# DETERMINATION OF THE UNIFORMITY OF SPRAYING THE SPRINKLER IRRIGATION IN THE FORESTRY NURSERY

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**Abstract**

The research was carried out in the Iarac forestry nursery in the O.S. Iuliu Moldovan during 2010-2011, on an alluvial soil (the vertical-gleyed subtype). The placement of the sample markets was carried out according to the "divided parcels method" in two repetitions, and the surface of a parcel was 450 m2. The present paper displays the results obtained after the sprinkler irrigation, when we determined the quantity of water spread by the 6 sprinklers on a 15m-radius, placed on the direction of the cardinal points. The purpose of the research was to observe the correlation between the qualitative work indexes of the sprinkling devices, by spreading a uniform quantity of water on the entire surface and the maintenance of an ecological balance of cultivation of the saplings in the forestry nursery. In a close connection with the purpose stated, the paper also focuses on the study of the work indexes of the sprinklers used in forestry nurseries, among which the most important is the uniformity of sprinkling. The uniformity of sprinkling, the intensity of watering, the fineness of the rain, and the energy of the drops are also called qualitative indexes or the sprinkling's characteristics- key elements for the assessment of the sprinkling irrigation devices. Sprinklers are active organs of the watering devices. They can transform the water pumped out into drops which can be spread on the surface that needs irrigation. The main means used for the improvement of sprinkling uniformity are the following: the usage of sprinklers with a small radius of sprinkling, having correct pluviometric curves; the correct placement of sprinklers on the terrain, according to the schemes of work recommended; avoiding to water when the speed of the wind surpasses the speed limit established for the sprinklers used.

**Key words**: sprinkler, sprinkler irrigation, uniformity of sprinkling, qualitative indexes of the sprinkling

The determination of the quality of rain obtained through sprinkling is made by means of qualitative indexes of effusion: uniformity of sprinkling, intensity of the rain and fineness of the rain. These indexes are able to provide enough data to establish if the rain provided through sprinkling corresponds to the conditions of correct watering techniques.

Thus, the condition of a uniform distribution of the water on the terrain is determined with the aid of an index of sprinkling uniformity. The condition of a minimum loss of water through surface leaking and the condition that the watering does not worsen the properties of fertility of the soils, through the deterioration of the soil (the formation of the crust) or through erosion are determined with the aid of an index of uniformity.

The condition of a minimum loss of water through evaporation during watering is determined through the index of the fineness of the rain. The same index serves together with the index of intensity for the appreciation of watering from the point of view of the formation of the crust and of the mechanical effects of the water on the tissues of the irrigated plants. (Nedelcu M., 2004)

In order to diminish the negative effect of the wind and to improve the uniformity of the sprinkling, it would be good to reduce the distance between sprinklers on the wing of sprinkling according to the speed of the wind. (Grumezea N., Kleps C., 2005)

The placement of the wings of sprinkling should be projected, if possible, perpendicularly on the direction of the dominant wind or at an angle of 45° in some places. The usage of high tap extensions at the improved sprinkler ameliorates the uniformity of watering; in conditions of good weather though, the loss through evaporation of the jet increases a lot, moreover when the speed of the wind grows.

The height of the sprinkler at 0.50 m when the wind blows is more favourable than at 1.50 and the stability to wind of the jet increases together with the size of the nozzle. Uniformity of watering depends on the speed of the wind and its direction, and also on some technical characteristics of the

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sprinklers, height of placement, etc. (Cazacu E., et all, 1989)

Up to a speed of wind of 2 m/s, there are no significant modifications in the uniformity of watering. This speed is frequently met in the irrigable zones from the country, being encompassed in the category of speed from1-3 m/s, dominant category in the period of irrigation March-October.

While modifying the schemes, we must take into consideration the speed of the wind at the height of the sprinkler. The wings are placed as possible perpendicularly on the dominant wind and the sprinklers at the height of 40-60 cm above the soil in order to avoid the turbulence of the wind which is formed immediately on the soil. (Vlad I. S., et all., 1982)

As the uniformity of the watering is concerned across the wings of sprinkling, this is considered satisfying if the loss of load between the first and last sprinkler (Kp) does not surpass 20% from the operating pressure: $K_p < 0{,}2H_a$ , in which Ha is the operating pressure of the sprinkler.

