RESEARCH ON WATER EFFICIENCY IN SPRINKLING IRRIGATION

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Abstract. Our research aims to show the uniformity of water distribution in sprinkler watering of an apple plantation. We used the sprinkling irrigation equipment in the 18 x 18 scheme under different climatic conditions for which we calculated the Christiansen uniformity coefficient and we determined the variation of the water amount supplied to the basic irrigation area. We calculated the actual irrigated area/basic plot area relation, which recorded a value of 2.51.

Key words: sprinkler, uniformity coefficient, basic plot, irrigation scheme, rainfall profile, isohyets

INTRODUCTION

Sprinkler irrigation method has emerged as a revolutionary sprinkler technique whose efficiency has been particularly evident, compared with surface drip irrigation: water saving, lower costs for land reclamation, better watering uniformity, etc. (1). Social economic evolution has led to changes in water resources management; thus, irrigation water sources have become less available, and this situation is continuously increasing. Therefore, research in this field are aimed to provide a more productive use of irrigation water by improving irrigation equipment, changing the physiological characteristics of crops and even new irrigation methods. Research refers to rotary sprinklers operating on medium pressures, i.e. lower than 4.5 at (3).

MATERIAL AND METHOD

Irrigation uniformity is estimated based on water distribution on soil; we consider good irrigation when water distribution is as uniform as possible so as to ensure uniform water infiltration into the soil. Regardless of the formula used for evaluation, for the calculation of irrigation uniformity it is necessary to know the water point height for each basic irrigated area (4). For this purpose, we can use the field method consisting in sprinkler arrangement in an irrigation scheme and uniform pluviometer arangement in the centre of each basic area. After sprinkler operating during a certain period of time, we measured the water amount in the pluviometers and calculated the water layer height (3).

Irrigation uniformity is expressed by the uniformity index that can be determined by the Christiansen method:

$$Cu = 100\ (1-\frac{\Sigma\Delta h}{n \cdot hm})\ \%,$$ where: $\Delta h=h_i - h_m$; h_i each individual rainfall value h_m; rainfall observation mean; n -number of pluviometers

We consider the absolute value of the deviation from the mean of the observations collected from the basic irrigated area consisting either in the area bounded by the

sprinklers operating within a particular irrigation scheme or in the area irrigated by one sprinkler.

Thus, the resulting uniformity coefficient must exceed 55-60%. The highest value, 100%, results from perfect irrigation uniformity (4). In this framework, at the Moara Domnească testing site we carried out research on sprinkler irrigation efficiency, aiming at: establishing the uniformity coefficient, viewing water distribution on land surface by drawing isohyets on the basic irrigation area, calculating the distribution of the sprinkler irrigation standards on the basic irrigation area (5). We performed tests on a basic experimental plot, bounded by four ASJ – 4-M sprinklers in the 18 x 18 working scheme. The basic area was grown with five rows of apple trees with spindle-shaped crowns, planted in the 3.5 x 1.0 scheme, with 19 trees on a row. The basic area consisted in: 5 rows x 19 trees: 95 trees. In the chosen scheme, the sprinkler working range was 16.1 m.

Experimental conditions:

- irrigation equipment IIAM Dn25
- sprinkler ASJ 1 M, with the following technical details:
  - nozzle diameter: 6 mm
  - operating pressure: 3.5 at
  - flow: 2.39 m^3/h
  - sprinkling diameter: 32.2 m
  - hourly pluviometry in the operating scheme 18 x 18: 7.4 mm/h
- wind speed: 2m/s

We carried out research in three versions, I, II and III, differentiated as follows:

Version I : - wind speed: 2 m/s
- operating pressure: 3.5 at
- pluviometry: 7.4 mm/hour

Version II : - wind speed: 2 m/s
- operating pressure: 3.0 at
- pluviometry: 6.8 mm/hour

Version III : - one sprinkler in operation, speed wind under 2 m/s.

