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# Mathematical Model for Maximizing Irrigation Water Benefits

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**Abstract**

Predicting impact of alternative management for enhancing the influence of soil parameters and water management on crop production is concerning in scientific community. This paper emphasis on the soil moisture behaviour at different profiles and their relation with soil temperature and dripper's discharge using a two boxes with diminution (1m X 1m X 1m) for cultivate Fenugreek (*Trigonella foenum-graecum L.,Fam. Fabaceae*) under sandy soil texture with test a two factors. First factor is the timing of irrigation (IRR1) at the morning and (IRR2) at the evening . Second factor is adding compost (C1) (6 ton/fed) and (C2) without compost. Experiment found out that the yield recorded highest production under C1 by 847% comparing with C2 without significant influence for the timing of irrigation. Moreover; using Robust Methods to determent the mathematical relationship with different parameter [soil temperature(C°) for different depths and water quantity (L/day) ] to estimate the ratio of soil moisture. Furthermore; using (matrix) Cramer's method to predict any of these parameters by know one parameter.

**Keywords:** soil temperature, soil moisture, timing of irrigation and mathematic relationship.

## Introduction

Agriculture is an essential industry supporting the increasing population on our planet Modern technology has greatly promoted agricultural ductivity by means of genetic improvement, fertilization, pesticide applications and irrigation water management models.

Irrigation water management (IWM) is the act of timing and regulating irrigation water application in a way that will satisfy the water requirement of the crop without wasting water, soil, and plant nutrients and degrading the soil resource. Moreover; the long existing rule of thumb for soils has been that most crops should be irrigated before more than half of the available soil water in the crop root zone has been used. It has also been demonstrated that certain crops respond with higher yields and product quality by maintaining a higher available soil-water content. Policies of water resource management and inexpensive energy have encouraged many irrigators to adopt irrigation practices consistent with an abundant and inexpensive water supply. Typically, these practices were designed to avoid moisture stress and strive for maximum yield.

Moisture and water distribution under drip emitters varies both spatially and temporally (Rolston et al., 1991). Furthermore, soil moisture depletion under drip irrigation has been demonstrated to a depth of 120 cm (Stevens and Harvey, 1996).

On the other hand Irrigation during the summer months increased evaporative cooling and improved soil-heat transfer (Wierenga et al. l97l). After an irrigation event (or rain), there is a significant reduction in maximum soil temperature at shallow soil depths (Singh and Sandhu 1979). However, irrigation increases soil temperature at greater depths, thus, providing a more favourable environment for biological activity (Leonard et al. l97l). so influence in crops or plant productivity.

For instance, Fenugreek (Trigonella foenum-graecum L.,Fam. Fabaceae) is one of the oldest medicinal plants and spice. Fenugreek is believed to be native to the Mediterranean region (Petropoulos, 2002), Applications of fenugreek were documented in ancient Egypt. In modern Egypt, fenugreek is still used as a supplement in wheat and maize flour for bread-making (Ionescu and Roman, 2013).

Yield of fenugreek seed showed on different dates differed in both seasons, sowing in the first two weeks of April resulted in considerably higher yield compared to sowing at the end of April and during May, (Radojka and Jevdjovic, 2007).

Finally; using mathematical models for the simulation of soil water movement in the unsaturated zone is a precise approach to rational irrigation and the key to irrigation water saving. (H. Georgoussis et al., 2007); Most of the mathematical models are simple water balance applications in contrast to the detailed mathematical ones that solve the partial differential equation This partial differential equation describes the movement of water through unsaturated porous media, subject to appropriate boundary and initial conditions, while it accounts for the water uptake from the plant roots. The solution of this equation provides the depth distribution of soil water in a cultivated soil at one point in time.

The objectives of this study were to 1) determine the soil moisture and soil temperature behaviour under drip irrigation system to irrigate a Fenugreek plant. 2) Obtain a mathematical model describes this relation which; contribution for maximizing irrigation water management.

**Material and methods**

The experiment was carried out in the cairo in north Egypt (latitude 30°07’40.42" N; longitude 31°20’53.33" E) in 2014 and 2015. This is a semi-arid area with a Mediterranean climate of hot, dry summers and wet winters. The mean annual air temperature is 21.4 °C, with the highest (34.6 °C) in July. Annual Penman-Montheith reference evapotranspiration amounts to 1869 mm, the highest of 234 mm occurring in July.

Furthermore; [fig(1)].using a two boxes with diminution (1m X 1m X 1m) for cultivate Fenugreek (*Trigonella foenum-graecum L.*,Fam. Fabaceae) on April under sandy soil texture , none saline, and none calcareous. Silt and clay content are quite low there for both field capacity and available water are very low 6.2 % and 5.1 %. Those boxes equipped with drip irrigation system (4L/h).

