J.Soil Sci. and Agric. Eng., Mansoura Univ., Vol. 8 (10): 497 - 508, 2017

Simulating the Overlapping Patterns of Irrigation Sprinklers Using Computer Model

Abd El Mageed, H. N.[1]; M. M. Ibrahim[1]; H. M. Abd El Mageed[2] and Abeer A. Hedia[2]
[1] Agric. Eng. Dept., Faculty of Agric., Al-Mansoura University.
[2] Agric. Eng. Res. Institute, ARC.

ABSTRACT

A comprehensive computer model, HEDIA, was created to simulate sprinklers water overlapping patterns theoretically by one sprinkler superimposition technique under selected layout design. This model can also calculate uniformity coefficients, application efficiency, storage efficiency and deep percolation by linear and normal distribution fit. Lab tests were established to verify HEDIA model. Their results indicated that HEDIA model accurately simulates sprinklers overlapping patterns shapes of square, rectangle and triangle and gets coefficients of determinations (0.97), (0.98), and (0.98) respectively compared with actual data. Moreover, analysis of variance by randomized complete block design for actual and simulated data of uniformity coefficients, linear and normal for water performance efficiencies were not significant at 1 % confidence under the three shapes of overlapping patterns separately. Correlation between actual and simulated data of water performance efficiencies by linear and normal distribution fit for square, rectangle and triangle overlapping shapes got coefficient of determination of [(0.98, 0.99), (0.99, 0.99), (0.99, 0.99)], respectively for storage efficiency and (0.99) for application efficiency in all overlapping shapes fits. So, HEDIA computer model was proved to be reliable and could be used confidentially to simulate overlapping patterns performance parameters.

Keywords: HEDIA computer model, sprinklers overlapping patterns, sprinklers arrangement shape and space, uniformity coefficients, water performance efficiencies, linear fit, normal distribution fit.

INTRODUCTION

One of the main advantages of sprinkler irrigation system under optimum operation conditions is its capability to distribute water fairly uniformly over the irrigated area. Several investigations evaluated the effect of sprinkler water application uniformity on crop and indicated that yield is better under good water distribution conditions (Roberto, *et al,* 2016 and Hanaa, *et al,* 2017).

Irregular water distribution creates drought areas in some parts of the sprinklers overlapped pattern that can only be overcome by the application of additional water, which affects in waste of water (Ransford, et al, 2017). Improved design of sprinklers overlapping pattern may conserve water, soil, labor, and money more over increase yields (Ali, *et al*, 2015).

Water distribution uniformity in overlapping patterns is an important indicator in the evaluation of sprinklers irrigation design quality (Dwomoh, *et al*, 2014 and Giuliani, 2016). Water distribution uniformity in overlapping pattern area was affected by the following; sprinkler design (nozzle type and shape, speed and uniformity of rotation); environment (wind velocity, evaporation); operation conditions (pressure, discharge); network design (risers, pipes) and selected sprinklers overlapping layout (shape, space) (Molenaar, 1954). An expensive field investigation must accomplished to select the best inter relationships between sprinkler operation conditions and economically design of sprinklers overlapping pattern shape and space.

Hard work done in filed can be easier by the theoretically study (Aqeel, *et al,* 2015). So analytically design of sprinklers overlapping patterns basically depends on knowing the water application pattern of a single sprinkler under operation conditions, and for selected sprinklers overlapping pattern shape and space, manually superimposition technique used to superimpose individual sprinkler patterns upon themselves to simulate overlapping pattern data (Dabbous, 1962). The data of overlapping patterns were compared by water distribution uniformity which has been commonly expressed in terms of uniformity coefficients so Christiansen, Hart and Karmeli were considered to be the most popular uniformity coefficients used in evaluation procedure (Wenting, et al, 2013).

Application efficiency, storage efficiency and deep percolation are additional indicators parameters used to evaluate the efficiency use of water under plant water requirement. These parameters indicated by fitting sprinklers overlapping pattern data by linear or normal distribution fit as clarified by (Karmeli, 1978 and Hart and Reynolds, 1965). Karmeli, (1978) compared linear fit with normal distribution fit and indicated that, in the higher quality distributions, the linear regression fit estimate the actual field data as well as the normal distribution fit. However, in lower quality distribution the linear regression fit proved significantly better than the normal distribution fit in its estimates.

CATCH3D, sprinkler pattern overlap program, version 4.60 has been created to design sprinklers overlapping pattern depending up on Christiansen and Wilcox uniformity coefficients without the calculation of water performance efficiencies under plant water requirement (Allen, 1996).

So the main objectives of this study was to create and verify a decision support computer model (HEDIA), helping to design the layout of sprinklers overlapping pattern by several uniformity coefficients and indicating water performance efficiencies by linear and normal distribution fit.

MATERIALS AND METHODS

Computer Model:

A computer model named HEDIA was established to simulate sprinklers overlapping patterns shape and space, with all statistics analysis describing the performance parameters of overlapping pattern. The model was created using Visual Basic, AutoCAD, MATLAB and Excel software with its powerful functions. These software programs made the calculations easier, fast and more efficient than the manual methods. HEDIA model is able to operate easily without the installation of MATLAB or AutoCAD software systems.

The model can quickly compute performance parameters draw sprinkler water distribution pattern and determine the best sprinklers combination shape and space design depending up on one sprinkler water distribution pattern data, sprinkler effective radius and catch cans space. This model could be divided into three sections: the first section contained the inputs of sprinkler water distribution pattern data and suggested sprinklers overlapping pattern shape and space, the second section contained the calculations of the program building equations which have been incorporated in it with the inputs data to produce the third section, that gave the outputs results which presents the overlapping pattern data and performance parameters.

Superimposition Technique for Square, Rectangle and Even Triangle Overlapping Shapes:

Simulation of sprinklers overlapping patterns through theoretical study by one sprinkler superimposition technique was used as clarified by (Dabbous, 1962) .This technique performed throw individual sprinkler water distribution pattern data recorded to a scale as a plan view on regular cross section graph paper. To collect overlapping pattern data theoretically by superimposition technique, spacing was considered to be represented by squares drawn on a transparent plastic sheet called template. This template had squares spaced at the same space scale as for a single sprinkler test. Superimposition technique increased sprinklers catch cans space in overlapping pattern by one catch can in the two directions, due to the arrangement of first catch can from sprinkler that took half the space of arrangement.

To explain the performance of template in collecting overlapping pattern data, an example is shown in table (1), when designer advised to arrange the sprinklers in square shape form with (9 × 9) catch cans space. Template with marked colors squares represents sprinklers geometric overlapping space (10×10) used. By putting this template on sprinkler distribution pattern data, all data located under the same marked squares were summited.