RESULTS AND DISCUSSIONS

Uniformity coefficient was calculated by the Christiansen formula, according to the above-mentioned conditions. We obtained a uniformity coefficient of 85% in version I and 90% in version II. This showed that sprinkler irrigation increased with wind speed and hourly-measured pluviometry decreasing (2). With one sprinkler in operation (version III), uniformity coefficient was 93%, with an average value of sprinkled water of 77.6 mm.

$$Cu = \left(1 - \frac{\Delta h}{m \cdot n}\right) \cdot 100 = \left(1 - \frac{1064,6}{7014}\right) \cdot 100 = (1 - 0,15) \cdot 100 = 85\%, \textit{Version I}$$

$$Cu = \left(1 - \frac{\Delta h}{m \cdot n}\right) \cdot 100 = \left(1 - \frac{726,81}{6863}\right) \cdot 100 = 90\%, \textit{Version II}$$

$$Cu = \left(1 - \frac{\Delta h}{m \cdot n}\right) \cdot 100 = \left(1 - \frac{438,8}{6286}\right) \cdot 100 = (1 - 0,07) \cdot 100 = 93\%, \textit{Version III}$$

Sprinkled water distribution on the basic irrigated area. The basic irrigated areea is the area bounded and simultaneously irrigated by four neighbouring sprinklers. In version I (fig.1.) we noticed that the highest water amount, 110 mm, was distributed in the central area bounded by the sprinkling equipment, compared with the areas adjacent to the sprinklers, where the water amount distributed on the plot was the lowest, 65-70 mm.

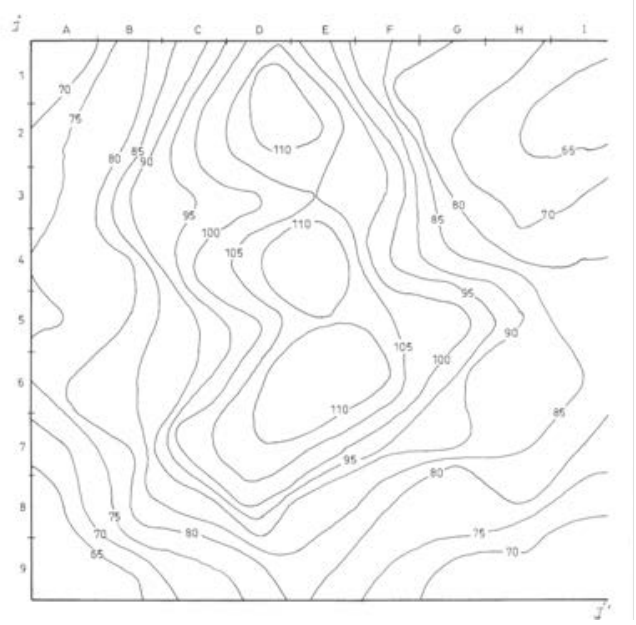

Fig.1. Isohyetal lines characteristic for sprinkling irrigation, version I

The rainfall profile on the direction I – I' (fig. 2.) showed that, on the diagonal distance measured between 5 and 18 m, the plot received a water amount higher than the average of 86.6 mm. The rainfall distribution diagram (fig. 3.) shows that 47% of the basic irrigated area received 61-80% of the sprinkled water, 34% of the area received 81-100% and 19% received more than the average rainfall amount.

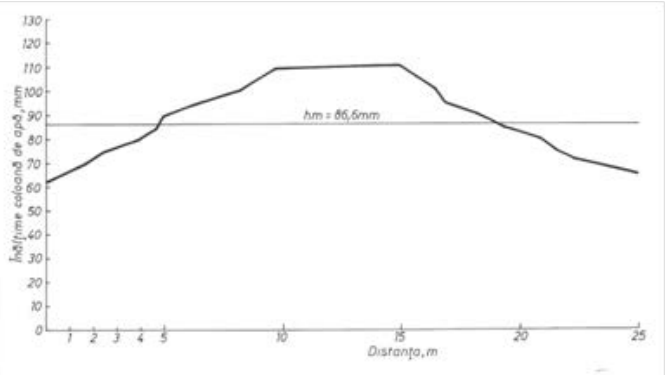

Fig. 2. Pluviometric diagram for diagonal I – I'

In version II (fig. 4.), under conditions of slight wind and lower rainfall, sprinkled water distribution in the basic plot was more uniform. The highest water amount (110 mm) was distributed in the overlapping irrigated area of the four sprinklers. The highest water amounts distributed on the plot recorded tha same values as version I, i.e. 110 mm

highest, 65 mm lowest. The rainfall profile (fig. 5.) measured on the diagonal II – II' showed that the distribution area of the sprinkled water exceeding the mean value (84.7 mm) varied between 7 and 19 m, with the highest value of 110 mm at a distance of 13 m.