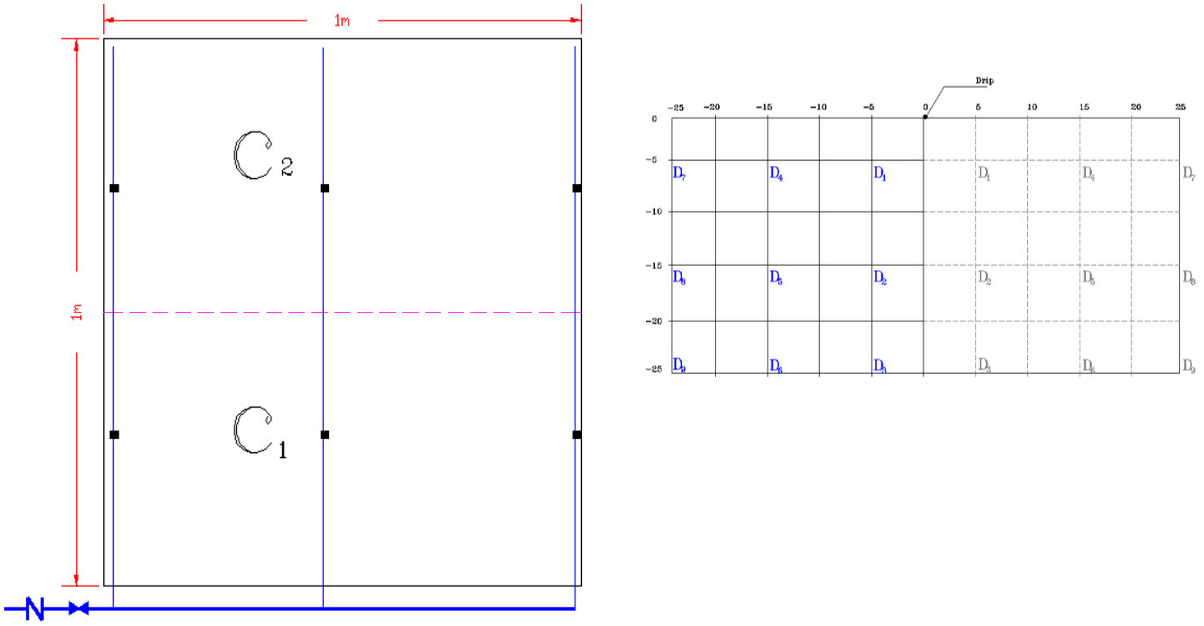


Figure 1. Layout of distribution factors and measuring points

After that; dividing the box into two section first for applying compost (C1) (6 ton/fed) and the other (C2) without compost then start irrigation treatments (IR1) for irrigating first box at the morning and (IR2) for irrigating second box at the evening as a perpendicular on the compost factor.

The total water applied for Fenugreek is (3281.15 $m^3$/fed) which distributed throw growing season to (99.75mm, 217.6mm, 354.37mm and 109.5mm) from April to July respectively.

Analyses of soil and some physical and chemical analyzed according to Martin, (1993). The soil of the experimental site is sandy texture, none saline, and none calcareous. Silt and clay content are quite low there for both field capacity and available water are very low 5.6 % and 4.5 %.

The data were analyzed using the three way ANOVA split plot procedure with Duncan's HSD test at $p<0.05$ using the NCSS10.0.05 System software.

## 1. Measurements and calculations

In addition; using (TDR300) Soil moisture meter to measure soil water content and soil temperature for horizontal and vertical axis for left and right sides from dripper point for instance $D_n(X_n,Y_n)$ [ $D_1$(5,-5)-$D_2$(5,-15)-$D_3$(5,-25)-$D_4$(15,-5)-$D_5$(15,-15)-$D_6$(15,-25)-$D_7$(25,-5)-$D_8$(25,-15)-$D_9$(25,-25)] as shown in fig (1) .

Mathematic model using “Robust Methods” Portnoy S. and He, X.(2000) Provides an alternative to least squares regression that works with less restrictive assumptions. Specifically, it provides much better regression coefficient estimates when outliers are present in the data. Outliers violate the assumption of normally distributed residuals in least squares regression. They tend to distort the least squares coefficients by having more influence than they deserve. Typically, you would expect that the weight attached to each observation would be about 1/N in a dataset with N observations. However, outlying observations may receive a weight of 10, 20, or even 50 %. This leads to serious distortions in the estimated coefficients. Robust method is an iterative procedure that seeks to identify outliers and minimize their impact on the coefficient estimates

Several families of robust estimators have been developed. This estimator minimizes the sum of a function *p* (0) of the residuals. That is, these estimators are defined as the β’s that minimize.

$$\min_{\beta} \sum_{j=1}^{N} \rho\left(y_{j-}x'_j\beta\right) = \min_{\beta} \sum_{j=1}^{N} \rho(e_j)$$

M in M-estimators stands for maximum likelihood since the function $\rho(\cdot)$ is related to the likelihood function for a suitable choice of the distribution of the residuals. In fact, when the residuals follow the normal distribution, setting results in the usual method of least squares $p(\mathrm{u})= 0.5\mathrm{U}^2$ Unfortunately, M-estimators are not necessarily scale invariant. That is, these estimators may be influenced by the scale of the residuals. A scale-invariant estimator is found by solving .He, X. and Portnoy, S.(1992)

$$\min_{\beta} \sum_{j=1}^{N} \rho \frac{\left(y_{j-}x'_j\beta\right)}{s} = \min_{\beta} \sum_{j=1}^{N} \rho(\frac{e_j}{s})$$

Where **S** is a robust estimate of scale. The estimate of **S** is

$$S = \frac{median\left|e_j - median(e_j)\right|}{0.6745}$$

This estimate of S yields an approximately unbiased estimator of the standard deviation of the residuals when N is large and the error distribution is normal. The function

$$\sum_{j=1}^{N} \rho\left(\frac{\left(y_{j-}x'_j\beta\right)}{s}\right)$$

Is minimized by setting the first partial derivatives of ρ(·) with respect to each to zero which forms a set of p + 1 nonlinear equations $\beta i$

$$\sum_{j=1}^{N} X_{ij}\omega\left(\frac{\left(y_{j-}x'_j\beta\right)}{s}\right) = 0; \quad i = 0,1,\dots\dots\dots,p$$