Table 1. Superimposition technique performance, on water distribution pattern data of individual sprinkler, mm/hr.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.5	0.9	0.9	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.1	1.0	1.9	1.8	1.6	1.6	1.8	1.9	1.0	0.1	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.4	1.9	[illegible]	[illegible]	0.8	0.7	0.7	0.8	1.1	1.5	1.9	0.4	0.0	0.0	0.0
4	0.0	0.0	0.3	1.6	1.9	0.7	0.6	0.5	0.7	0.7	0.5	0.6	0.7	1.9	1.6	0.3	0.0	0.0
5	0.0	0.1	1.8	1.3	0.7	[illegible]	[illegible]	0.5	0.5	0.5	0.5	0.0	0.6	0.7	1.3	1.8	0.1	0.0
6	0.0	1.2	1.6	0.8	0.6	0.5	0.5	0.8	0.9	0.9	0.8	0.5	0.5	0.6	0.8	1.6	1.2	0.0
7	0.1	1.8	1.1	0.6	0.5	0.5	0.9	1.2	1.4	1.4	1.2	0.9	0.5	0.5	0.6	1.1	1.8	0.1
8	0.4	1.6	0.8	0.5	0.5	[illegible]	[illegible]	1.8	2.2	2.2	1.8	1.2	0.8	0.5	0.5	0.8	1.6	0.4
9	0.8	1.6	0.7	0.5	0.5	0.8	1.4	2.3	2.6	2.6	2.3	1.4	0.8	0.5	0.5	0.7	1.6	0.8
10	0.8	1.6	0.7	0.5	0.5	0.8	1.4	2.3	2.6	2.6	2.3	1.4	0.8	0.5	0.5	0.7	1.6	0.8
11	0.4	1.6	0.8	0.5	0.5	0.8	1.2	1.8	2.2	2.2	1.8	1.2	0.8	0.5	0.5	0.8	1.6	0.4
12	0.1	1.8	1.1	0.6	0.5	0.5	0.9	1.2	1.4	1.4	1.2	0.9	0.5	0.5	0.6	1.1	1.8	0.1
13	0.0	1.2	1.6	0.8	0.6	0.5	0.5	0.8	0.9	0.9	0.8	0.5	0.5	0.6	0.8	1.6	1.2	0.0
14	0.0	0.1	1.8	1.3	0.7	0.6	0.0	0.5	0.5	0.5	0.5	0.0	0.6	0.7	1.3	1.8	0.1	0.0
15	0.0	0.0	0.3	1.6	1.9	0.7	0.6	0.5	0.7	0.7	0.5	0.6	0.7	1.9	1.6	0.3	0.0	0.0
16	0.0	0.0	0.0	0.4	1.9	1.5	1.1	0.8	0.7	0.7	0.8	1.1	1.5	1.9	0.4	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.1	1.0	1.9	1.8	1.6	1.6	1.8	1.9	1.0	0.1	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.5	0.9	0.9	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0

The same process was repeated, by moving the template one interval down each time until it covers the sprinklers arrangement space in vertical direction. Simulated data of (9 × 9) square overlapping shape by the superimposition technique are represented in table (2).

Superimposition Technique for Odd Triangle Overlapping Shape:

Figure (1a) shows the data of sprinklers triangular overlapping shape with even catch cans space between sprinklers on lateral were easy to generate directly by superimposition technique. Odd space between sprinklers on lateral in triangular overlapping shape had a negative effect on specifying triangle head location, which was located by superimposition technique between two catch cans data as in figure (1b).

Table 2. Simulated (9 × 9) square overlapping shape data, mm/hr.

	1	2	3	4	5	6	7	8	9
1	4.3	4.4	2.3	1.3	1.0	1.3	2.3	4.4	4.3
2	4.2	5.2	3.9	2.3	1.2	2.3	3.9	5.2	4.2
3	2.2	3.8	3.1	3.0	4.8	3.0	3.1	3.8	2.2
4	1.6	2.5	3.0	3.6	5.0	3.6	3.0	2.5	1.6
5	1.0	1.2	3.6	3.8	2.8	3.8	3.6	1.2	1.0
6	1.6	2.5	3.0	3.6	5.0	3.6	3.0	2.5	1.6
7	2.2	3.8	3.1	3.0	4.8	3.0	3.1	3.8	2.2
8	4.2	5.2	3.9	2.3	1.2	2.3	3.9	5.2	4.2
9	4.3	4.4	2.3	1.3	1.0	1.3	2.3	4.4	4.3

So the concept used in indicating odd triangular overlapping pattern depended up on overlapping several rectangular spacing overlaps as clarified by (Karmeli, 1978). In which the new catch cans values for shifted rectangular overlapping data by spline method overlapped with the former catch cans values along the un-shifted sprinkler spacing. So, the odd triangular overlapping pattern area was presented by rectangular area with sprinklers at all four corners and with a sprinkler at the center as in figure (2).

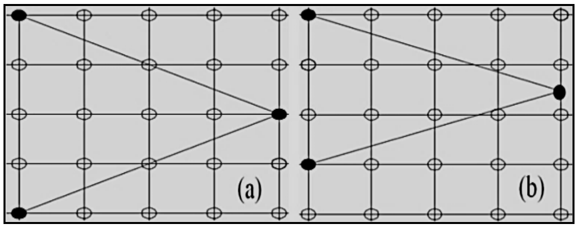

Fig.1. Catch cans overlapping triangular shape head location for (a) even space on lateral and (b) odd space on lateral.

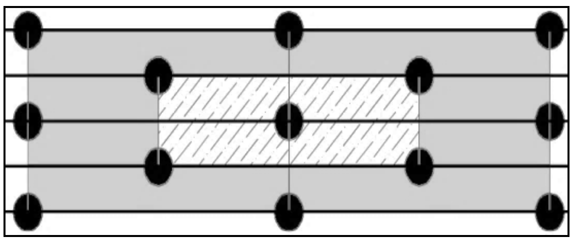

Fig. 2. Odd triangular overlapping pattern area.

Evaluation of Performance Parameters:

Uniformity Coefficients:

Sprinkler irrigation quality parameters include uniformity coefficients which have been as a verification measure to define uniformity of water in overlapping pattern. Sprinklers water distribution pattern data, sprinklers arrangement shape and space are the important factors affecting water application uniformity in overlapping patterns. So Christiansen (UCC), Hart and Reynolds (UCH) and Karmeli (UCL) uniformity coefficients were used with the acceptable uniformity when (UCC) and (UCL) ≥ 70% and (UCH) ≥ 73%, to calibrate water uniformity as in equations (1), (2) and (3) as follows:

$$UCC = 100\left(1 - \left[\sum_{i=1}^{n} abs(x_i - \bar{X}) / (NC \times \bar{X})\right]\right) \quad (1)$$

Where; **(x_i) is the individual observation of applied water, ($\bar{X}$) is the mean depth for all observation and (NC) is the total number of observation as produced by (Christiansen, 1942).**

$$UCH = 100\,[1 - (0.798\ SD) / \bar{X}] \quad (2)$$

Where; **(UCH) based on fitting overlapping pattern data by normal distribution fit depending upon standard deviation (SD) to the mean ($\bar{X}$) as developed by (Hart and Reynolds, 1965).**

$$UCL = 100\,[1 - 0.25b] \quad (3)$$

Where; **(UCL) established depending on fitting overlapping pattern data by linear regression fit and use linear slope (b) in defining the water uniformity as verified by (Karmeli, 1978).**

Water performance efficiencies:

The frequency of water distribution in area of sprinklers overlapping pattern was fitted by normal and linear fit as settled by (Hart and Reynolds, 1965 and Karmeli, 1978). So, application efficiency (E_a), storage efficiency (E_S) and deep percolation (D_p) were calculated by linear and normal distribution fit from the following equations:

Linear Fit:

Depending upon the location case of plant water requirement depth (Y_R) to the minimum (Y_{min}), the maximum (Y_{max}) and average (Y_{av}) precipitation depth on linear fit (E_a), (E_s) and (D_p) were calculated (Karmeli, 1978) as follows:

