the end of moisture onion, wetting front state measured and studied in different points.

Figure 1. Vertical section of soil profile after irrigation in S25Q4T2 treatment (right) Site of farm experiments (left).

Quantities of wetted soil diameter per different discharges, different practical water volume, soil infiltration rate, irrigation different times in different slopes, were measured and one sample of them is presented in Fig 2.

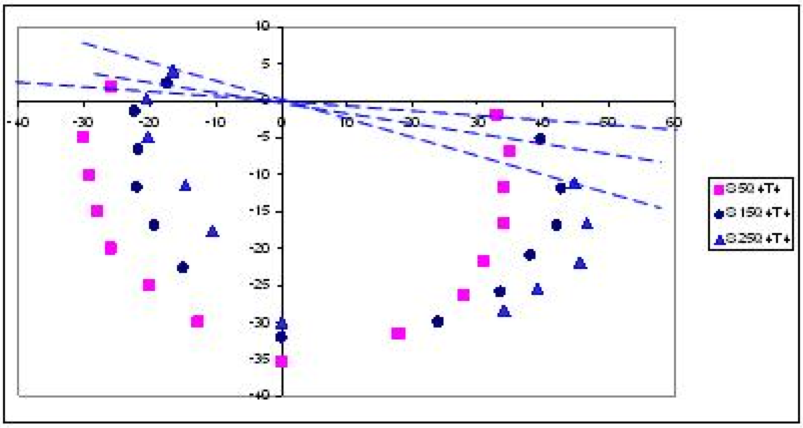


Figure 2. Measured wetting front by emitter 4 L/hr in different slopes**.**

Theory:

Based on rules governing on water movement in the soil. Inference is that geometrical shape of wetted soil volume from the one pointed feed source at the end of irrigation depends on soil infiltration rate (I_b), dripper flow rate (q), total water entering the soil (V), depth (Z) and diameter of wetted soil (d). Diameter and depth of wetted soil are two important characteristics for describing wetted soil volume. Wetted soil diameter around emitter is function of emitter discharge, soil infiltration rate, application water volume and wetted soil depth. Thus, it can be write:

$$d = f(q, I_b, v, z) = 0 \qquad (1)$$

Dimensions of variables in equation (1) could be expressed as follows:

$$d = f(q, I_b, v, z) = 0 \qquad (2)$$

$$q = L^3.T^{-1}$$
$$V = L^3$$
$$Z = L$$
$$q = L$$
$$I_b = L.T^{-1} \qquad (3)$$

Here, there is 5 dimensional variable (I_b, q, v, z, d) and two main variable (L,T). n=5 and m=2. thus, n-m=3,therefore there are 3 dimensionless numbers and basic dimensions of q and z chooses and equation 2 changes:

F (II_1 , II_2, II_3)= 0 (4)

Here, II_1, II_2, II_3 are dimensionless numbers, they can be substituted by L,T. Now for II_1 we can write:

$$II_1 = V.q^a.Z^b.L^3.(L^3T^{-1})^a.L^b = L^{3+3a+b}.T^{-a}$$
$$L: 0 = 3 + 3a + b$$
$$T: 0 = -a$$

(5) (5)

By solving the above equations, a= 0 and b=-3 are obtained and II_1 will be as follows:

$II1=V/Z^3$ (6)

Similarly, II_2 and II_3 are as follows:

$II_2=d/z$ (7)

$II_3=z\ (I_b/q)^{1/2}$

Volume dimensionless $V^*$and diameter dimensionless d^*can be obtained from combination of dimensionless terms, II_1, II_2 and II_3 which are as follows:

$$V^* = II_1.II_3 = V/Z^3.Z(I_b/q)^{1/2} = V/Z^2.(I_b/q)^{1/2} \quad (8)$$

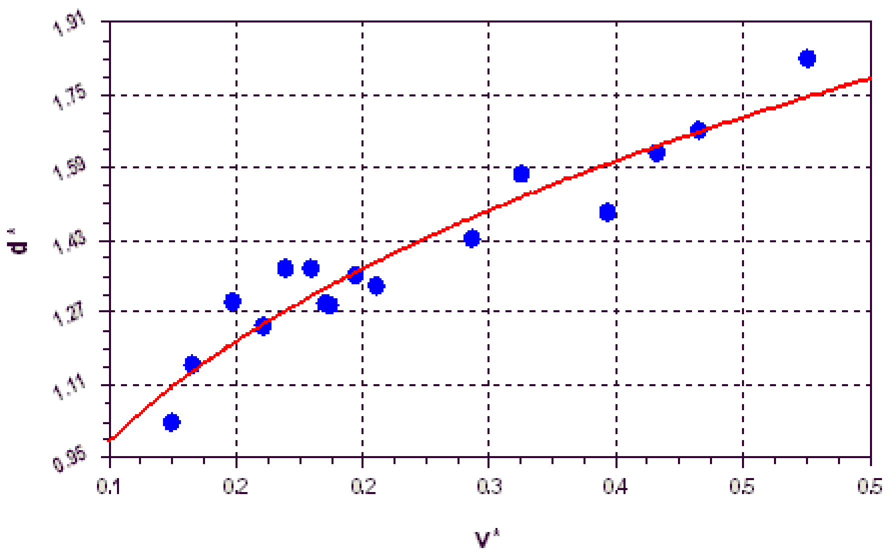
$$d^* = \sqrt{\Pi_3.(.\Pi_2)^2} = \sqrt{z}.(I_b/q)^{1/4}.\sqrt{(d/z)^2} = d.(I_b/q)^{1/4}.\sqrt{z}/z$$