Where $\omega(u) = p'(u)$ is the influence function

1.1 Cramer's method.

Cramer's rule is an explicit formula for the solution of a system of linear equations with as many equations as unknowns, valid whenever the system has a unique solution. Zhiming Gong,*et al* (2002)**;** It expresses the solution in terms of the determinants of the square coefficient matrix and of matrices obtained from it by replacing one column by the vector of right hand sides of the equations

General case:

$$X_i = \frac{\det(A_i)}{\det(A)} \qquad i = 1,\dots\dots\dots\dots\dots,n$$

And about the determinant of a matrix for :

$$A_{ij} = \begin{pmatrix} a_{1,1}\dots\dots a_{1,j-1} & a_{1,j+1}\dots\dots\dots\dots a_{1,n} \\ \\ a_{i-1,1}\dots\dots a_{i-1,j-1} & a_{i-1,j+1}\dots\dots\dots\dots a_{i-1,n} \\ a_{i+1,1}\dots\dots a_{i+1,j-1} & a_{i+1,j+1}\dots\dots\dots\dots a_{i+1,n} \\ \\ a_{n,1}\dots\dots a_{n,j-1} & a_{n,j+1}\dots\dots\dots\dots a_{n,n} \end{pmatrix}$$

The determination can be calculated with this formula.

$$\det(A) = \sum_{j=1}^{N} a_{i,j}(-1)^{i+1}\det(A_{i,j})$$

**Result Discussion**

1. Yield production

As shown at fig (2) data indicated that there is a significant effect of yield production under (C1) which recorded 847% comparing with (C2). on the other hand there is no any significant influence in yield production whenever applied (IR1) or (IR2) both of them achieved 790kg/fed as an average.

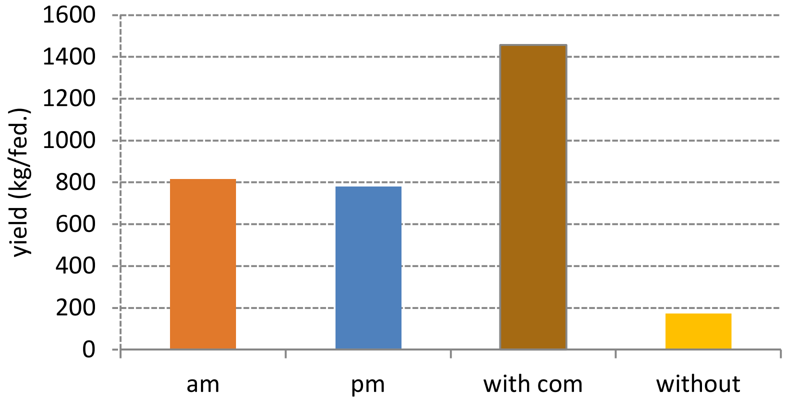


Figure 2. Influence of treatments on yield production.

2. Soil temperature distribution.

As shown it table (1) the data present that there are a significant effect for (IR1) and (IR2) on soil temperature on various depths whatever near or far from dripper at May and June however at first month for seedling (April ) the significant influence recorded at ($Td_1$ & $Td_2$ and $Td_3$) and there is no any significant disparate for data at ($Td_4$,$Td_5$,$Td_7$,$Td_8$) this may related to that applied low amount of water at the first stage thus the contribution of their influence appeared at the nearest distance to dripper comparing with other distance which placed far from dripper. On the other hand, at ($Td_6$ and $Td_9$) data reflect a significant influence for (IR1 and IR2). May this action appeared inasmuch as they placed at the end of section thus the influence of water may appear on temperature's value comparing with $Td_9$.consequaently.

In addition, as shown in fig (3). The distribution soil temperature (DST) has a different behaviour related to IRR1 and IRR2 also C1 and C2. For instances; DST under C1 at April has high record 26C°for short distance at the IRR1treatment; furthermore, under IRR2 the same value recorded for long distance below the dripper. On the other hand, DST under C2 has patches values below the dripper whatever applying IRR1 or IRR2 treatments.

Moreover, on May the DST recorded almost a similar values among IRR1 and IRR2 treatments but between C1 and C2 treatments values has a different behaviour where under C1 the high value 30C° recorded for short distance no more than 7cm below the dripper but under C2 the same value has recorded no more than 11cm below the dripper whatever the time of irrigation.

Furthermore; on June the DST has different behaviour related the influence of treatments. For instance; after applied IRR1 under the two treatments C1 and C2 the observation of values recorded high soil Temperature 32 C° at 12 cm behind the dripper but