- **Case 1:** when plant water requirement (Y_R) was less than the estimated minimum precipitation depth (Y_{min}), the following equations were used:

$$E_a = Y_R \quad (4)$$

$$E_S = 1 \quad (5)$$

$$D_P = 1 - Y_R \quad (6)$$

- **Case 2:** when plant water requirement (Y_R) more than the estimated minimum precipitation depth (Y_{min}) and less than average (Y_{av}), water performance efficiencies were calculated as below:

$$E_a = Y_R - [(Y_R - 1 + b/2)^2 / 2b] \quad (7)$$

$$E_S = 1 - [(Y_R - 1 + b/2)^2 / 2bY_R] \quad (8)$$

$$D_P = 1 - Y_R - [(Y_R - 1 + b/2)^2 / 2b] \quad (9)$$

- **Case 3:** when plant water requirement (Y_R) more than the average precipitation depth (Y_{av}) and less than maximum (Y_{max}), the following equations were used:

$$E_a = 1 - [(1 + b/2 - Y_R)/2 \times 1 - (Y_R - 1 + b/2)/b] \quad (10)$$

$$E_S = 1 - [(Y_R - (1 - b/2))^2 / 2bY_R] \quad (11)$$

$$D_P = ((1 + b/2 - Y_R)/2) \times (1 - (Y_R - 1 + b/2)/b) \quad (12)$$

- **Case 4:** when plant water requirement (Y_R) more than the maximum precipitation depth (Y_{max}), efficiencies equations were calculated by:

$$E_a = 1 \quad (13)$$

$$E_S = 1 / Y_R \quad (14)$$

$$D_P = 0 \quad (15)$$

Normal Fit:

Equation for cumulated normal probability was used in normal distribution fit to indicate infiltrated water depth by the total number of observation of area, as illustrated by the following equation:

$$a_a = (1/SD\sqrt{2\pi}) \int_{x_-}^{\infty} e^{-0.5[(x_a - \bar{x})/SD]^2} dx \quad (16)$$

Where; **(a_a) is the fraction of the area under a normal curve from (x_a to ∞), (x_a) is the minimum water application depth on the area (a_a), mm (Hart and Reynolds, 1965).**

So estimating (E_a), (E_S) and (D_p) by normal distribution fit depended on defining the areas under normal curve as in figure (3) by the follow equations:

$$E_a = A / (A+B) \quad (17)$$

$$A = \sum_{i=1}^{i=n} [(0.5\,(a_{a+1} + a_a))\,(x_a - x_{a+1})] \quad (18)$$

$$B = 1 - A \quad (19)$$

$$E_S = A / x_a \quad (20)$$

$$Dp = 1 - A \quad (21)$$

$$C = x_a - A \quad (22)$$

Where; **(A) is the area of total water stored, (B) is the area of deep percolation and (C) is the deficit area in the root zoon under the normal curve.**

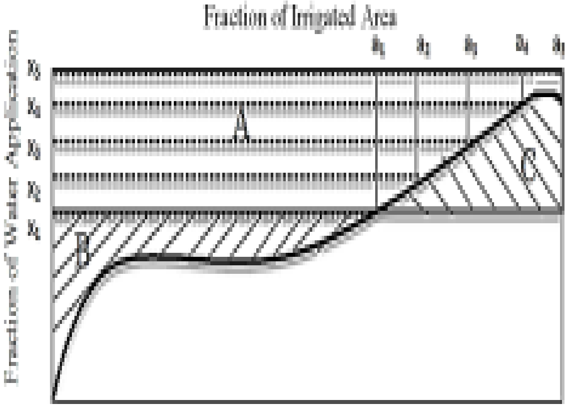

Fig. 3. Areas under cumulated normal probability curve (Hart and Reynolds, 1965).

Statistical analyses:

Analysis of variance by Complete Block Design was used at 1% confidence in Microsoft Excel (version 14.0.4760.1000) to calibrate the significance of variance between actual and simulated data (blocks) and their performance parameters (treatments).

Lab Test:

Actual lab test was conducted in Research laboratory of National Irrigation Laboratory of Agriculture Engineering Research Institute (AEnRI), Dokki, Giza, Egypt to verify the output results of developed model. Four PGP Hunter sprinklers were used in verification tests, with rectangle nozzle (3.4 × 2.2 mm) and trajectory angle of 14 degrees. The sprinkler height with the pop up part was 75 cm a discharge of 6 L/min; wetted radius 10.8 m and time rotation 2 minutes per rotation for base pressure of 2 bar. Pressure gauge was used to measure the sprinklers base pressure. Plastic cylindrical collectors (catch cans) with 9.5 cm diameter and 15 cm height were used to collect water application rate from sprinklers at its rotation time. The collected data were quarter part sector of single sprinkler water distribution pattern and several data of sprinklers overlapping patterns shapes, where square shape sprinklers overlapping pattern had (10.8 × 10.8 m) dimensions, rectangular shape (8.4 × 10.8 m) and finally equator triangular shape had (10.8 × 10.8 m) overlapping space when catch cans space was (1.2 m).

RESULTS AND DISCUSSION

Verify the Acceptable Use of Simulated Overlapping Patterns Data:

In lab test under operation condition (9 × 9 grid catch cans) the amount of water in grid distribution catch cans of sprinkler quarter part sector were collected as shown in table (3). Figure (4) shows data of sprinkler quarter part sector used in HEDIA model to generate the three simulated overlapping pattern shapes data. In figure (5), data of actual lab test of square overlapping (9 × 9 grid catch cans) were indicated by head to head sprinklers arrangement shape. Previous square overlapping pattern shape in the vertical direction axes was decreased by two catch cans, to get (7 × 9) grid catch cans. Finally data of triangular overlapping pattern (9 × 9 grid catch cans) were formed by shifting the position of second lateral by half space of sprinklers arrangement on laterals while the first one stayed in its location.

Table 3. Sprinkler quarter part sector, water application pattern, mm/hr.

0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.5	0.9	9
0.0	0.0	0.0	0.0	0.1	1.0	1.9	1.8	1.6	8
0.0	0.0	0.0	0.4	1.9	1.5	1.1	0.8	0.7	7
0.0	0.0	0.3	1.6	1.9	0.7	0.6	0.5	0.7	6
0.0	0.1	1.8	1.3	0.7	0.6	0.0	0.5	0.5	5
0.0	1.2	1.6	0.8	0.6	0.5	0.5	0.8	0.9	4
0.1	1.8	1.1	0.6	0.5	0.5	0.9	1.2	1.4	3
0.4	1.6	0.8	0.5	0.5	0.8	1.2	1.8	2.2	2
0.8	1.6	0.7	0.5	0.5	0.8	1.4	2.3	2.6	1
9	8	7	6	5	4	3	2	1	●

The actual and simulated overlapping patterns data were combined in one figure in order to indicate the relation between them. In (9 × 9) square overlapping pattern shape, simulated data from HEDIA model seemed to be in high correlation with the actual measured data in lab test as in figure (6 A) with a coefficient of determination of 0.97, the intercept was 0.11 and linear slope was 0.88. Simulated data of rectangle overlapping pattern shape justified the actual data with R^2 = 0.98, b = 1.07 and a = -0.07 (figure (6 B)). While, the correlation between actual and simulated triangle overlapping pattern shape shown in figure (6 C) indicated the coefficients of determination 0.98 when the slope and intercept were 1.1 and -0.10 respectively.

Verifying the Model with Respect to Some Common Performance Parameters:

Uniformity Coefficients:

Actual and simulated uniformity coefficients of Christiansen (UCC), Hart (UCH) and Karmeli (UCL) values are shown in table (4) for the three overlapping patterns shapes.