Results and Discussion

B.Zur and et al (1996) showed that between d^* and V^*, there is a relation which is as follows:

$$d^* = F(v^*) \quad (9)$$

Relationship between d^* and v^* has been shown in Fig 3.



Figue 3. Relationship between V^* and d^* quantities

By drawing quantities of V^* against d^* it was observed that index relationships can be established among them as follows:

$d^* = m.(V^*)^n$

M=2.2, n=0.3 (10)

Substituting quantities V^* and d^* from equations 8 and 9 in equation 10, it can be written as follows:

$$d = (I_b/q)^{-1/4}.\sqrt{z} \times F\left[(v/z^2).(I_b/q)^{1/2}\right] \quad (11)$$

Wetted soil diameter on slope land

On the other hand, Relationship between wetted soil diameters with under study different slopes after designing will be as follows:

$$ds = d + b.s + c.s^2 \quad (12)$$

In this equation, s is slope land. ds is wetted soil diameter on slope land,

d is wetted soil diameter in level land and a, b and c are fixed coefficients of equation. In case level land , slope is zero, above equation changes as follows:

$$d_s=d \qquad (13)$$

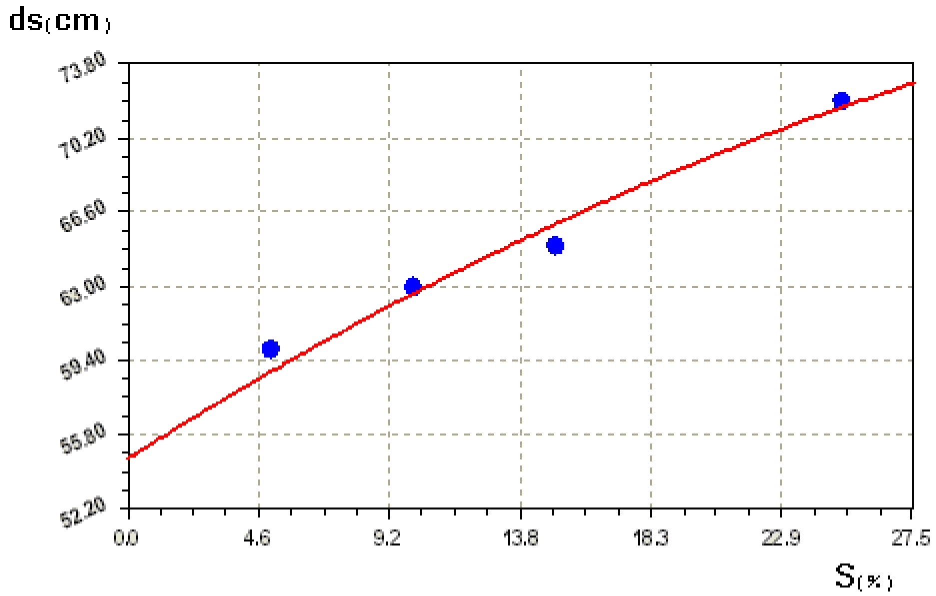


Figure 4. Relationship between S(%) and ds

Equation (11) in the sloped land can be written as follows:

$$d_s=(I_b/q)^{-1/4}\times\sqrt{z}\times F[v/z^2.(I_b/q)^{1/2}]+bs+cs^2$$

(14)

$$d_s=(I_b/q)-^{1/4}\times\sqrt{z}\times 2.2[v/z^2.(I_b/q)1/2]^{0.33}+$$
$$0.94.S+1.34.S^2$$

quantities of measured wetted soil diameter and simulated quantities in Fig. 5 are shown.