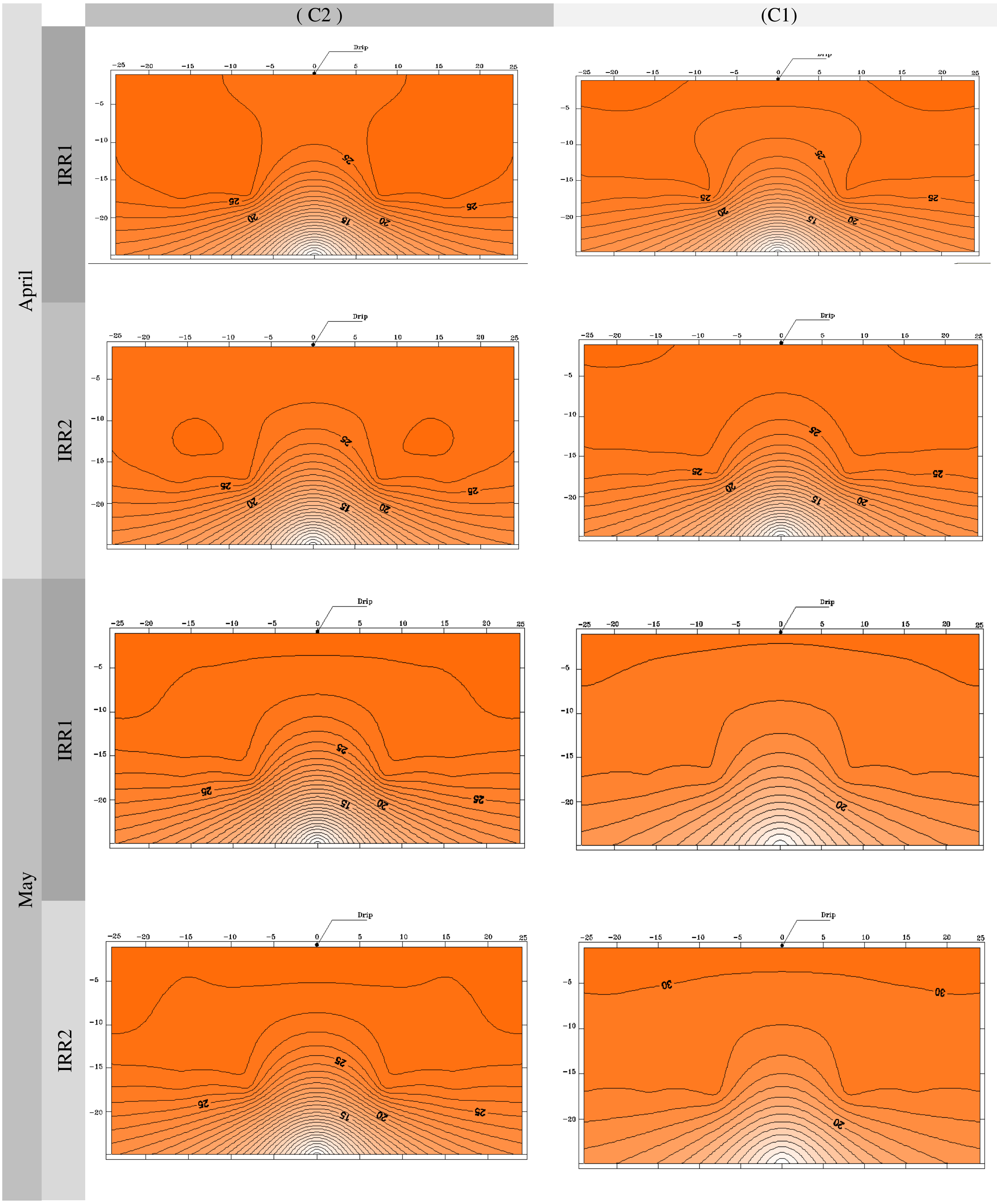


Figure 3. Influence of treatments on distribution of soil temperature.

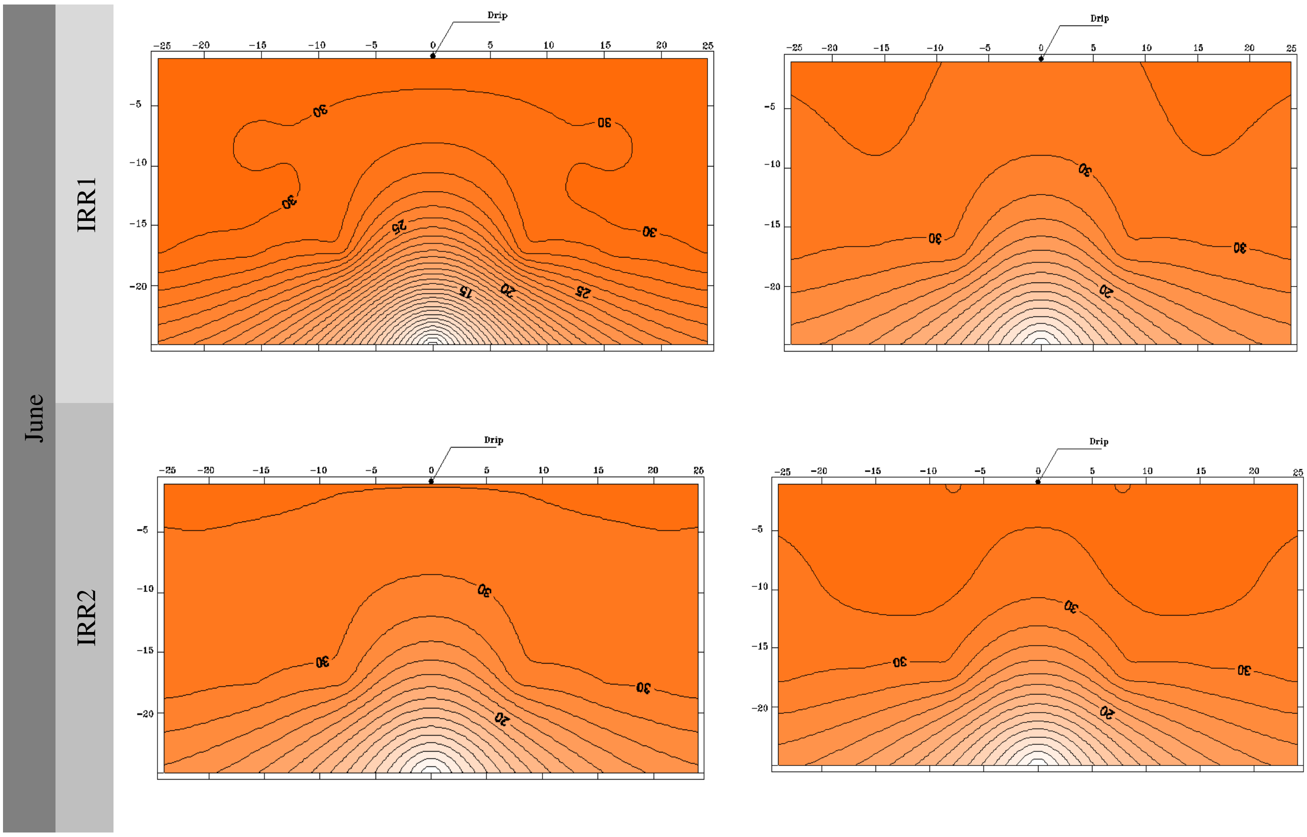


Figure 3. Continue. Influence of treatments on distribution of soil temperature.