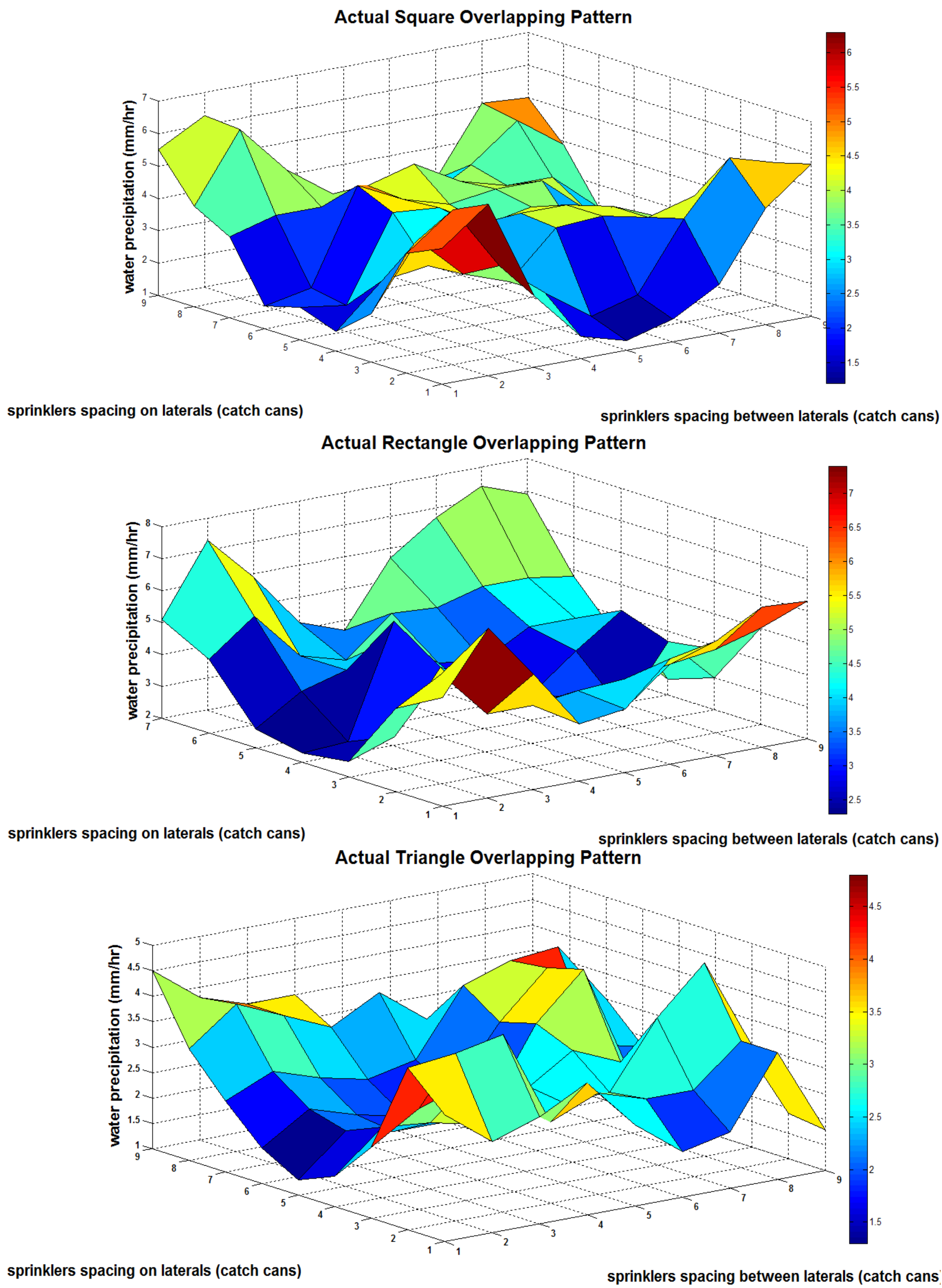

Fig. 4. Actual (9 × 9) square, (7 × 9) rectangle and (9 × 9) triangle overlapping patterns data, mm/hr.

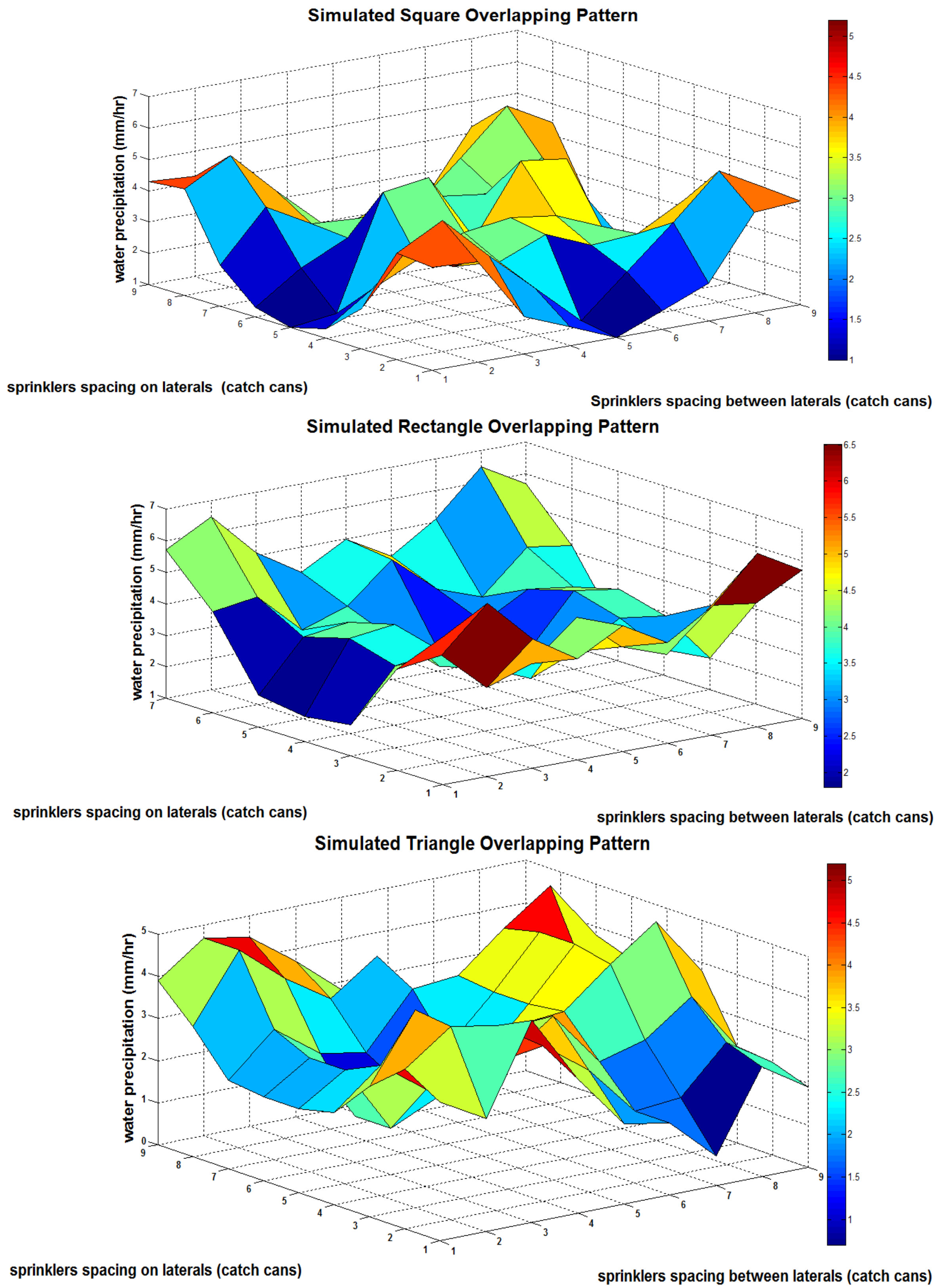

Figure 5. Simulated (9 × 9) square, (7 × 9) rectangle and (9 × 9) triangle overlapping patterns data, mm/hr.