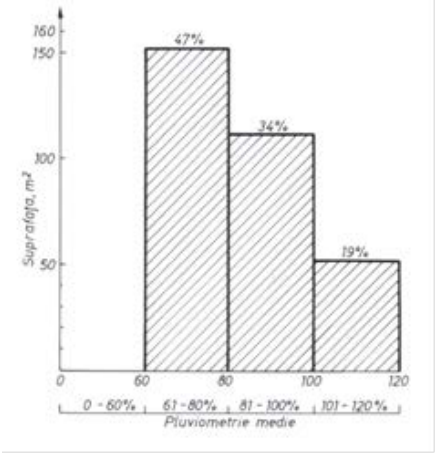

Fig. 3. Pluviometric distribution diagram, version I

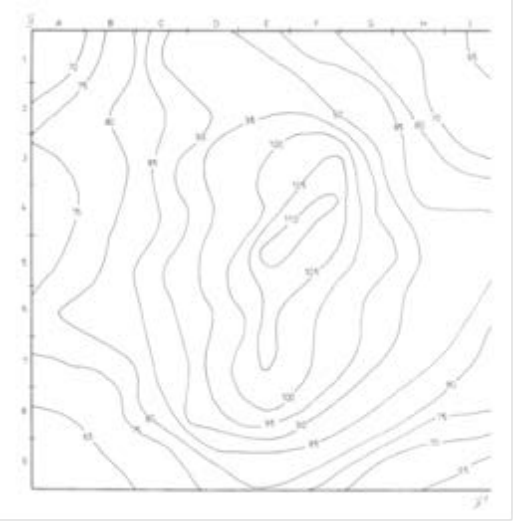

Fig. 4. Characteristic izohyetal lines for sprinkling irrigation, version II

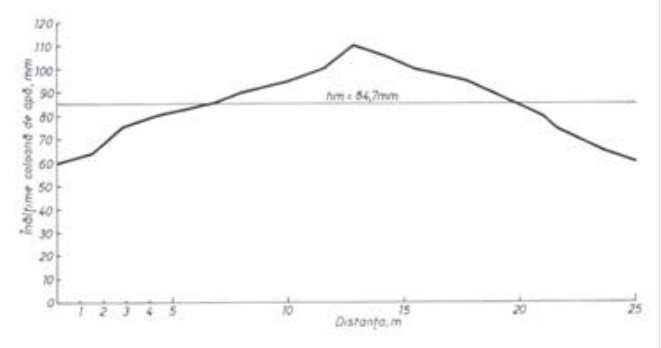

Fig. 5. Pluviometric diagram for diagonal II – II', version II

The rainfall distribution diagram (fig. 6) does not differ from the distribution model of version I, which indicated that rainfall recorded values between 60 and 120 mm. Thus, sprinkling irrigation distributes the watering amount unevenly.

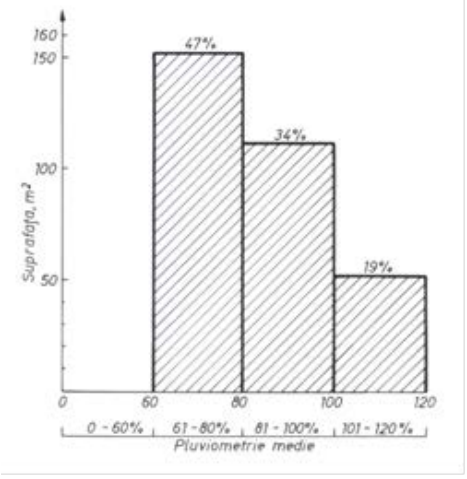

Fig. 6. Pluviometric distribution diagram, version II

Research on the distribution of water produced by one sprinkler (version III) under conditions of wind speed lower than 2m/s (fig.7) showed that irrigation was more uniform; the difference between the highest (95 mm) and the lowest (70 mm) amount of rainfall was smaller than in the irrigation scheme. This was explained by the fact that there was only one sprinkler watering the area.