Under C2 this value did not recorded. on the other hand; after applied the IRR2 the DST has recorded the high value 32 C° under both treatments C1 and C2 but under C1 this value observed for short distance 5 cm below the dripper compare with C2 which observed the same value for long distance 13cm below the dripper.

3. Soil moisture distribution. (SMD)

As shown it table (2) the data present that there are a significant influence for (IR1) and (IR2) on soil moisture on various depths whatever near or far from dripper at April and May however at the end of season (June ) the significant influence recorded at all depths under both treatments however at ($Md_2$ and $Md_6$ ) there is no any significant effect under treatment IRR1 and IRR2.may this data observed related to that the value for air temperature at these months was very high thus effect on evaporation from soil surface so data recorded with significant influence. in addition; at the last period of plant the the total water applied was low amount of water comparing with deferent stages of plant thus there is not significant influence for some depths ( $Md_2$ and $Md_6$).

As shown in fig (4). The soil Moisture distribution (SMD) has a different behaviour related to IRR1 and IRR2 also C1 and C2. For instances; SMD under C1 at April has a homogenous for vertical and horizontal axis comparing with SMD under C1where the water cover the long distance from dripper comparing with C2. in addition; the IRR2 recorded the high performance water distribution under C1 and C2. however; the best performance for applied IRR2 with C1. may this happened because that the irrigation action done at noon with adding some compost on soil which helping to retention the water at different depths and wide distances from dripper.

| | April | | | | May | | | | June | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | am | pm | without | with com | am | pm | without | with com | am | pm | without | with com |
| **Td1** | 26.1a | 25.8b | 26.3a | 25.6b | 29.05b | 29.3a | 27.9b | 30.45a | 29.21a | 29.35a | 28.95a | 29.61a |
| **LSD0.05** | 0.138 | | 0.215 | | 0.0801 | | 0.215 | | 0.622 | | 0.727 | |
| **Td2** | 25.8b | 26.3a | 26.2a | 25.9b | 29.5b | 29.7a | 29.35b | 29.85a | 30.25b | 31.55a | 30.1b | 31.7a |
| **LSD0.05** | 0.8 | | 1.49 | | 0.179 | | 0.124 | | 0.0801 | | 0.447 | |
| **Td3** | 26.11b | 26.7a | 26.2b | 26.6a | 31b | 31.4a | 30.7b | 31.7a | 31.05b | 32.05a | 31.25b | 31.85a |
| **LSD0.05** | 0.185 | | 0.189 | | 0.08 | | 0.124 | | 0.212 | | 0.124 | |
| **Td4** | 25.85a | 25.85a | 26.4a | 25.3a | 29.2b | 29.55a | 29.15b | 29.6a | 29.65b | 30.15a | 30a | 29.8a |
| **LSD0.05** | 0.768 | | 1.432 | | 0.196 | | 0.248 | | 0.16 | | 0.248 | |
| **Td5** | 26.5a | 26.6a | 26.7a | 26.4b | 30.15a | 31.05b | 30b | 31.2a | 30.9b | 31.9a | 30.55b | 32.25a |
| **LSD0.05** | 0.16 | | 0.124 | | 0.138 | | 0.328 | | 0.113 | | 0.124 | |
| **Td6** | 27a | 26.35b | 25.95b | 27.4a | 31.25b | 31.65a | 30.2b | 31.1a | 31.4b | 32.45a | 31.3b | 32.55a |
| **LSD0.05** | 0.113 | | 0.124 | | 0.113 | | 0.328 | | 0.0801 | | 0.124 | |
| **Td7** | 25.5a | 25.4a | 25.5a | 25.4a | 29.8b | 30.1a | 29.75b | 30.15a | 30.35b | 30.95a | 30.75a | 30.55a |
| **LSD0.05** | 0.113 | | 0.328 | | 0.138 | | 0.328 | | 0.179 | | 0.215 | |
| **Td8** | 26.35a | 26.15a | 26.4a | 26.1a | 30.5b | 30.85a | 30.25b | 31.1a | 30.75b | 31.55a | 30.5a | 30.31a |
| **LSD0.05** | 0.764 | | 1.308 | | 0.113 | | 0.248 | | 0.226 | | 0.215 | |
| **Td9** | 27.1a | 26.9b | 26.6b | 27.4a | 31.25b | 31.6a | 30.8b | 32.05a | 31.35b | 32.35a | 31.35b | 32.35a |
| **LSD0.05** | 0.277 | | 0.124 | | 0.179 | | 0.124 | | 0.113 | | 0.215 | |

Table 1. Effect of treatments factors on soil temperature distribution.