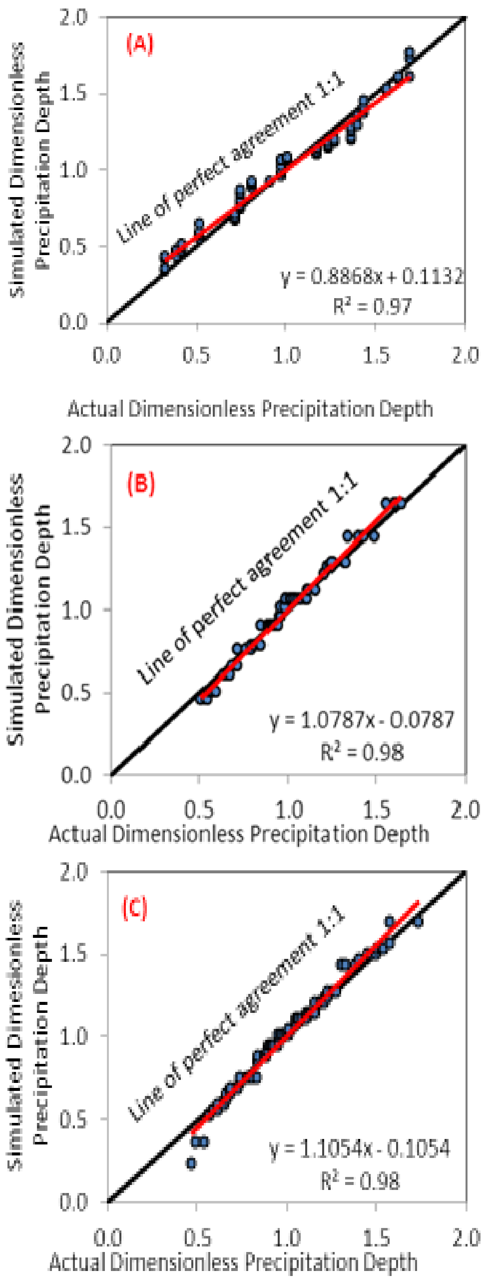

Fig. 6. Correlation between actual and simulated dimensionless precipitation depth for (A) (9 × 9) square; (B) (7 × 9) rectangular and (C) (9 × 9) triangular overlapping pattern.

Analysis of variance by complete block design indicated that F value for blocks (actual and simulated data) and treatments (uniformity coefficients) were not significant at 1% level of confidence. So, simulated square, rectangle and triangle overlapping patterns accurately simulated actual data and the deviation between the values of their uniformity coefficients could be neglected.

Table 4. Actual and simulated uniformity coefficients and its deviations from actual data in several overlapping pattern shapes.

Overlap Pattern	Coefficients	Actual data, %	Simulated data, %	Deviations , %
(9 × 9) Square	UCC	71.00	66.61	4.39
	UCH	71.61	68.32	3.29
	UCL	69.85	66.10	3.75
(7 × 9) Rectangle	UCC	77.67	75.86	1.81
	UCH	77.46	75.45	2.01
	UCL	76.26	74.23	2.03
(9 × 9) Triangle	UCC	75.24	72.62	2.61
	UCH	76.13	73.45	2.68
	UCL	74.57	71.65	2.92

Water performance efficiencies:

Verification of fitting overlapping pattern data by linear and normal distribution fit used under square, rectangle and triangle overlapping patterns shapes for actual and simulated data was performed to determine the most accurate one. In figures (7) and (8), linear and normal distribution fit for actual and simulated data of square and triangle overlapping patterns shapes representing the data very accurately. So the linear regression fit estimate the actual field data as well as the normal distribution fit for high quality distributions as approved by (Karmeli, 1978). On the other hand, fitting actual and simulated (7 × 9) rectangle overlapping shape by linear fit got coefficient of determination more than 0.95 when the slope was close to 1. For normal distribution fit, there was little deviation between actual and simulated data. While in lower quality distribution, the linear regression fit was proved to be better than normal distribution fit as indicated by (Karmeli, 1978). Analysis of variance by randomized complete block design for actual and simulated efficiencies from linear and normal distribution fit indicated that the variance not significant at 1 % level of confidence. So, linear and normal distribution fit were acceptable in predicting application efficiency, storage efficiency and deep percolation in all overlapping patterns shapes as actual data. Figure (9) shows the correlation between actual and simulated values of application efficiency for linear and normal distribution fit for the three overlapping patterns. It is observed from the regression analysis that all R^2 values exceed 0.99. And slope close to 1. For the square pattern the intercept was round 8, while for the other patters, this value went to 5. With respect to storage efficiency which are shown in figure (10), there is a similarly between the square and rectangle patterns as detected from the line of perfect agreement. On the other hand, the smallest value of deflection was observed with the triangle pattern, but still there is a slight difference between linear and normal distribution fit as a whole.