It is also noteworthy that the highest water amount distributed on the land was displaced, compared with the sprinkler location along the wind direction. Rainfall profile (fig. 8) on the diagonal (III-III') of the irrigated area showed that the distributed water amount (77.6m) was higher on a distance of 14 m and average on a distance of 11 m.

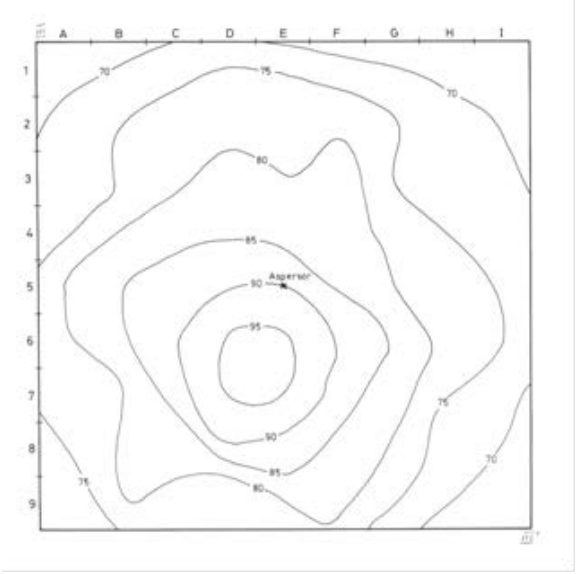

Fig. 7. Characteristic izohyetal lines for sprinkling irrigation, version III

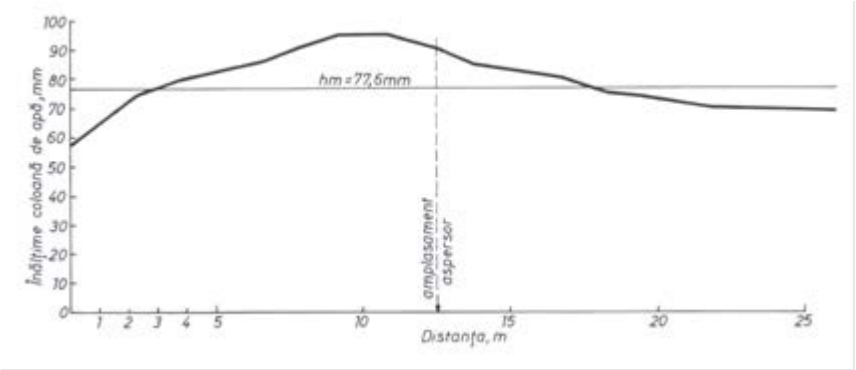

Fig. 8. Pluviometric diagram for diagonal III – III', version III

Sprinkling water distribution in the fruit-tree plantation. Sprinkling irrigation is performed by equipment on which sprinklers are attached in order to water a circular area. If the irrigation scheme is 18 x 18, the basic irrigated area has a square shape with 18 m sides. Each of the four sprinklers irrigates a part of this area. For full watering purposes, the irrigation areas of the four sprinklers should overlap, which means that the soil receives different water amounts (fig.9).