| | April | | | | May | | | | June | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | am | pm | without | with com | am | pm | without | with com | am | pm | without | with com |
| **Md1** | 13.05b | 14.25a | 12.95b | 14.35a | 13.6b | 14.6a | 13.4b | 14.7a | 12.8b | 13a | 11.65b | 14.15a |
| **LSD0.05** | 0.844 | | 1.103 | | 0.196 | | 0.215 | | 0.179 | | 0.372 | |
| **Md2** | 13.16b | 14a | 12.75b | 14.416a | 13.5b | 13.8a | 12.95b | 14.35a | 13.1a | 13.1a | 11.9b | 14.3a |
| **LSD0.05** | 0.046 | | 0.189 | | 0.138 | | 0.215 | | 0.08 | | 0.372 | |
| **Md3** | 12.816b | 13.9a | 14.16a | 12.55b | 12.85b | 14.2a | 12.55b | 14.5a | 12.3b | 12.8a | 11.85b | 13.95a |
| **LSD0.05** | 0.092 | | 0.312 | | 0.179 | | 0.124 | | 0.16 | | 0.43 | |
| **Md4** | 11.61a | 12.3a | 9.55b | 14.36a | 11.05b | 11.75a | 8.9b | 13.9a | 11.05b | 11.5a | 8.25b | 14.3a |
| **LSD0.05** | 0.774 | | 1.316 | | 0.16 | | 0.215 | | 0.179 | | 0.215 | |
| **Md5** | 11.25b | 11.9a | 9.15b | 14a | 10.75b | 11.55a | 8.6b | 13.7a | 10b | 10.3a | 13.15a | 7.15b |
| **LSD0.05** | 0.138 | | 0.124 | | 0.0801 | | 0.372 | | 0.16 | | 0.248 | |
| **Md6** | 10.95b | 11.63a | 8.93b | 13.65a | 10.45b | 10.65a | 7.9b | 13.2a | 9.7a | 9.7a | 6.6b | 12.8a |
| **LSD0.05** | 0.217 | | 0.071 | | 0.179 | | 0.124 | | 0.113 | | 0.328 | |
| **Md7** | 10.65b | 11.85a | 8.8b | 13.7a | 10.1b | 11.7a | 8.5b | 13.3a | 10.65a | 10.4b | 7.5b | 13.55a |
| **LSD0.05** | 0.896 | | 1.1178 | | 0.212 | | 0.124 | | 0.08 | | 0.447 | |
| **Md8** | 10.316b | 11.8a | 8.55b | 13.56a | 9.85b | 11.6a | 8.2b | 13.1a | 10.05b | 10.3a | 6.85b | 13.5a |
| **LSD0.05** | 0.046 | | 0.189 | | 0.226 | | 0.328 | | 0.179 | | 0.215 | |
| **Md9** | 10.2b | 11.3a | 8.15b | 13.35a | 9.85b | 11.033a | 7.53b | 13.35a | 10.28a | 9.5b | 6.53b | 13.25a |
| **LSD0.05** | 0.179 | | 0.124 | | 0.244 | | 0.143 | | 0.146 | | 0.436 | |

Table 2. Effect of treatments factors on soil moisture distribution.

