STUDY OF MOISTURE DISTRIBUTION IN DRIP-IRRIGATED CAMBIC CHERNOZEM IN THE CRACAU PLAIN

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Abstract

Drip irrigation allows plants to be watered by slowly wetting the soil on a small surrounding area using special devices that distribute water drop by drop. The main advantage of drip irrigation compared to classic irrigation methods is that the necessary water amount is considerably reduced by wetting the soil strictly in the area that contains the roots for the plant. This allows a rigorous dose of the distributed water amount. On a clay loam cambic chernozem in the Cracau Plain that has a present moisture content of 19% g/g, field capacity of 23.2 % g/g, wilting coefficient of 14.8% g/g and bulk density of 1.36 g/cm^3 (mean values for a depth range of 0 - 80 cm), we performed water irrigation for a duration of 10 hours using spiral microtube dripping devices. The total water discharge per dripping unit ranged from 19.6 – 36.1 l, and the water flux ranged from 1.96 – 3.65 l/hour. Twenty-four hours after irrigation, we observed that the distribution of about 20 l of water, with a water flux of about 2 l/hours, provided soil wetting of the zone under the dripping device at higher values than the field capacity at a depth of 80 – 90 cm. The diameter of the wetting contour ranged from 60 – 100 cm at a depth from 40 – 50 cm, and the border diameter of the wetting zone ranged from 100 – 400 cm at a depth from 50 – 70 cm. Higher water flux values or longer irrigation durations resulted in a longer overwetting state in the upper half of the active layer of the soil and in water loss by percolation.

Key words: drippers, cambic chernozem, moisture content, wetting contour

Unlike the surface irrigation or in sprinkler irrigation, dripping irrigation distributes water to the through a microtube device. This fact creates a particular humidity distribution in the active of soil.

The knowledge of the humidity distribution particularities for different types of soil is useful in order to establish precisely the irrigation condition elements and in order to do a proper adjustment of the tehnical parameters of the watering equipment.

Studies about water distribution by microtube source in the soil have been comunicated by (Kumar M., Kumar R., 2017; Batista R. O. *et al*, 2018; Batista R.O., Oliveira R.A., 2016; Bozkurt Colak Y. *et al*, 2020; Messina G., Modica G., 2020; Ihuoma S.O., Madramootoo C.A., 2017).

These authors studied the water distribution on the soil profile obtained by localized irrigation of vineyard on the sands of the left bank of Cracau river and on a medium to heavy soil, respectively.

The research for the present study has been carried out in the in the Cracau Plain, in a field of SC Triticum SRL Savinesti, Neamt County, on a clay loam chernozem, with a minimum moisture content of 19 % g/g, a field capacity of 23,2 % g/g, a wilting coefficient of 14,8 % g/g and a bulk density of 1,36 g/cm^3 (medium values for a depth range of 0-80 cm).

MATERIAL AND METHOD

A high density plastified polyethene irrigation pipe, with a 12 mm nominal diameter was equiped with 4 pairs of microtube dripper with a 0,8 mm diametre. The distance between 2 pairs of drippers was a 5,2 m and the distance between the spiral microtubes of each pair was of 400 mm. The microtube length and the number of spires for the 2 drippers of each pair were equal. The 4 dripper pairs were sized in order to turn around the irrigation pipe for 9, 7, 6 and 5 spires.

So, the following rate in the different pairs of drippers ranged between 1,96 l/hour for the drippers with 9 spires and 3,65 l/hour for the drippers with 5 spires. The values of the flowing rates are presented in *table 1*.

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Table 1

Tehnical characteristics of the drippers

Number of spires	Total microtube length (mm)	Flowing rate (l/hour)	Distributed amount of water (l)
9	680	1.96	19.6
7	530	2.26	22.6
6	455	2.69	26.9
5	380	3.65	36.5

Irrigation was done at the moment when the calue of the medium humidity on the soil profile was close tominimum moisture content (MMC).

The irrigation pipe, placed on the ground surface, was suspended at a height of about 8 cm above the ground level, at the sites where the drippers were placed. Under one dripper of esch pair a collecting bin was placed, in order to collect the entire water amount that was lowed through the dripper. The second dripper of esch pair distributed water directly on the ground surface. The collecting bins were maintained covered, to avoid the water losses by evaporation.

The water quantities accumulated in the collecting bins were rigorously measured in a cylindrical graded beaker, every 30 minutes, for 10 hours. Subsequently, the medium flowing rate for each dripper was calculated.