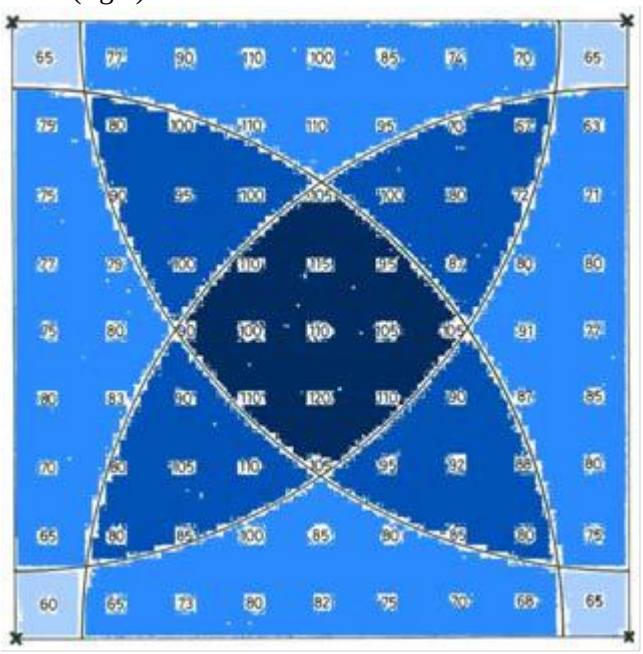

Fig. 9. Rainfall rate for a sprinkling irrigation system, working diagram 18 x18

The location of the watering equipment in the fruit-tree plantation (fig. 10) showed the following:

- there were 95 trees on the basic irrigation area;
- depending on the overlapping areas irrigated by the four sprinklers, the trees were watered according to the following scheme:
- 57 trees (60%) watered by two sprinklers
- 21 trees (22%) watered by three sprinklers
- 13 trees (14%) watered by four sprinklers

- the actual irrigated area on the basic plot must be evaluated as follows:
  - area irrigated by one sprinkler (S)

$$S = \pi r^2 = \pi \times 16.1^2 = 813.9 \text{ m}^2$$

  - area of basic plot irrigated by one sprinkler (Sa)

$$S = 813.9 : 4 = 203.5 \text{ m}^2$$

  - total area irrigated by sprinklers in the irrigation scheme (S_T)

$$S_T = 203.5 \times 4 = 814 \text{ m}^2$$

  - area of basic irrigated plot (Sp) :

$$Sp = 18 \times 18 = 324 \text{ m}^2$$

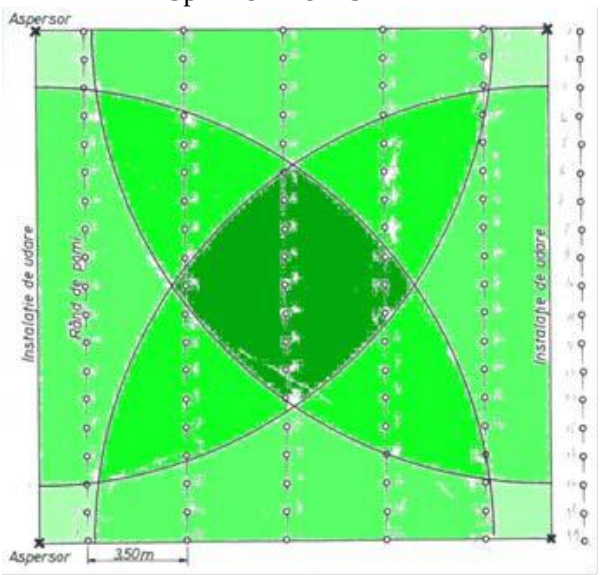

Fig. 10. Watering norm variation for sprinkling irrigation system used in a tree plantation

The relation between the actual irrigated area and the actual area of the basic plot was: 814 : 324 = 2.51.

In the working scheme 18 x 18 the sprinklers irrigated an area of 814 m^2, compared with 324 sqm, i.e. the actual area of the experimental plot. Therefore, the actual irrigated area exceeded 2.5 times the area of the basic irrigation plot.

In the case of classic irrigation equipment, water distribution was uneven and required different irrigation management.

CONCLUSIONS AND RECOMMENDATIONS

1. The technical characterization of sprinkling irrigation is performed by research on water distribution on the basic irrigation area. Under the experimental conditions, uniformity coefficient recorded values of 85-90% of the working scheme and 93% in the case of one sprikler in operation.

2. The water amount distributed on the basic irrigation area indicated that the central plot received more water (19% of the area) while 47% of the area received only 61-80% of the distributed water amount.

3. The highest water amount distributed on the area was displaced from the sprinkler location along the wind direction.

4. In the case of classic irrigation equipment, under the experimental conditions the sprinkling equipment watered an actual area 2.5 times higher than the area bounded by sprinklers.

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