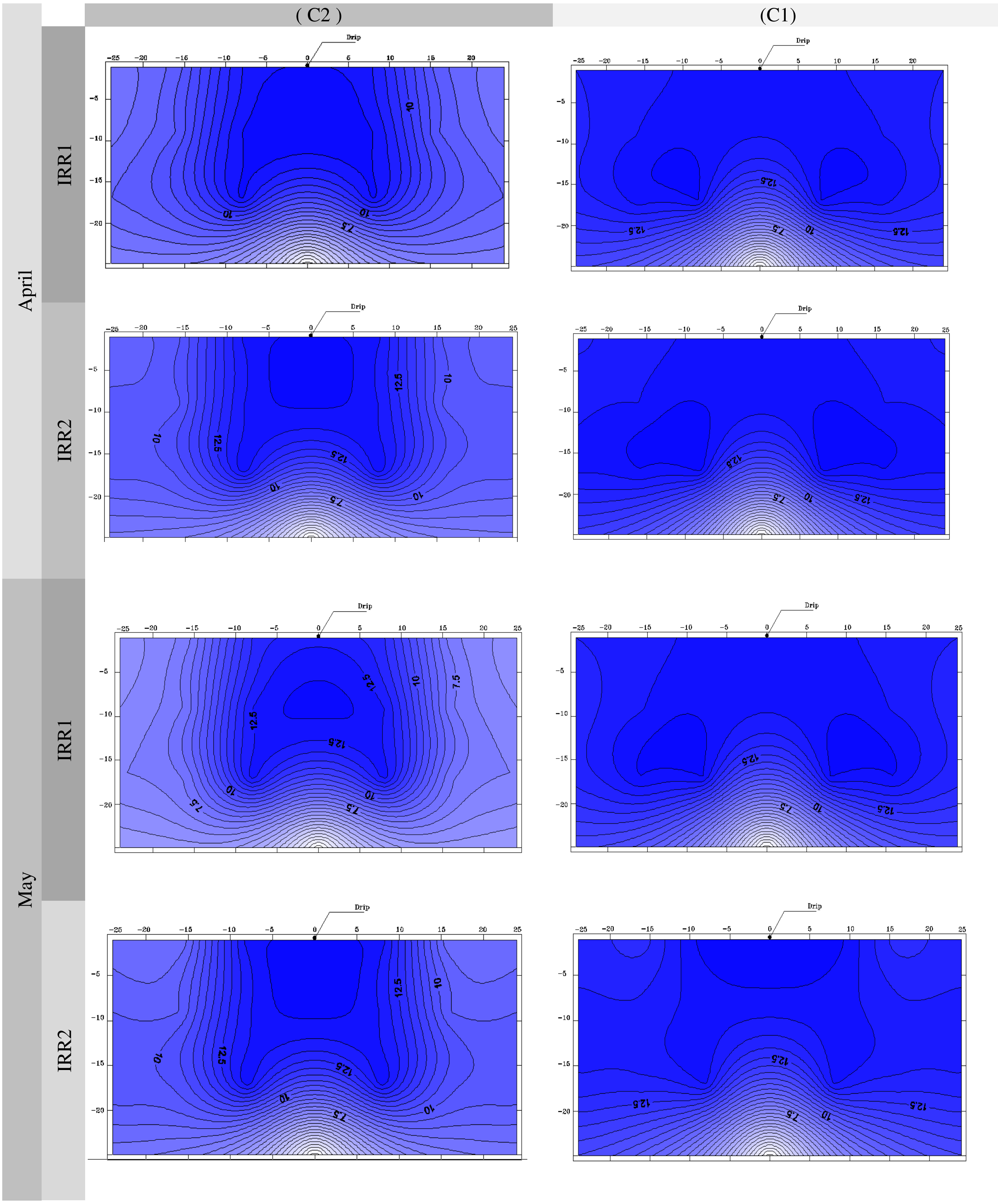


Figure 4. Influence of treatments on distribution of soil moisture.

 

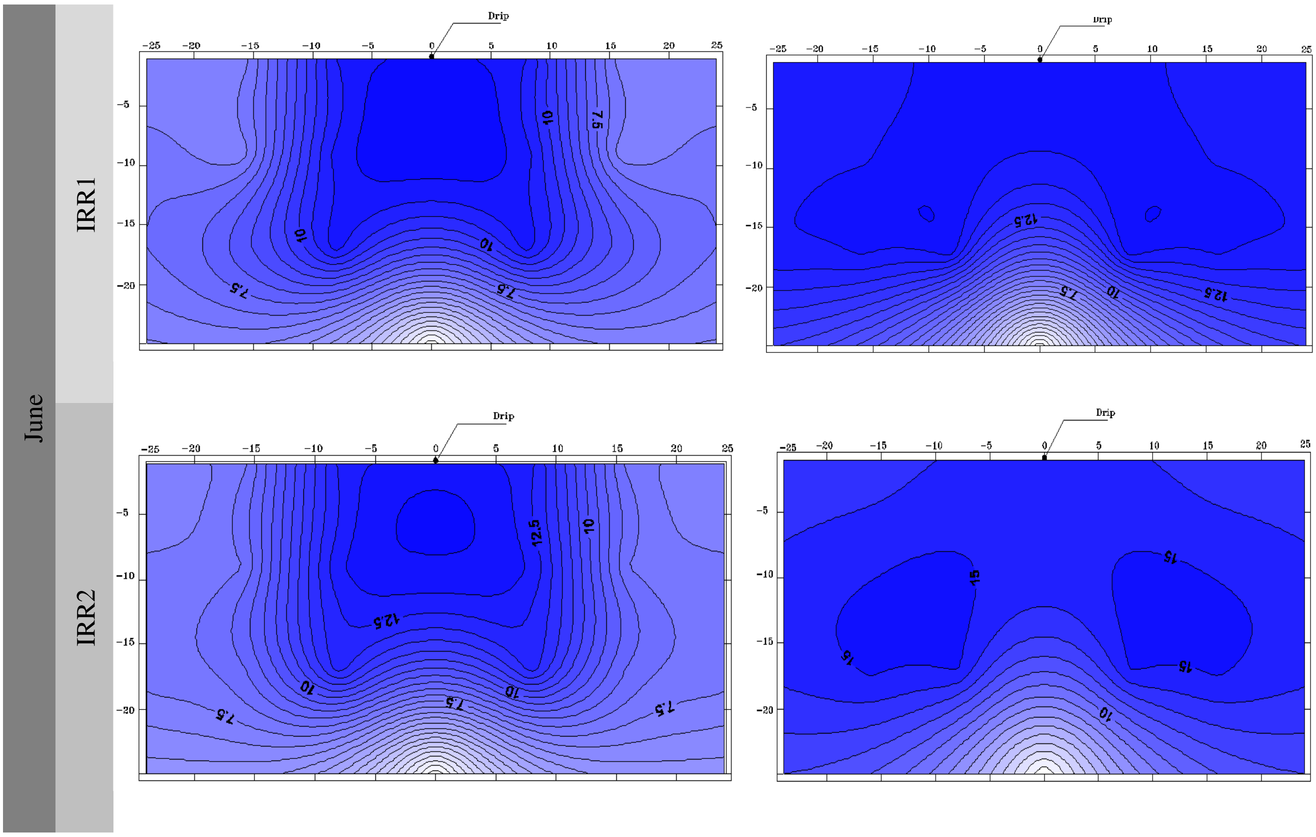


Figure 4. Continue. Influence of treatments on distribution of soil moisture

On the other hand; at May the value of SMD has a different behaviour related to increasing air temperature value specially with treatments IRR1 and C2 where SMD acquired the short distance from dripper under C1 comparing with observation data at April for the same treatment. Moreover; under IRR2 the data acquired the same behaviour by short distance comparing with the treatment on April. But the best identity of the SMD observed under IRR2 and C1 too.

Likewise; on June the SWD acquired the same behaviour on May under different treatments and the best homogenous distribution also acquired with IRR2 and C1. This help to explain that the data of yield production acquired highest value under C1 comparing with C2 may that SWD performance is significant homogenise which helped to make a good environment for growth crops.

