Irrigation uniformity for micro-sprinkler operating bellow of the working head in different distances simulations

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Abstract

The distribution uniformity evaluation of an irrigation system would have to be an essential element to the project and irrigation management. Some data of hydraulic characterization normally are supplied by manufacturers; however, generally, the number of information is very limited, diminishing the capacity of use of the equipment. What is normally found are recommendations of distances for determined service pressures. These recommendations are based in laboratory analysis, that is, with absence of winds. A previous evaluation of the sprinkler, to the field, can determine other possibilities of use. The present work evaluated the uniformity and application potential efficiency of a micro-sprinkler in three pressures of service below of the recommended ones for the manufacturer, for different distances, in intention to inquire the possibility of use with lesser expense of energy. The results show that some are viable alternatives tested.

Key words: micro-sprinkler irrigation; distribution uniformity; application efficiency; distances simulations.

Introduction

The micro sprinkler are small applicators (sprinklers in miniature) covering areas of 1 to 10m2, with flow rates from 50 to 200 Lh^{-1} and pressures that vary from 100 to 300 kPa (TESTEZLAF 2002). The system of irrigation with micro sprinkler belongs to the method of irrigation located, just like the dripping. However, many times, the practice is also used as irrigation by conventional spraying, irrigating the entire surface of the land and applying water on plants. This situation occurs mainly in the production of seedlings and the cultivation of vegetables (MAROUELLI et al., 2002; BEZERRA, 2003).

Because it presents hydraulic characteristics more similar to the spraying water than the dripping, the same mathematical models of hydraulic simulation can be used in spraying, especially when the purpose of the use is not a located irrigation (CONCEIÇÃO, 2002). Rocha et al (2000) used the software CATCH-3D (version 3.50b), originally created to characterize sprinklers, to characterize a micro sprinkler. Before using a sprinkler in irrigation, is very important to know its hydraulic characteristics: the flow-pressure relation, wet diameter, coefficient of variation of manufacturing, angle of projection of the jet water, etc.

Ullmann et al. (1997) evaluated the hydraulic characteristics of 153 combinations of water nozzles and found that 70% and 50% of the sprinklers of medium and high pressure, respectively, showed flow other than that specified by the manufacturers. In addition to the hydraulic characteristics inherent in the water sprinkler, its performance still depends on the pressure of service, the choice of spacing and climatic conditions (mainly wind speed).

These variables will influence the uniformity of water distribution, the potential of application efficiency (APS), designed as the relationship between the amount of water used and the amount that reaches the ground, and the intensity of application (IA). According to Bernardo (1995), the speed of infiltration basic (VIB) is around 10 mm h^{-1} for clay soils. In order not to occur runoff or accumulations of water in places with depression, the VIB must always be smaller than IA. The CUC (Coefficient of Uniformity Cristhiansen) is the most used index to evaluate the distribution uniformity of water in irrigation by sprinkler.

Ramos and Mantovani (1994) evaluated the influence of water distribution in the corn productivity. They pointed out that to produce 12,000 kg ha^{-1}, the irrigation per cycle should be 500, 700 and 1,100 mm respectively, for a CUC of 95. 75 and 55%. The CUC must be at least equal to 85% for vegetables, 75% for cereals and 70% for fruit. The evaluation of a sprinkler gives reliable data to carry out a project and then manage the irrigation. This study aimed to evaluate a model of micro sprinkler which should then be employed in a clay soil area with vegetables.

Material and methods

The micro sprinkler were assessed according to the NBR-8989 (ABNT, 1985) and 7749-2 (ISO, 1990) standards. In order to evaluate the uniformity of distribution, three pressures were taken in the micro sprinkler exit: 30 kPa, 60 kPa and 90 kPa, all of them below the range recommended by the manufacturer, from 100 to 300 kPa. Before the start of the assessment, the corresponding flow was determined for each pressure.