On the basis of the different indexes found in the specialty literature, we acknowledge the limit speed of the wind at 5m/s, bigger speeds being prohibitive for the sprinkling. At a wind speed of 1.5-5m/s, one needs special schemes of placement of the sprinklers. At wind speeds less than 1.5m/s, the influence of the wind is considered to be insignificant for the uniformity of the sparkling. (Mihai S., 1970,a)

Knowing the technical elements of the watering (schemes of watering, intensity of the rain, duration of watering, fineness of the rain, uniformity of the sprinkling) creates the premises necessary for the application of a uniform watering, the correlation of the intensity of the rain with the speed of infiltration of the water in the soil, but also possibility of appreciation of the quality of watering. (Mihai S., b 1970)

An ideal sprinkler must accomplish an intensity whose value grows continuously, with smaller values from the periphery of the jet towards the sprinkler. These types of sprinklers ensure a good uniformity of watering when the work schemes are established judiciously, according to the distribution of the intensity on the radius. (Chiru V., Mihai S., 1972)

The intensity and the uniformity of watering are in a large extent influenced by the work pressure and the nozzle used. Thus, when the sprinkler functions at a too low pressure, it produces too big drops and an un-uniform distribution of the water. When the pressure is too high, the jet of the sprinkler is pulverized in smaller drops which are distributed around the sprinkler. (Pleşa I., el all, 1986)

Thus, the present research had as a purpose the study of the possibility of introducing in the exploitation other types of sprinklers, adaptable to the requirements of the cultures and soils in question.

## MATERIAL AND METHODS

The research was carried out in the Iarac forestry nursery in the O.S. Iuliu Moldovan during 2010-2011, on an alluvial soil (the vertical-gleyed subtype). At the time when the measurements were taken, the meteorological conditions were: temperature of 24$^o$ C; wind speed of 2 m/s; total nebulosity: 4 ; and relative humidity 49. The placement of the sample markets was carried out according to the “divided parcels method” in two repetitions, and the surface of a parcel was 450 m$^2$.

The present paper displays the results obtained after the sprinkler irrigation, when we determined the quantity of water spread by the 6 sprinklers on a 15m-radius, placed on the direction of the cardinal points.

The determination of the uniformity of sparkling by measuring the quantity of water sprinkled, which is collected in pluviometers, placed after a certain rule on the watered surface.

In the case of the determination of the uniformity of sprinkling of an isolated sprinkler, the pluviometers are placed at equal distances of 1-2 m, on a radius, in conditions of atmospheric calmness or on four radiuses, in a cross, if windy.

In the case of the determination of the uniformity of sprinkling under a wing of rain, it is necessary to use a greater number of pluviometers, placed on two perpendicular directions, under the form of a grid.

Thus, we can produce a regular geometrical platform, having the width equal with the distance between two neighbouring sprinklers, and the length equal with the distance between the two neighbouring wings of rain.

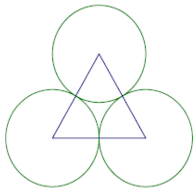
The graphic of the isohyet is made by uniting the points which have the same collected quantity of water in the pluviometers. With the circle watering, the isohyets appear under the form of a concentric curve.

In order to determine the quantity of water distributed from the sprinkler to the surface of the soil, we placed pluviometers at each meter on two diagonals (cardinal points), until the distance of 15 m, thus registering the quantity of water distributed, in mm or l/m$^2$.

Thus, we established two surfaces for the sampling of the observational data, in a rectangular form, with a 450 m$^2$ (30 x 15 m) surface, among which one was the witness sample –the un-irrigated soil, and the other surface suffered successive modifications through the sprinkler irrigation. At each surface, we sampled 60 primary data, placed on the direction of the cardinal points (N, S, E, W) for each of the six sprinklers henceforth abbreviated (A1…A6).

The distribution scheme of the sprinklers and pluviometers for the determination of sprinkling uniformity is given in Figure 1 and Figure 2.

The equilateral triangle



$$C_T = \frac{S_C}{S_T},\; S_C = \frac{1}{2}\pi \cdot r^2$$

$$C_T = \frac{S_C}{S_T} = \frac{\frac{1}{2}\pi \cdot r^2}{\frac{1}{2}(2r)^2 \cdot \sin 60^O} = \frac{\pi}{2\sqrt{3}}$$

where:

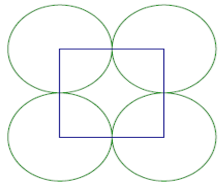
$C_T$ is coverage

$S_c$ - surface parts covered

$S_T$ - surface unit triangle

r – radius

The square



$$C_S = \frac{S_C}{S_S},\; S_C = \pi \cdot r^2 \; C_S = \frac{S_C}{S_S} = \frac{\pi \cdot r^2}{(2r)^2} = \frac{\pi}{4}$$

where:

$C_S$ coverage;

$S_c$ - the area covered parts;

$S_s$ - square unit area,

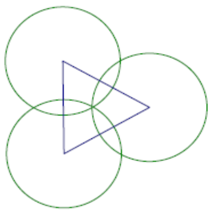
r – radius

Calculation of the surface irrigated ($S_N$):

$$S_N = 4r^2 - \pi \cdot r^2 = r^2 (4 - \pi) \approx 0.86 \cdot r^2$$

Figure 1 **The arrangement reciprocal of coverage area without sprinklers**

The equilateral triangle



$$O_T = \frac{S_O}{S_T},$$

$$S_O = \frac{3}{2}\left(\frac{2}{6}\pi \cdot r^2 - r^2 \sin 60^O\right) = \left(\frac{\pi}{2} - \frac{3\sqrt{3}}{4}\right) r^2$$

$$O_T = \frac{S_O}{S_T} = \frac{\left(\frac{\pi}{2} - \frac{3\sqrt{3}}{4}\right) r^2}{\frac{1}{2}\left(2 \cdot \frac{\sqrt{3}}{2} r\right)^2 \sin 60^O} = \frac{\frac{\pi}{2} - \frac{3\sqrt{3}}{4}}{\frac{3\sqrt{3}}{4}} = \frac{2\sqrt{3}\pi}{9} - 1$$

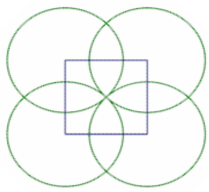
where:

$O_T$ is the rate of overlap;

So - surface parts that overlap;

$S_T$ - surface unit triangle.

The square



$$O_S = \frac{S_O}{S_S},$$

$$S_O = 2\left(\frac{2}{4}\pi \cdot r^2 - r^2\right) = (\pi - 2) r^2$$

$$O_S = \frac{S_O}{S_S} = \frac{(\pi - 2) r^2}{(\sqrt{2} r)^2} = \frac{\pi}{2} - 1$$

where:

$O_S$ is the rate of overlap;

So - That surface overlap shares;

$S_S$ - surface unit triangle.

Figure 2 **The arrangement sprinklers in areas of reciprocal coverage**

## RESULTS AND DISCUSSIONS

The determination of the sprinkling uniformity is made with the aid of some indexes:

***1. Christiansen coefficient of uniformity:***

$$C_u = 100\left(1 - \frac{\sum |a|}{m \cdot n}\right) \qquad (1)$$

in which:

$\sum a$ represents the sum of the partial deflections from the average volume of water collected in pluviometers, in $cm^3$;

m - the average volume of water collected in pluviometers, in $cm^3$;

n – number of pluviometers.

The condition of a good uniformity is: $C_u$ > 80-85%. (Popescu I., Popescu S., 2000)

The distribution scheme of the water sprinkled on the surface of the soil is of great importance for the acknowledgement of the quality of watering. This distribution, expressed through the coefficient of uniformity, has deep implications on the development of cultures and, thus, on the productions obtained.

In the experiments of both our Romanian and foreign researchers, the coefficient mostly used is that of uniformity (Cu), after Christiansen.

$$C_u = 100\left[1 - \frac{\sum(h-\overline{m})}{\overline{m \cdot n}}\right][\%] \qquad (2)$$

in which:

h is the height of the water in each pluviometric box, in mm;

$\overline{m}$ - average height of water fallen in pluviometers, mm;

n – number of pluviometers.

For the interpretation: when
Cu=100-85% good and very good uniformity,
Cu=85-75% average uniformity,
Cu=75-65% weak uniformity,
Cu=65% inadequate uniformity.

The values obtained for the Christiansen coefficient of uniformity are presented in Table 1:

Table 1

**Values of the Christiansen coefficient of uniformity determined for the six sprinklers according to the cardinal points**

| Coefficient of uniformity | | | | |
|---|---|---|---|---|
| Cardinal points / Sprinkler | NORTH | EAST | SOUTH | WEST |
| A1 | 84.262 | 99.777 | 110.655 | 105.305 |
| A2 | 98.497 | 102.741 | 93.192 | 105.570 |
| A3 | 92.490 | 107.949 | 98.463 | 101.098 |
| A4 | 78.125 | 101.042 | 112.083 | 108.750 |
| A5 | 75.158 | 98.795 | 111.876 | 114.171 |
| A6 | 79.732 | 104.899 | 104.899 | 110.469 |

***2. Pernes coefficient of uniformity:***

$$C_u = 100\left(\frac{H_o}{H_m} \cdot \frac{s}{S}\right) \qquad (3)$$

in which :

$H_o$ is the minimum height of the rain fallen on the irrigated surface, in mm;

$H_m$ – is the average height of the fallen rain, in mm;

s – the irrigated surface which received from 80% to 120% from the height of the average rain in $m^2$ ;

S – the total surface watered, in $m^2$.