Twenty-four hours after irrigation had been done, soil samples were taken, in order to establish the humidity values. The samples were taken from the spots under the drippers and from points situated at distances of 30 cm, 50 cm and 70 cm, respectively, from the locations of the drippers, on 4 perpendicular directions. Soil samples were taken at every 10 cm depth, for a depth ranging between 10-100 cm. Soil samples were also collected from the neighbouring area that hadn't been influenced by the irrigation.

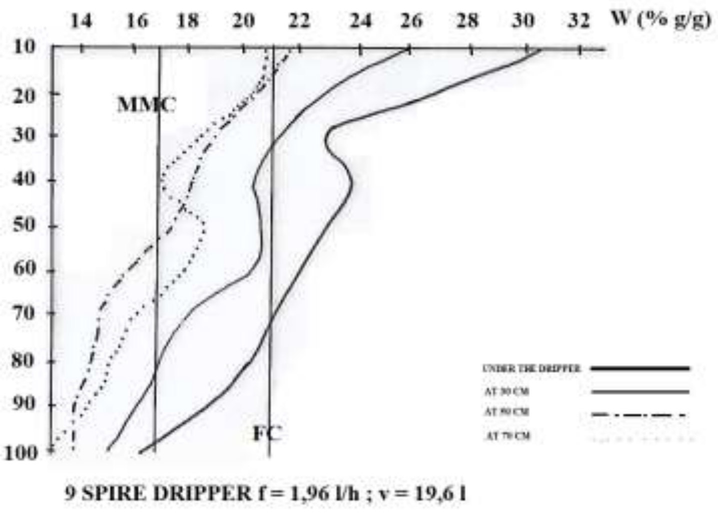
The humidity of the soil samples was obtained by gravimetric method.

The calculated medium values for humidity were used for obtaining humidity distribution diagrams, for a 100 cm depth (*figure 1 a,b,c,d and figure 2 a,b,c,d).*

RESULTS AND DISCUSSIONS

Some hours after the beginning of irrigation an almost circular area could be observed on the ground, under esch dripperm differing from the surrounding soil by the specific colour of the overwetted soil.

The diameter of the wetted areas increased progressively, and after 10 hours, when irrigation was stopped, the medium values of the wetted areas diameters ranged between 35-45 cm for all the 4 drippers. Microdepressions with a depth of 1-2 cm and a diameter of 5-7 cm were formed in the middle of the overwetted areas, as an effect of the impact of water drops with the soil. During the second half of the irrigation interval, a thin layer of water, with a 2-5 mm depth, accumulated in the microdepressions.



a)

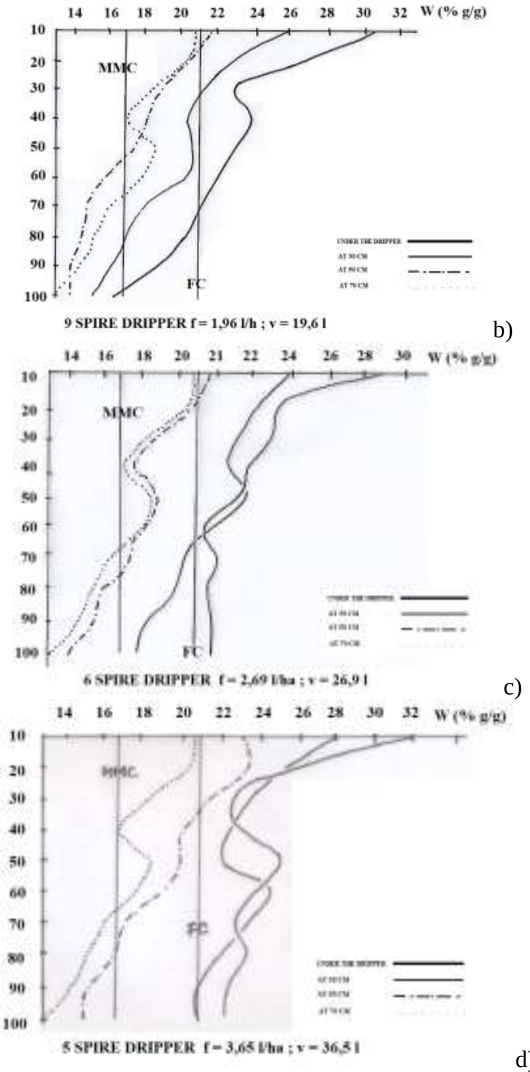
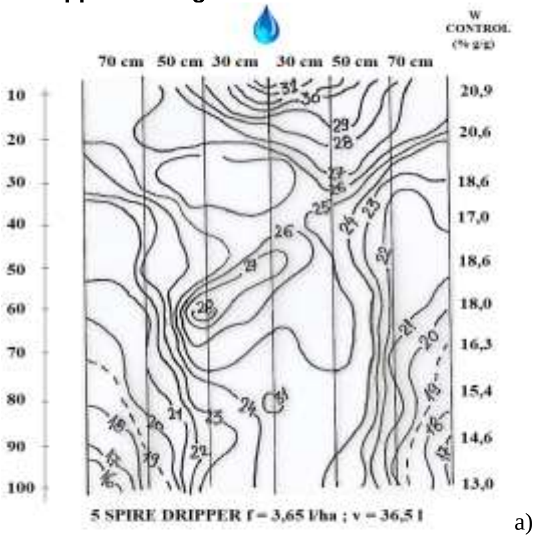