The flow was taken spilling the sprinkler in a bucket and then measuring the volume collected in a measuring cylinder of 1000 mL, with precision of 2.5 mL. For each pressure, three repetitions were made, with time of collection equal to one minute. For evaluation, four 250 mL rays of collectors were used, 0.3 m above the ground, spread in 90 º, with the micro sprinkler in the center. It was used a spacing of 0.4 m between collectors with 8 collectors per ray, totalizing 32 collectors. The volumes collected at the end of each test were measured in a beaker of 100 mL, with precision of 1 mL.

The tests were conducted with duration of thirty minutes, taking on this period of time, the direction and speed of the wind in these specific times: 4:30 P.M (test 1 - pressure of 30 kPa) on May 11th, 10:00 A.M (test 2 - pressure of 60 kPa) and 11:30 A.M (test 3 - pressure of 90 kPa) on May 12th, 2007.

All tests were carried out in the Irrigation Technology Center of the State University of Maringa, geographically located at 25 ° 25' South latitude and 51° 57' West longitude and altitude of 542 meters. Eight combinations of spacing were examined: 2 m x 2.4 m, 2.4 m x 2.4 m, 2.4 m x 2.8 m, 2.8 m x 2.8 m, 2.8 m x 3.2 m; 3.2 m x 3.2 m, 3.2 m x 3.6 m, 3.6 m x 3.6 m. The simulation of spacing and the respective values of CUC and IA were estimated using the Computer Program CATCH-3D, version 3.50b (ALLEN; MERKLEY, 2004).

Results and discussion

The values of potential of application efficiency (APS), intensity of application (IA) and coefficient of uniformity of Cristhiansen (CUC) were obtained from the original data of the collected volumes (Table 1) and flow rates taken before each test. This information served to feed the database of Computer System CATCH-3D. The average flow rates achieved in the trials were 61.2 L h^{-1}, 82.8 L h^{-1} and 86.4 L h^{-1} respectively to 30 kPa, 60 kPa and 90 kPa. With the average time of 30 minutes for each test, the respective volumes were applied: 30.6 L h^{-1}, 41.4 L h^{-1} and 43.2 L h^{-1}. In assay 1 (30 kPa) the volume that reached the soil was equal to 22.5 L. Both in assay 2 and in assay 3, a volume equal to 35.3 liters reached the ground. Through the relationship between the volumes that hit the ground and the volumes applied, the following potential efficiencies of application were estimated: 74.4%, 85.3% and 81.8% respectively for assays 1, 2 and 3. It was concluded that in respective tests the following losses occurred by drift: 25.6%, 14.7% and 18.2%. During the trial 1 the wind speed was equal to 2 m s^{-1} in the southwest direction, whereas for the assays 2 and 3, the wind speed remained at 1 m s^{-1} towards west.

In assay 1, examining the various combinations, the best performance of uniformity was the spacing 2 x 2.4 m, with a CUC of 86.9%. The other values of CUC were less than 85%, considered unsuitable for irrigation of vegetables (RAMOS; MANTOVANI, 1994). In terms of intensity of application (IA) all values were below 10 mm h^{-1}, therefore, suitable for clay soils. On table 2 are presented, according to the spacing, the coefficients of uniformity of Cristhiansem (CUC) and intensities of application (IA) obtained in the assay 1. In figure 1 are shown the graphics of surface from assay 1.

A obtained in assay 2. In figure 2, are shown through graphics, the profiles of water in assay 2.

In assay 2, the best performances of uniformity were the spacing of 2 x 2.4 m, 2.4 x 2.4 m, 2.4 x 2.8 and 2.8 m x 2.8 m, with CUC values respectively equal to 92.2% and 92.6% and 89.3% and 85.5%. However, from these spacing, the only the spacing

Table 1. Volumes collected in the trials. Collected volumes (ml) in test 1 with pressure of service equal to 30 kPa.