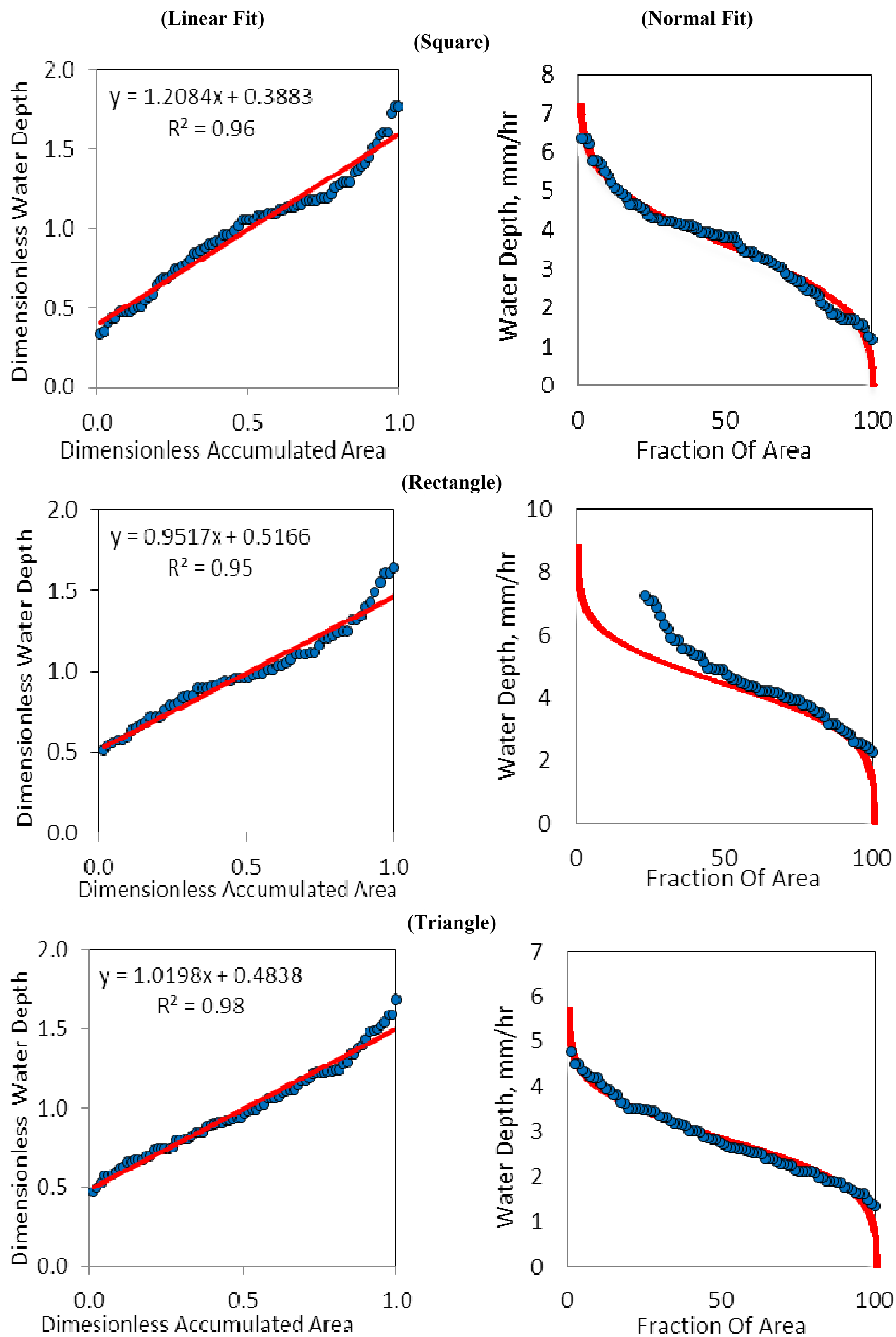

Fig. 7. Actual linear and normal distribution fit for (9 × 9) square, (7 × 9) rectangle and (9 × 9) triangle overlapping pattern data.

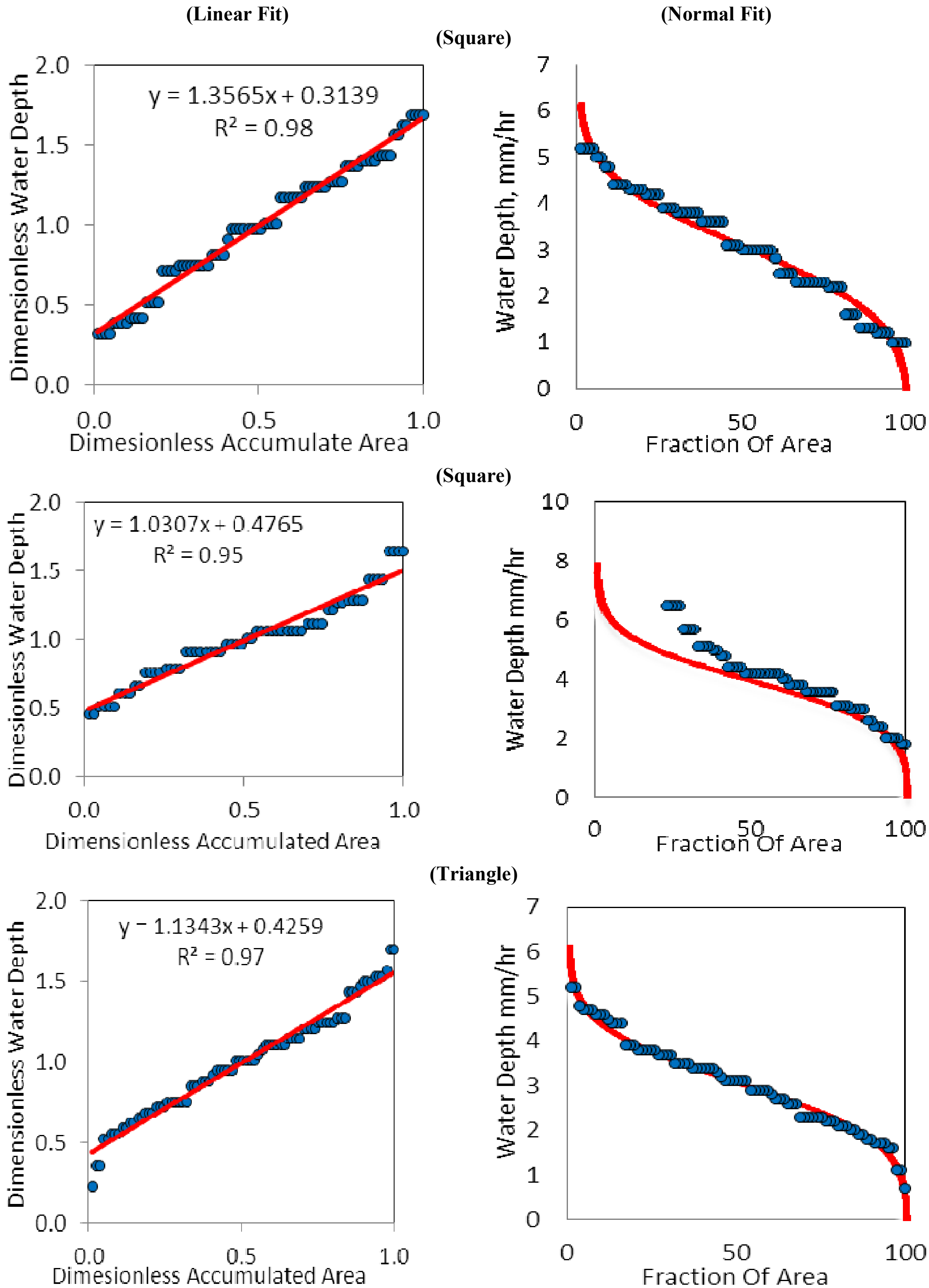

Fig. 8. Simulated linear and normal distribution fit for (9 × 9) square, (7 × 9) rectangle and (9 × 9) triangle overlapping pattern data.