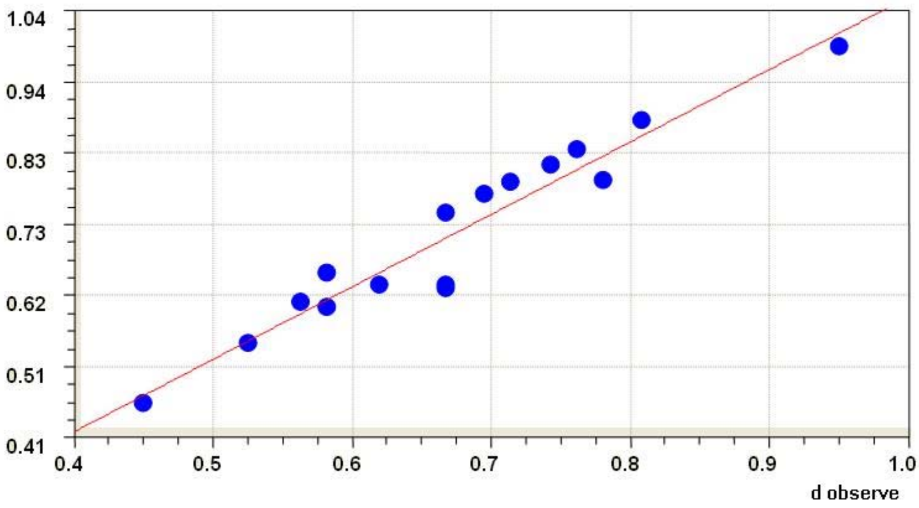


Figure 5. Relationship between d measured and d estimated

As it is observable, there is a good agreement between measured and simulated quantities from model.
Estimating wetted soil diameter, the possibility of calculating wetted soil surface provides. Wetted soil surface minimum in trickle irrigation take place in a depth between 15 to 30 cm under soil surface. In this research, wetted soil area has been measured in soil surface and in different depths of soil. Quantities of maximum wetted area have been showing in different depths. And relation between them is presented in table number .3 and Fig .6

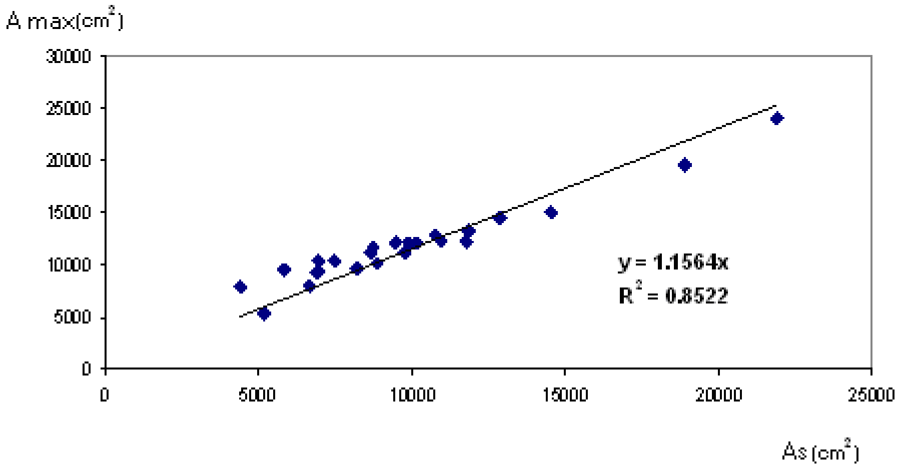


Figure 6. Relation between maximum wetted areas in different depth of soil to wetted area in soil surface

Evaluation of simulation model

Evaluation model performance by error maximum parameters (MXE), error average (RMSE) conducts which calculate as follows: (willmott, 1982).

$$MXE = /(o_i - p_i)/$$
$$RMSE = \sqrt{\sum (o_i - p_i)2 / N}$$
$$ME = \sum (f_i - e_i) / N$$
$$ME = \sum (o_i - p_i) / N \qquad (15)$$

where, N is umber of measured value, o_i is the ith simulated data ,p_i is the ith observed data .These three statistical index applies to measure model performance power. MXE may be considered as a local indicator of goodness of the estimates. But ME is the prescience and existence of one bias and deviation of evaluated quantities from valued quantities will be specified. And RMSE presents one idea from dispersion between model data and observational data.

Conclusion

A set of farm experiments conducted in treatment and they were repeated necessarily and in enough way and collecting experimental data and their analysis and using dimensional analysis technique, equation presented for estimating wetted soil diameter which is function of soil infiltration rate, discharge of emitter , volume of irrigation water and land slope. Evaluation of model performance conducts by error maximum parameters (MXC) and error average (ME) and error square average root. Optimal quantity of average error square root is zero and it is when all of predicted quantities an measurement are equal to each other. Quantity of this index is 0.043 and it presents good adaptation between measured and stimulated quantities. Also, absolute error average which is its optimal quantity is zero.

And its high quantity is representative of the worst model performance state. Quantity of this index is 0.027. and thus, it is a good representative of model work and maximum quantity of error is 0.063 and its quantity is in the limitation of relatively good way. But some errors especially are existed in wet soil diameter maximum. Due to complexity of water movement in soil and slope factor in trickle irrigation, there is some unsurely in simulation, and necessity of comprehensive study includes some other effective factors which should be done in the future. Thus, briefly it can be said that presented equation is able to specific texture of soil ,emitter with certain discharge, required water volume for irrigation and land with different slopes, wetted soil diameter and following it wetted area should be determined accurately.

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