Volumes coletados (mL) no ensaio 1 com pressão de serviço igual a 30 kPa							
Raio 1	6	8	11	11	7	0	0	0
Raio 2	11	6	3	0	0	0	0	0
Raio 3	6	5	6	8	8	3	0	0
Raio 4	9	5	4	5	6	7	5	0
Volumes coletados (mL) no ensaio 2 com pressão de serviço igual a 60 kPa								
Raio 1	9	8	6	14	9	5	4	0
Raio 2	16	13	9	8	8	5	4	0
Raio 3	10	4	7	8	7	4	2	0
Raio 4	8	7	7	9	7	4	2	0
Volumes coletados (mL) no ensaio 3 com pressão de serviço igual a 90 kPa								
Raio 1	12	7	6	8	6	5	2	0
Raio 2	9	9	11	9	12	6	7	0
Raio 3	9	4	11	14	9	5	1	0
Raio 4	7	5	6	7	5	4	1	0

Table 2. Values of CUC (%) and IA (mm h-1) obtained in the assays 1. Spaces (m x m).

	Spacing (m x m)							
	2 x 2.4	**2.4 x 2.4**	**2.4 x 2.8**	**2.8 x 2.8**	**2.8 x 3.2**	**3.2 x 3.2**	**3.2 x 3.6**	**3.6 x 3.6**
CUC (%)	86.9	82.6	79.8	73.5	74.4	71.4	72.9	76.4
IA (mm h^{-1})	9.5	7.9	6.8	5.8	5.1	4.4	4.0	3.5

of .28 x 2.8 m showed intensity of application (IA) below 10 mm.h^{-1} with 9.0 mm.h^{-1}. On table 3 are, according to the spacing, the values of CUC and I

In trial 3, the best performances of uniformity were the spacing of 2 x 2.4 m, 2.4 x 2.4 m, 2.4 x 2.8 m, with CUC valued respectively equal to 92.6%, 91, 6% and 88.0%. However, from these spacing, none of the spacing showed intensity of application (IA) less than 10 mm.h^{-1}. On table 4 are, according to spacing, the values of CUC and IA obtained in test 3. In figure 3, are shown through graphics, the profiles of water in assay 3.

From the twenty-four combinations of spacing tested, eight had coefficients of uniformity (CUC) greater than 85%, however, only the combinations of 2 x 2.4 m of the assay 1 (30 kPa) and 2.8 x 2.8 m of the assay 2 (60 kPa) also had intensity of application (IA) less than 10 mm h^{-1}. This does not eliminate for definite the other alternatives of spacing. The 2.4 x 2.8 m spacing of assays 2 (60 kPa) and 3 (90 kPa), with intensities of application (IA) equal to 10.5 mm h^{-1}, and CUC equal to 89.3% and 88% respectively, can also be used, since AI is very close to the maximum allowed. The option 2 x 2.4 m of the assay 1 (30 kPa), although having IA and CUC acceptable, should be seen as the economic point of view, because if taken, will lead to a greater number of sprinklers by area. The same considerations apply to the options 2.4 x 2.8 m of assays 2 and 3, since these will also generate a greater number of sprinklers.

Conclusions

The micro sprinkler evaluated has conditions to operate below the pressure range of service recommended by the manufacturer, demanding a lower consumption of energy.

The spacing 2.8 x 2.8 m with 60 kPa of pressure, ended up being the best option, because it demands a smaller number of sprinklers by area, with intensive application of less than 10 mm h^{-1} and coefficient of uniformity greater than 85%.

Table 3. Values of CUC (%) and IA (mm h-1) obtained in assay 2.

	Spacing (m x m)							
	2 x 2.4	2.4 x 2.4	2.4 x 2.8	2.8 x 2.8	2.8 x 3.2	3.2 x 3.2	3.2 x 3.6	3.6 x 3.6
CUC (%)	92.2	92.6	89.3	85.5	83.5	82.1	82.2	82.3
IA (mm h^{-1})	14.7	12.3	10.5	9.0	7.9	6.9	6.1	5.5

Table 4. Values of CUC (%) and IA (mm h-1) obtained in test 3.