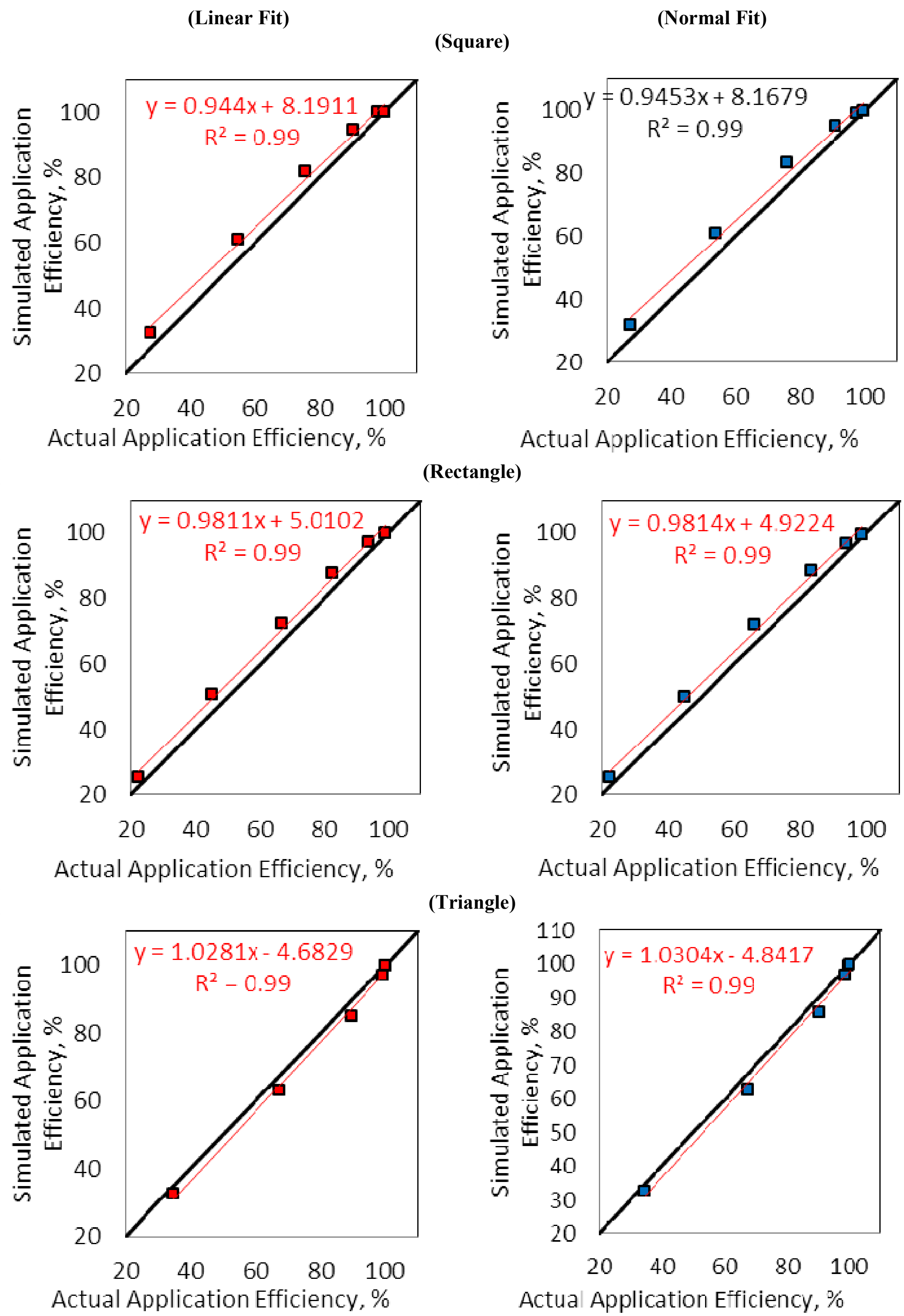

Fig. 9. Correlation between actual and simulated application efficiency % by linear and normal distribution fit for (9×9) square overlapping; (7×9) rectangle overlapping and (9×9) triangle overlapping.

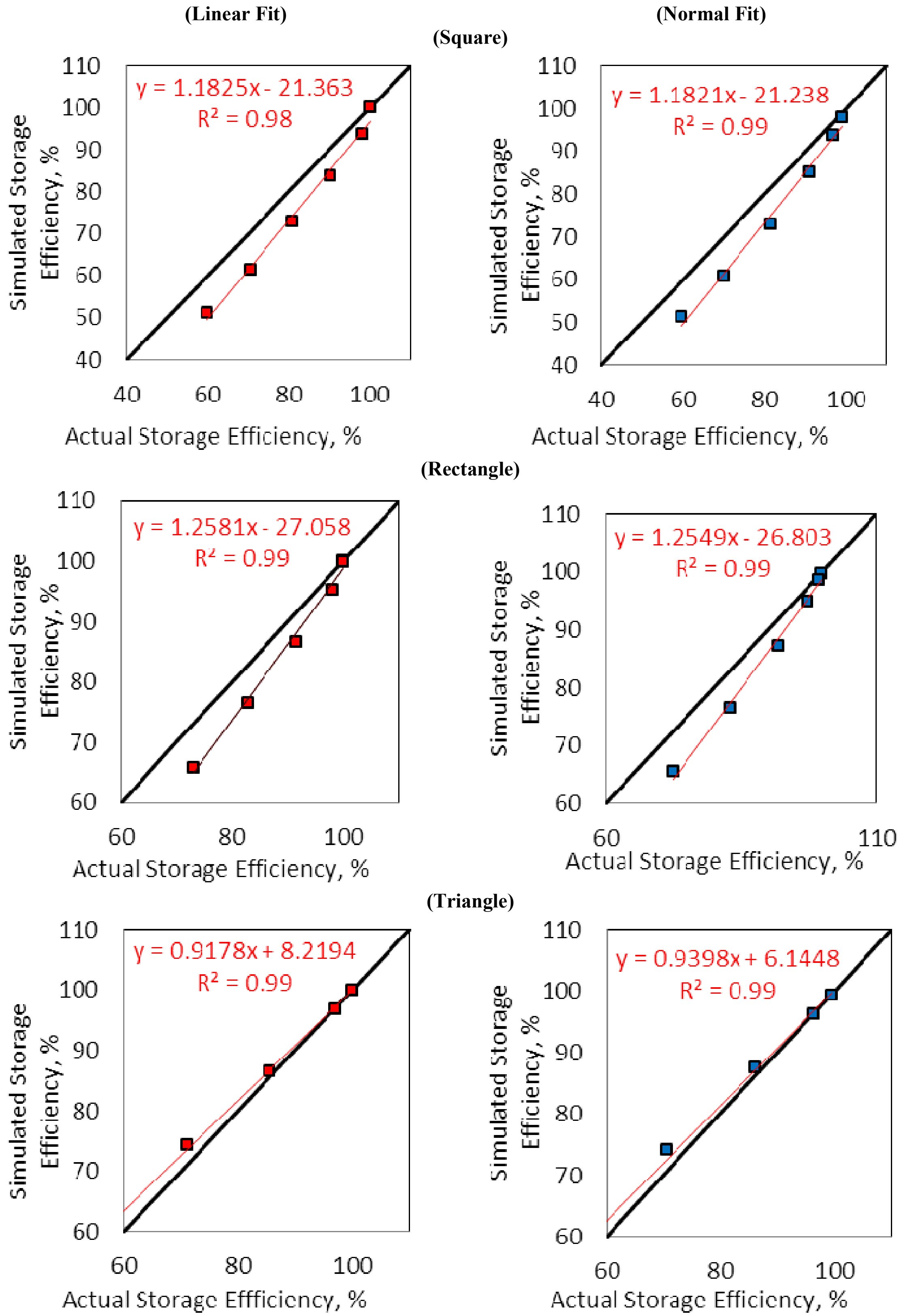

Fig. 10. Correlation between actual and simulated storage efficiency % by linear and normal distribution fit for (9×9) square overlapping (7×9) rectangle overlapping and (9×9) triangle overlapping.

CONCLUSION

From the results, it can be is concluded that HEDIA computer model was capable of simulating sprinklers overlapping patterns data and performance parameters in the three overlapping patterns shapes. Verification of the model using actual lab tests proved the sufficiency of using of it in simulating the performance of sprinklers.