Finally; Mathematic relation using Robust and Cramer's methods to explain the behaviour for influence water quantity and soil temperature to estimate soil moisture for specific depth under C1 is:-

$$M\begin{pmatrix} d_1\\ d_2\\ d_3\\ d_4\\ d_5\\ d_6\\ d_7\\ d_8\\ d_9 \end{pmatrix} = \begin{pmatrix} 29.858\\ 20.13\\ 31.236\\ 27.23\\ 24.897\\ 19.652\\ 34.52\\ 29.074\\ 31.73 \end{pmatrix} + td_1\begin{pmatrix} 0.113\\ -0.184\\ -0.220\\ 0.015\\ 0.005\\ 0.287\\ -0.04\\ -0.156\\ 0.054 \end{pmatrix} - td_2\begin{pmatrix} 1.205\\ 0.645\\ 2.058\\ 0.595\\ 0.870\\ -0.078\\ 1.292\\ 1.152\\ 1.418 \end{pmatrix} + td_3\begin{pmatrix} 0.623\\ 0.003\\ 0.498\\ 0.565\\ 0.607\\ 0.853\\ 0.85\\ 0.855\\ 1.347 \end{pmatrix} + td_4\begin{pmatrix} 1.496\\ 1.002\\ 2.603\\ 0.504\\ 0.606\\ -0.331\\ 2.606\\ 2.660\\ 1.306 \end{pmatrix} - td_5\begin{pmatrix} 0.250\\ 0.323\\ -0.447\\ 0.877\\ 0.273\\ 0.845\\ -0.218\\ -0.364\\ 0.305 \end{pmatrix}$$

$$- td_6\begin{pmatrix} 2.275\\ 0.498\\ 3.5\\ 0.903\\ 1.574\\ 0.188\\ 3.760\\ 3.021\\ 2.346 \end{pmatrix} - td_7\begin{pmatrix} 3.088\\ 0.833\\ 3.674\\ 0.817\\ 1.646\\ 0.084\\ 3.533\\ 2.897\\ 3.076 \end{pmatrix} + td_8\begin{pmatrix} 4.024\\ 1.437\\ 4.125\\ 1.751\\ 1.941\\ 0.155\\ 3.67\\ 2.692\\ 3.287 \end{pmatrix} + td_9\begin{pmatrix} -0.317\\ -0.276\\ 0.78\\ -0.348\\ 0.603\\ 0.091\\ 0.204\\ -0.123\\ 0.093 \end{pmatrix} + Q\begin{pmatrix} 2.212\\ 0.856\\ 2.442\\ 1.585\\ 1.153\\ 0.362\\ 2.525\\ 1.9\\ 2.368 \end{pmatrix}$$

On the other hand; under $C_2$ the equation is

$$M\begin{pmatrix} d_1\\ d_2\\ d_3\\ d_4\\ d_5\\ d_6\\ d_7\\ d_8\\ d_9 \end{pmatrix} = -\begin{pmatrix} 36.005\\ 28.605\\ 66.305\\ 99.974\\ 73.445\\ 38.334\\ 102.512\\ 108.054\\ 83.031 \end{pmatrix} + td_1\begin{pmatrix} 0.445\\ 0.276\\ 1.715\\ 2.473\\ 1.763\\ 1.423\\ 2.627\\ 2.879\\ 2.668 \end{pmatrix} - td_2\begin{pmatrix} 0.273\\ -0.065\\ 0.0746\\ 0.434\\ 0.208\\ 0.091\\ 0.09\\ 0.388\\ 0.246 \end{pmatrix} + td_3\begin{pmatrix} 0.669\\ 0.677\\ 0.472\\ -0.229\\ 0.0236\\ -0.086\\ -0.199\\ 0.101\\ 0.222 \end{pmatrix} + td_4\begin{pmatrix} 2.554\\ 2.377\\ 3.179\\ 4.108\\ 3.128\\ 1.006\\ 4.103\\ 3.821\\ 3.014 \end{pmatrix} + td_5\begin{pmatrix} 1.205\\ 1.069\\ 1.090\\ 3.838\\ 2.084\\ 1.126\\ 1.676\\ 2.757\\ 0.526 \end{pmatrix} -$$

$$td_6\begin{pmatrix} 0.419\\ 0.336\\ 1.203\\ 0.376\\ 0.793\\ 0.982\\ 1.744\\ 1.445\\ 1.788 \end{pmatrix} + td_7\begin{pmatrix} 0.218\\ 1.129\\ 2.408\\ 1.880\\ 1.241\\ 1.419\\ 4.098\\ 2.850\\ 2.988 \end{pmatrix} - td_8\begin{pmatrix} 1.608\\ 2.426\\ 2.957\\ 4.69\\ 2.956\\ 0.942\\ 4.568\\ 3.601\\ 2.621 \end{pmatrix} - td_9\begin{pmatrix} 0.657\\ 0.999\\ 1.171\\ 1.956\\ 0.721\\ 0.714\\ 0.991\\ 1.896\\ 0.701 \end{pmatrix} - Q\begin{pmatrix} 1.983\\ 1.680\\ 2.834\\ 3.159\\ 2.953\\ 2.294\\ 4.124\\ 4.133\\ 3.611 \end{pmatrix}$$

Where:-

$Md_n$ = Ratio of soil moisture for specific depth (%).

$Td_n$ = soil temperature for specific depth (C°).

Q = the amount of water from dripper (Litter).

## Conclusion

It could be concluded from these obtained results that the time of irrigation has not the effective influence on yield and crop production. Nevertheless; adding compost with (6 ton/fed) effect on both yield by 847% and ratio of soil moisture. Moreover; the mathematic model helping to determine the relation between soil temperature under different depths with water discharge from dripper and the ratio of soil moisture which trace on ideal water management under such conditions.

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