	Espaçamentos (m x m)							
	2 x 2.4	**2.4 x 2.4**	**2.4 x 2.8**	**2.8 x 2.8**	**2.8 x 3.2**	**3.2 x 3.2**	**3.2 x 3.6**	**3.6 x 3.6**
CUC (%)	92.6	91.6	88.0	81.9	80.9	78.8	78.7	78.5
IA (mm h^{-1})	14.7	12.3	10.5	9.0	7.9	6.9	6.1	5.5

Figure 1. Profile of the water distribution in test 1, with pressure of 30 kPa.

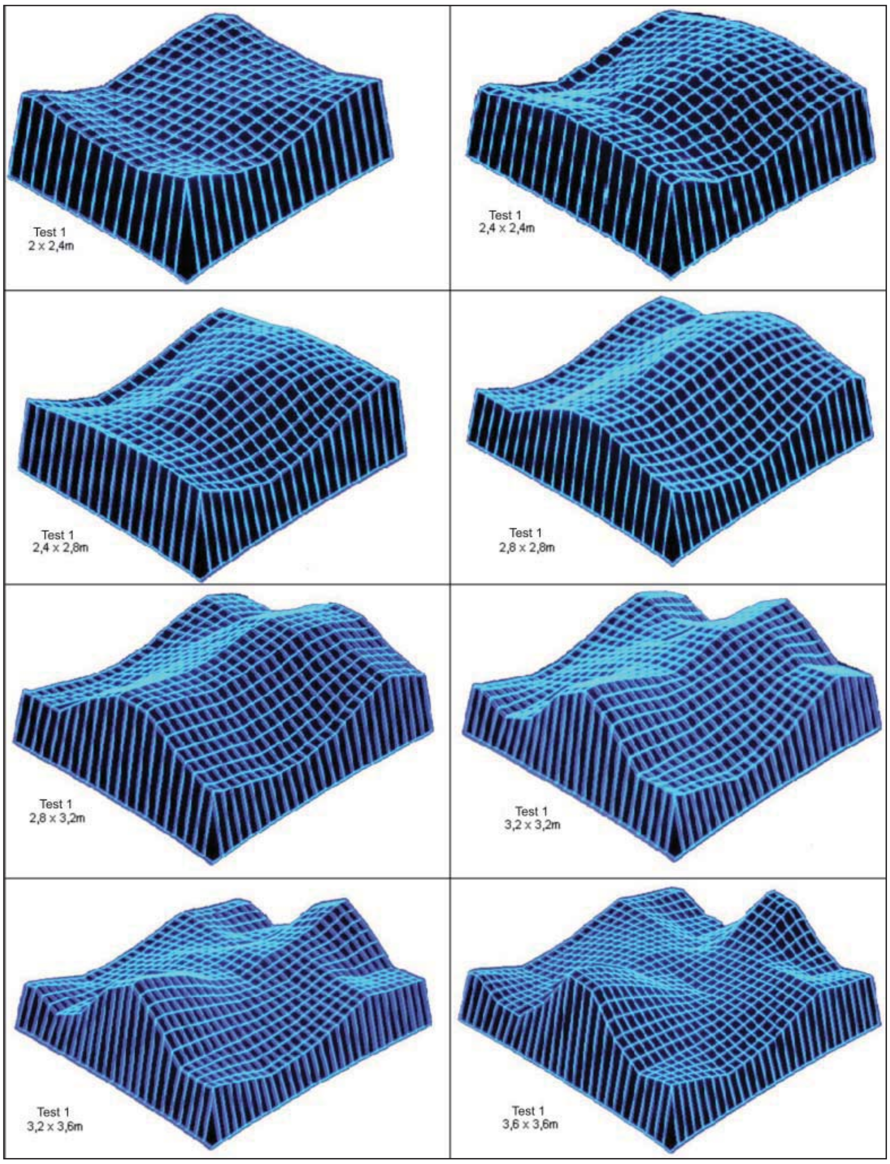


Figure 2. Profile of the water distribution in test 2, with pressure of 60 kPa.