The interpretation of the results is made as it follows:
$C_u$ < 50% - inadequate uniformity;
C,, < 75% - medium uniformity;
$C_u$ >75%-very good uniformity.(Siseşti V. I., 1971)

Table 2

**Values of the Pernes coefficient of uniformity grouped according to the distance to sprinkler**

| Distance from the sprinkler, m | Coefficient of uniformity |
|---|---|
| 1 | 76.50 |
| 2 | 72.73 |
| 3 | 78.18 |
| 4 | 66.43 |
| 5 | 63.05 |
| 6 | 58.14 |
| 7 | 60.37 |
| 8 | 69.98 |
| 9 | 59.77 |
| 10 | 49.67 |
| 11 | 44.14 |
| 12 | 29.70 |
| 13 | 37.65 |
| 14 | 43.64 |
| 15 | 46.83 |

***3. Pearson coefficient of variance:***

$$C_v = 100\frac{\tau}{m} \qquad (4)$$

in which : $C_v$ coefficient of variance, in %;

s – the average square deflection of the partial volumes, as compared to the average volume of water collected in pluviometers, in $cm^3$.

m – average volume of water collected in pluviometers, in $cm^3$.

The values obtained for the *Pearson* coefficient of variance are presented in the following Table:

Table 3

**Values of the coefficient of variance of the sprinkling uniformity grouped according to the distance from the sprinkler**

| Distance from the sprinkler, m | Coefficient of variance |
|---|---|
| 1 | 4.19 |
| 2 | 8.14 |
| 3 | 3.56 |
| 4 | 16.16 |
| 5 | 17.38 |
| 6 | 19.10 |
| 7 | 21.68 |
| 8 | 16.96 |
| 9 | 25.84 |
| 10 | 44.07 |
| 11 | 36.85 |
| 12 | 48.92 |
| 13 | 43.94 |
| 14 | 32.05 |
| 15 | 30.98 |

The quantity of water distributed by the six sprinklers included in the experiment is presented through average values in Table 4, at distances from m to m on a 15 m- radius, placed on the direction of the cardinal points.

Analysing the average values from the table below, we could observe the presence of some optimal values of the water accumulated in pluviometers, after the sprinkling, up to an 8m-distance; on this radius, the quantity of water accumulated presents quite big variances because of the speed of the wind or the functioning of the sprinkler.

Table 4

**Average values of the sprinkling uniformity in connection with the cardinal points**

| Distance from the sprinkler, m | Average values in connection with the cardinal points, mm | | | |
|---|---|---|---|---|
| | North | East | South | West |
| 1 | 7.50 | 7.00 | 6.88 | 7.40 |
| 2 | 5.75 | 6.43 | 5.28 | 5.77 |
| 3 | 5.48 | 5.48 | 5.57 | 5.90 |
| 4 | 5.52 | 6.22 | 4.75 | 4.32 |
| 5 | 5.13 | 5.62 | 4.45 | 3.73 |
| 6 | 5.30 | 5.38 | 4.77 | 3.43 |
| 7 | 6.00 | 4.63 | 4.55 | 3.53 |
| 8 | 5.12 | 3.63 | 4.22 | 3.63 |
| 9 | 4.30 | 2.40 | 3.38 | 2.77 |
| 10 | 4.15 | 1.58 | 2.05 | 2.40 |
| 11 | 2.12 | 0.88 | 1.35 | 2.03 |
| 12 | 1.52 | 0.40 | 0.92 | 1.47 |
| 13 | 0.68 | 0.28 | 0.52 | 0.90 |
| 14 | 0.32 | 0.15 | 0.28 | 0.35 |
| 15 | 0.23 | 0.12 | 0.20 | 0.27 |

In the specialized literature is referred to minimum amount of water sprayed crop's needs, ranging from 2-6 mm / h depending on soil texture and crop species. (Trifu St.., 1973)

Analyzing information collected from our research these values are obtained and 10-11 m from the sprinklers.