The following points summarize the verification main results:

- Correlation between actual and simulated data of square, rectangle and triangle overlapping shapes got coefficient of determination of 0.97, 0.98 and 0.98, intercept of 0.11, -0.07 and -0.1 and slope of 0.88, 1.07 and 1.1, respectively.
- Analysis of variance between actual and simulated uniformity coefficients showed that it was not significant at 1 % confidence.
- Analysis of variance between actual and simulated water performance efficiencies by linear and normal distribution fit showed that it was not significant at 1 % confidence.
- Correlation between actual and simulated application efficiencies (Ea) and storage efficiencies (Es) by linear and normal distribution fit for square, rectangle and triangle overlapping patterns shapes had coefficient of determination more than 0.98.

REFERENCES

Ali, Y.; O. Bahmani and H. Sedghi. (2015). Technical Evaluation of Efficiency and Uniformity Coefficients for Sprinkler Irrigation Systems in Hamedan-Iran. Indian Journal of Fundamental and Applied Life Sciences ISSN.Vol.5 (S1), pp. 827-833.

Aqeel, A. and H. H. Kraidi. (2015). Simulation Techniques for Sprinkler Irrigation Design System at ADIWANIYAH Government –IRAQ. International Water Technology Journal, IWTJ Vol. 5 –No.3.

Allen, R. G. (1996). CATCH3D, sprinkler pattern overlap program, version 4.60. Utah state university, Logan, Utah.

Christiansen, J. E. (1942). Irrigation by Sprinkling. California Agriculture Experiment Station Bulletin, No. 670.

Dabbous, B. (1962). A Study of Sprinkler Uniformity Evaluation Methods. M. SC. Thesis Utah State University Logan, Utah, PP: [1557].

Dwomoh, F. A.; Y. Shouqi and L. Hong. (2014). Computation Model of Sprinkler Spacing and Layout. International Journal of Engineering Sciences & Emerging Technologies, ISSN, Volume 7, Issue 1, pp.: 481-489.

Giuliani, D. P. (2016). Water distribution from medium-size sprinkler in solid set sprinkler systems. R. Bras. Eng. Agríc. Ambiental, v.20, n.3, p.195–201.

Hart, W. E. and W. N. Reynolds. (1965). Analytical design of sprinkler systems. Transactions of the ASAE, 8: 83–89.

Hanaa, D.; R. C. Maria; M. G. José; P, Paula and S. P. Luis. (2017). Comparing Sprinkler and Surface Irrigation for Wheat Using Multi-Criteria Analysis: Water Saving vs. Economic Returns. International Water Technology Journal, IWTJ Vol. 9 –No.50.

Karmeli, D. (1978). Estimating sprinkler distribution pattern using linear regression. Transactions of the ASAE, 21: 682–686.

Molenaar, A. (1954). Factors Affecting Distribution of Water from Rotating Sprinklers. Washington Agricultural Experiment Station, Circular, 244.

Roberto, S. M; M. Jesús ; C. Juan; M. T. José and d. J. Arturo. (2016). Effects of Water Distribution Uniformity of Sprinkler Irrigation Systems on Corn Yield. Researchgate, open access at https://www.researchgate.net/publication/242765387

Ransford, O. D; S. Yuan; Y. H. Liu and X. Zhu. (2017). Overview of advances in improving uniformity and water use efficiency of sprinkler irrigation. Int J Agric & Biol Eng Vol. 10 No.2. Open access at https://www.ijabe.org.

Wenting, H. (2013). A Dynamic-simulation System for Sprinkler Water 3D-distribution Using Multiple Tools Integration. Journal of Convergence Information Technology (JCIT) Volume8,Number 2.

محاكاه أنماط التداخل لرشاشات الرى بأستخدام الحاسب الالى

هشام ناجى عبد المجيد[١]، محمد ماهر إبراهيم[١] ، هاشم محمد عبد المجيد[٢] و عبير احمد هديه[٢]

[١] قسم الهندسة الزراعية – كلية الزراعة – جامعة المنصورة

[٢] معهد بحوث الهندسة الزراعية – مركز البحوث الزراعية – الجيزة

يهدف هذا البحث الى الى زيادة كفاءة الري بالرش و ترشيد استهلاك المياه عن طريق وضع تصور لانسب مسافات توزيع للرشاشات وشكل التوزيع تحت الظروف التشغيليه و البيئيه الفعليه. لذا تم تطوير نموذج حاسوبي يمكن من خلاله انتقاء افضل تصميم لنظم الري بالرش من خلال ابعاد وتوزيعات الرشاشات والتى يطرحها البرنامج و يعمل البرنامج ايضا على اختبار الكفاءة عن طريق مفاضله كفاءه التوزيع للمياة فى منطقة التداخل بين الرشاشات بالاضافه الى ان البرنامج يقوم بحساب كفاءه الاضافه و التخزين و التسرب العميق. تم تقدير مدى صحة استخدام البرنامج بمحاكاة استخدامة معمليا وتقدير مدى حساسيتة لتغيير المدخلات فأعطى معامل ارتباط ٠.٩٧ و ٠.٩٨٤ و ٠.٩٨٢ للمربع و المستطيل و المثلث على التوالى و ذلك للبيانات المقاسة معمليا و المحاكاه بأستخدام البرنامج. كما تم تحليل بيانات كفاءه التوزيع للمياه احصائيا بأستخدام تحليل التباين للقطاعات العشوائيه الكامله و التى اثبتت عدم وجود تباين واضح بين البيانات المعمليه والتى تم محكتها بأستخدام البرنامج وذلك لكل شكل من اشكال التوزيع للرشاشات وايضا لكل كفاءه توزيع للمياه وذلك عند مستوى معنويه ١ %. تم الاستعانه بمعادله الانحدار الخطى للبيانات و كذلك منحنى التوزيع الطبيعى فى البرنامج لعمل علاقه بين كميه المياه المجمعه لوحده المساحه فى منطقه تداخل بين الرشاشات والتى يمكن من خلالها التنبؤ بكفاءه اضافه المياه وتخزينها والتسرب العميق بها وذلك لعمق المياه المطلوب اضافته فى منطقه الجذور و. قد تم عمل علاقه ارتباط بين البيانات المقاسة معمليا و المحاكاه بأستخدام البرنامج لكفاءة الاضافه و التخزين بأستخدام الانحدار الخطى و منحنى التوزيع الطبيعى للبيانات لاعماق مياه تتراوح بين ١ الى ٦ مم فأعطى معامل ارتباط لكفاءة الاضافه (٠.٩٩) للمربع والمستطيل والمثلث و اعطى معامل ارتباط لكفاءة التخزين (٠.٩٨ - ٠.٩٩) للمربع و (٠.٩٩) للمستطيل والمثلث. و قد تم تحليل بيانات كفاءات استخدام المياه المستنتجه من كلا المنحنيين وذلك للبيانات المقاسه معمليا و كذلك للبيانات المستنتجه من النموذج الحاسوبى. حيث اثبت التحليل الاحصائي من خلال جدول تحليل التباين ان البيانات المستنتجه من النموذج الحاسوبى تحاكى البيانات الواقعيه وكذلك لا توجد فروق معنويه بين النتائج المستخلصه من معادله الانحدار الخطى ومنحنى التوزيع الطبيعى وذلك عند مستوى معنويه ١ %. وبالتالى يمكن توفير الجهد والوقت فى اختيار انسب توزيع هندسى لمنطقة التداخل بين الرشاشات تحت الظروف التشغيله و البيئيه ومن ثم الحصول على اقل تكلفه تصيم وافضل انتظاميه لتوزيع المياه و كذلك امكانيه تعيين مدى كفاءه اسخدام المياه فى ذلك التصميم لنبات معيين بأستخدام النموذج الحاسوبى المقترح .