Figure 1 **The profile distribution of soil humidity according to the position of the sampling spots from the dripper, the dripper flowing rate and the distributed water volume**



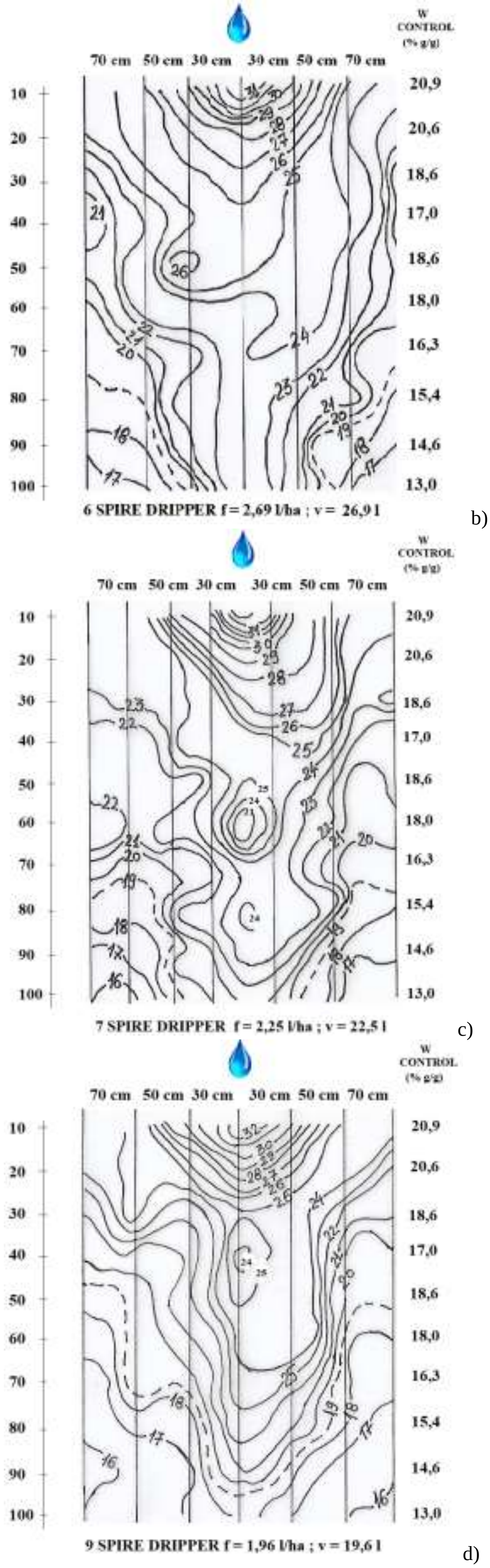


Figure 2 **The isopletes of soil humidity 24 hours after irrigation**

After 24 hours, when the samples were drawn for humidity, we observed the presence under the microtube dripper of the wet zones, dark coloured, but with an important decrease of the water content and an increased of diameters to values of 50-60 cm for the microtubes having a flow of 2 l/h of 65-75 cm at those having a flow of 2,7 l/h and 3,7 l/h, respectively.