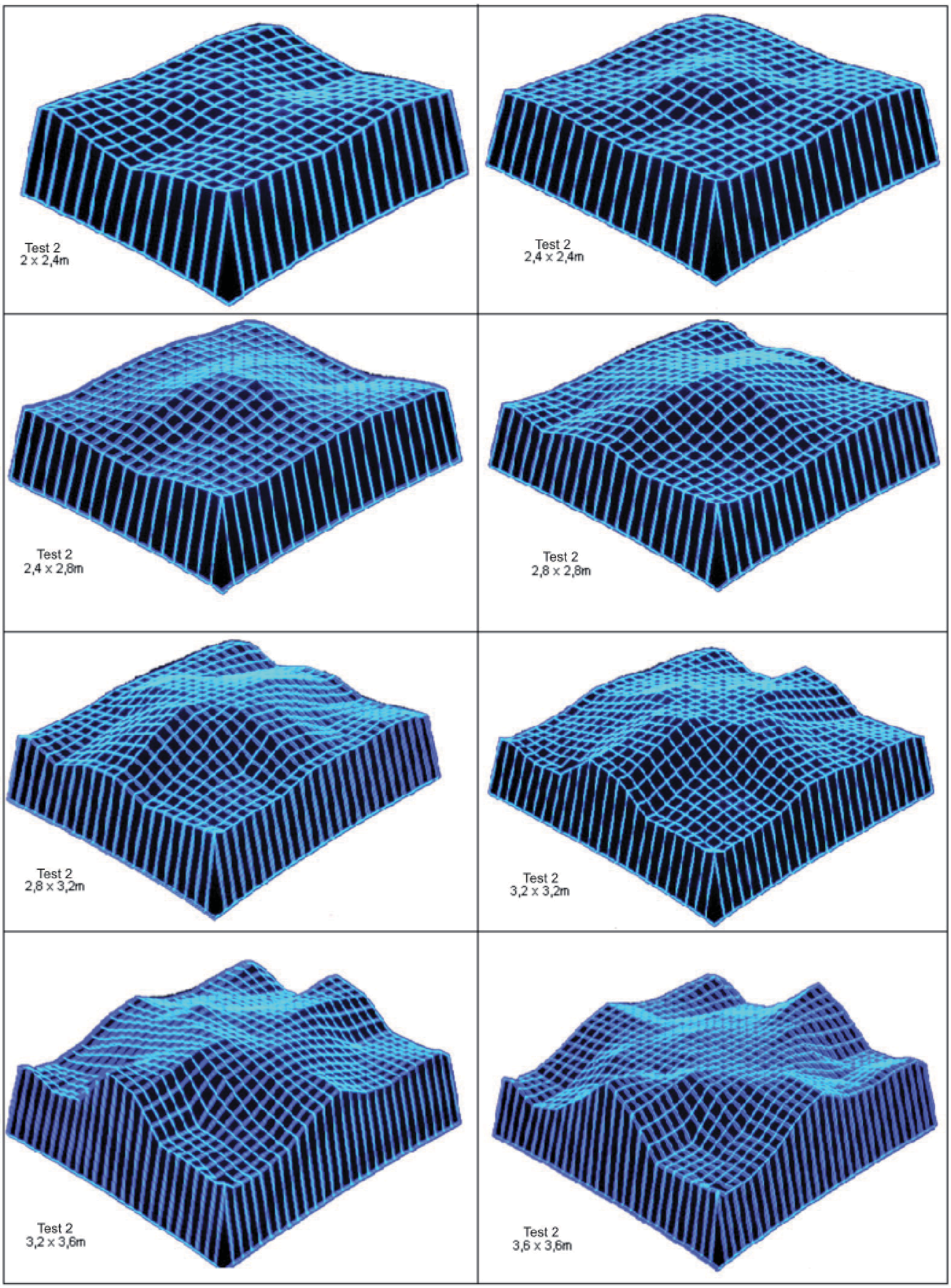
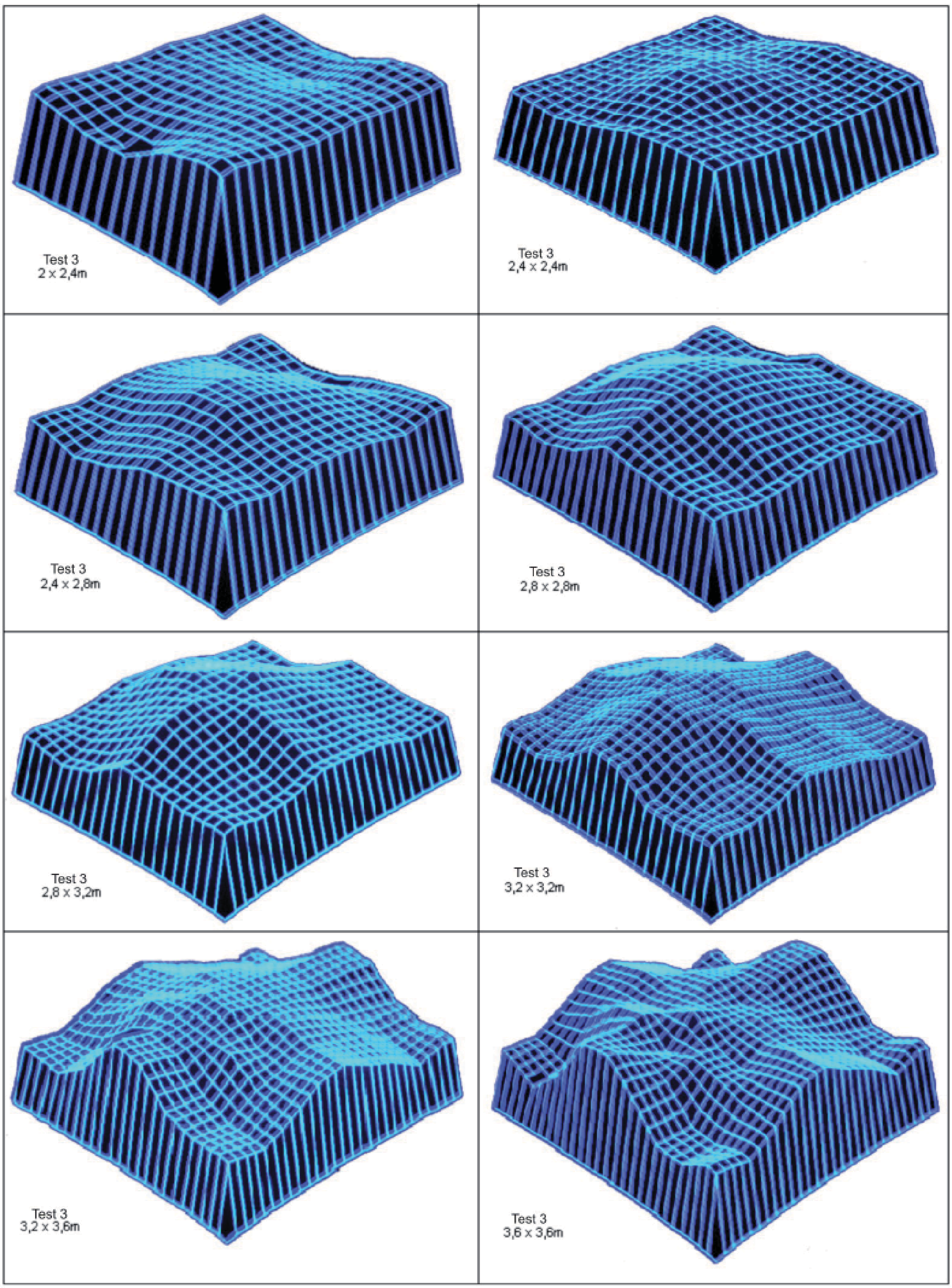


Figure 3. Profile of the water distribution in test 3, with pressure of 90 kPa.



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