This is particularly important because it provides information about the optimal distance between sprinklers in order to comply with the initial condition that the entire surface to distribute the same amount of water.

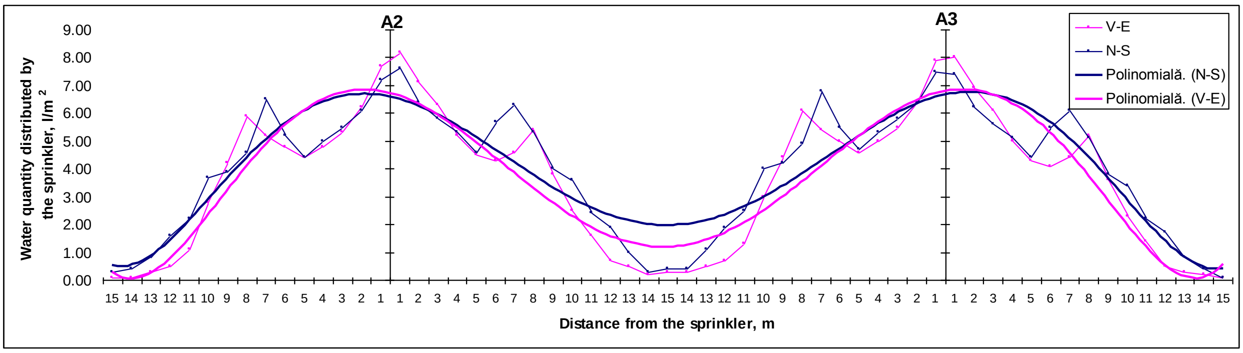



Figure 3 **Variance of the uniformity of sprinkling of the sprinkler 2 and 3**

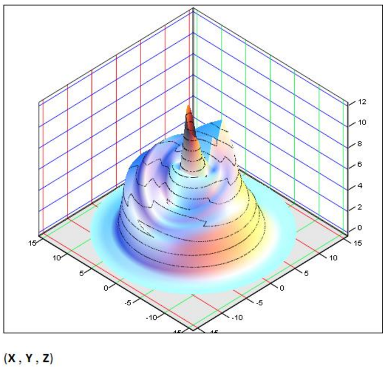



Figure 4 **The uniformity variation around the sprinkler spray 2**

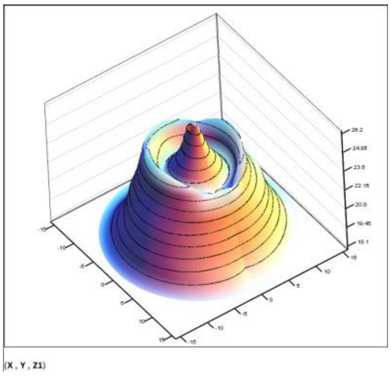



Figure 5 **The uniformity variation around the sprinkler spray 3**

## CONCLUSIONS

When watering through aspersion, the uniformity of distribution of the water for irrigation is rather reduced because of some definite causes. One of the causes for the lack of uniformity of the water on the irrigated terrain through sprinkling is the watering of the sprinklers on circular surfaces. For the integral coverage with rain of the terrain, the circular surfaces must overlap in a smaller or greater extent according to the distribution scheme of the sprinklers. In conditions of correct placement of sprinklers on the terrain, the surface watered twice varies between 15 and 33%.

Another cause which influences the uniformity of sprinkling is the functioning of a sprinkler. It is obvious that the water jet, even at the improved sprinklers cannot be distributed in an absolute uniformity on all its length. That is why the circular surface watered by a sprinkler appears, from the point of view of the uniformity of sprinkling, under some concentric zones, more or less differentiated according to the characteristics and functioning state of the sprinkler used.

At the improved sprinklers, small quantities of water are distributed at the periphery of the circular surfaces. Thus, by overlapping the circular surfaces, we could ameliorate the uniformity of sprinkling. The uniformity of distribution of the sprinkler is best given with the aid of a pluviometric curve. Another major source of non-uniformity of the watering through sprinkling is represented by the influence of the wind. The wind deforms the circular form of the surface sprinkled, which becomes a more or less normal ellipsis and a more or less flattened ellipsis, according to the uniformity and intensity of the wind.

Among the main means used for the improvement of sprinkling uniformity are the following:

The usage of sprinklers with a small radius of sprinkling, having correct pluviometric curves;

The correct placement of sprinklers on the terrain, according to the schemes of work recommended;

Avoiding to water when the speed of the wind surpasses the speed limit established for the sprinklers used;

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