Soil humidity after 24 hours from the watering application had the greatest values in the central zone from under the microtube dripper for all the 4 flows experimented (*figure 1*). Diagrams from fig. 1 and the images of moisture content isopletes (*figure 2 a, b, c, d*) show that the humidity decreases slowly with the depth and quicklier horrizontally. In all instances, the state of humidity superior to the values of 27-38 % g/g was specific for a zone (quasiconical) with a base of 30-50 cm, at a depth of 10 cm and which narrowing gradually place their peak, aproximately on thr vertical of the dripper, in the first third of the soil active layer. This zone with the humidity a little reduced than the zone appropiate of the total capacity for water was different from the point of view of form and surface, according to the different flows distributed. Next to the zone from the proximity of source, there was indentified a zone of wet or transmission, wider, developped due to the hydraulic gradient more present deeply, charger in the superior part and narrower towards the top, with an irregular contour, where the humidity decreases slowly up to around the field capacity, unlike the distributed flow.

The relative uniformity of humidity distribution over these zones, at the 4 values of the distributed flows, shows that, the zone of transmission increases its space of action by appling new quantities of water, but the humidity remains practically unchanged.

The depth of wet from at FC Level is different, for the same duration of wet, according the size of dripper᾿s flow.

So, for the dropper having the flow q = 1,96 l/h, the limit soil wet at FC value didn᾿t exceed 70-75 cm in depth, while at the dropper having q = 2,26 l/h reached 90 cm. For greater flows, the wet front of the transmission zone exceeded the depth of 1 m on a section the vertical dripper, with a diameter of 20 cm for q = 2,69 l/h and on a larger opening (Ø 60 cm) when q = 3,65 l/h.

At the exterior limit of the transmission zone there was emphasized a third zone, relativery narrow, of moderate humidity, water content decreasing from FC up to the soil humidity uninfluenced by the water of irrigation. This zone was characterized by contour with many inflexions, determined by the non-uniformity of hydraulic conditions of circulation through the whole space. For all the experienced flows, the inferior limit of the zone of moderate humidity reached or exceeded the depth of 1m.

Oncerning the humidity distribution horizontally there was observed that, the transmission zone had the diameter of wet diameter on the thickness of rable layer, generally greater than 140 cm; at the depth of 40-50 cm the width of the zone ranged between 60-100 cm and at the base of the active layer, this parameter ranged between 0-60 cm.

Because the waters are applied at last when supply reaches the MMC value, that results in the fact that, for appreciating the state of the wet created by the dripper must be considered the limit of the moderate humidity zone that limits the uninfluenced soil from the irrigation water. So, for the conditions in which the researches were conducted, at a depth of 50-70 cm, up to which almost all roots of plants develop, the soil got wet at MMC values superior within a radius of 50-70ncm, the superior limit corresponding to the greater flows of 2 l/h.

This observation offers the possibility of establishing the distance between drippers on the water wing. In the instance of this experiment, the realization of a continuous strip of optimally wet soil in the active layer, along the plants rows (vegetables, flowers), with the superposition in a percentage of 10 % of the wet zones implies the placement of the drippers on the water wing distances of 90-125 cm.

Dripper placement on water pipes at smaller distances determines for the cultivated plants, long periods with poor condition of aeration within the space of the root system and suplementary expanses.

CONCLUSIONS

1. In soil space under the dripper, water distribution from microtube sourse on clay loam combic chernozem procures a suprawet zone of quasiconical form, top down and irregular contour, having diameter of base and the depth, of 30-50 cm, according to the value of dripper flow and the water duration.

2. After water cessation, the water circulation continues under the influence of the fields of forces which act in the soil, being governed by the hydraulic gradient that determines the gradual diminution vertically and horizontally of the water content from the layer of wet soil (transmission zone), simultaneously with the deepning of the wet front and with the decrease of the influence radius horizontally.

3. In research conditions, dripper flow of almost 2 l/h represents the limit flow up to which the soil humidity at valus FC superior don't extend under the thickness of the active layer at a wet duration of 10 hours; using greater flows we can induce the decrease of water duration, for getting similar results.

4. In the instance of clay loam combic chernozem, the diameter of wet zone (by a dripper at a depth of 50-70 cm) is about 100-140 cm for the flow of 2 l/h after 24 h from the water application and the distributed water volume of 20 l, and the depth of wet from ranges between 90-100 cm; for greater flows and volumes, the front of transmission zone exceeds the active layer of soil, without the significant increase of wet radius, horizontally.

5. Distance between drippers of 90-125 cm ensures the corresponding soil wet up the depth of 50-75 cm, in a continuous strip along water pipe at 24 h from the application of 20-25 l/dripper (with the flow of 2 l/h); drippers placement at smaller distances on water pipes is uneconomic and maintains overwet the superior half of the active layer for a longer period of time: in plantations of trees and vine, the drippers must be positioned at 40-60 cm far from their stem.

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