CALCULATION OF DISTANCE BETWEEN DRAINS IN CONTROLLED REGIME

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Abstract: *Controlled drainage is a method used for the integration of irrigation management with drainage management. It implies the reduction of drainage flow in order to maximize the crop's water utilization. In the same time, controlled drainage prevents the humidity excess and the salts accumulation in soil profile. Controlled drainage has the potential to improve the efficiency of water utilization by maintaining high agricultural productions even in water scarcity situations and to assure the exploitation of land drainage systems with high benefits for farmers. Even the method has a large tradition in countries with experience in drainage field (USA, Netherlands), at this hour, in Romania, we don't apply this type of drainage, the researches in this domain being at an incipient level. The formula recommended for the calculation of distance between drains, in controlled drainage regime, is a variation of Hooghoudt formula for drainage design, in a modified form initially proposed by Fox in 1956 and corrected to actual form by Ernst in 1975. This method uses Dupuit-Forchheimer assumptions of horizontal flow, Skaggs demonstrating that it is adequate for flow modelling in the case of subirrigation. In USA the researchers are using American standard EP 479 and subsequently modelling software specialized on drainage issues instead of selecting depths and distances between drains in the situation of designing a controlled drainage system. This paper will present the results obtained in computing the distances between drains in controlled regime for soils with humidity excess from western Romania*

Key words: *controlled drainage, efficiency, water utilization, drainage system*

INTRODUCTION

Controlled drainage (fig. 1) is a method of integrating irrigation and drainage management. It involves reduction of drainage flows in order to bring to maximum the crop utilization of water provided by irrigation or rainfall. Meanwhile, controlled drainage prevents water-logging and the accumulation of salinity in the soil profile. The water is "saved" and it will be available for use without the substantial decrease in water quality that would have occurred if it had been passed through the drainage system before reuse. [1, 2]

Controlled drainage is a technique proper for areas with temporary humidity excess (from precipitations) and situated in arid – half arid areas. In Romania, one of the areas suitable for this kind of drainage is in western part and north-western part of Timiş County. Until few years ago, an important part of Timiş County was affected by humidity excess of different types. Because of that, were designed and installed many drainage and surface drainage arrangements which worked intensive. During drought periods, were created perfect conditions for most of the crops without or with a reduced help from the drainage systems.

In the international special literature, regarding drainage arrangements and efficient methods to combat drought, appeared the controlled drainage systems. Controlled drainage integrates irrigation techniques with drainage management. Being based on the reduction of drainage flows, this method maximize the crop utilization of water provided from precipitations or irrigation rates. Another benefit is that controlled drainage prevents water-logging with side effects as salinity accumulation but also prevents the eutrophication of fresh water bodies, avoiding the elimination of nutrients by keeping them in the soil profile. [1, 2]

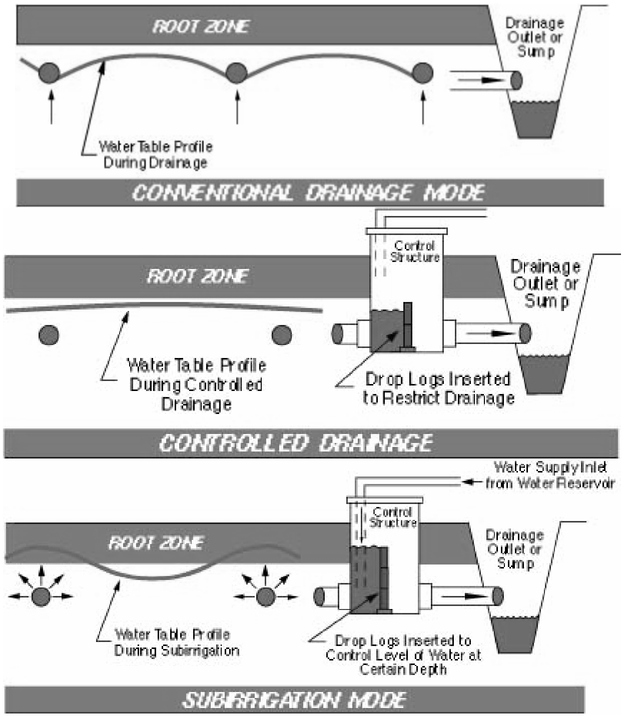

Fig. 1 Conventional and Controlled drainage, Subirrigation Mode [1]

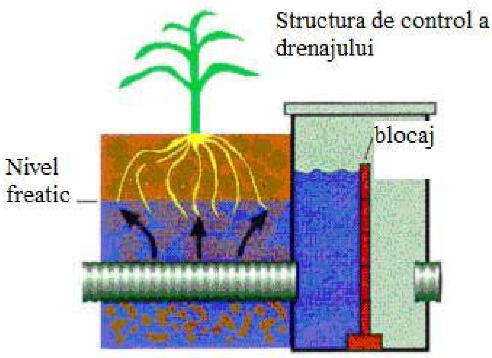

Fig. 2 Controlled drainage [2]

Raising the water table after planting, the water and the nutrients will be keeping available for growing season avoiding in this way their discharges in water bodies. Researches realized in Canada shows that using controlled drainage systems the flow rate from drainage systems was reduced with 50% while nutrients loss reduction was 38% in comparison with a classical drainage system. Also, crop yields knew important increases on lands with controlled drainage systems. [4]

For better results, at this controlled drainage systems can be added bio-reactors (fig. 2). Bio-filters are subsurface structures, so they interact with tile water. Using a mixture (by example gravel with corncobs) which assures steady flow conditions and also food for bacteria, these structures reduce the nutrients migration into water bodies. Their efficiency was proved by researchers from United States and Canada. [4]

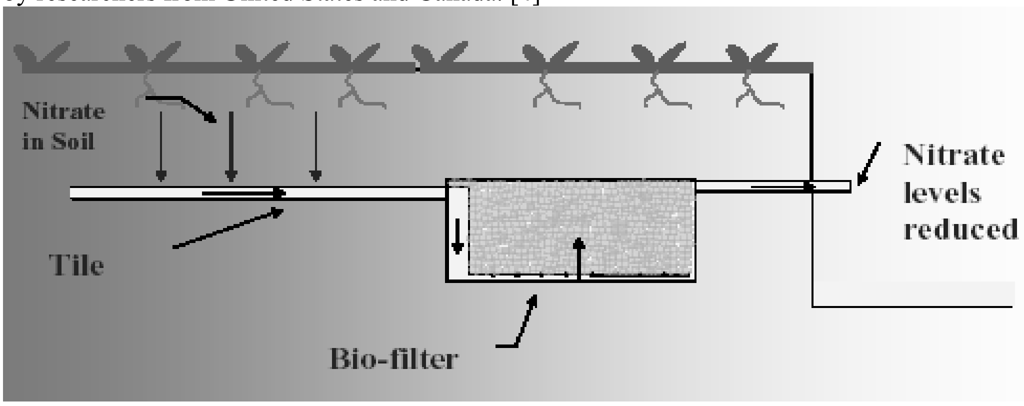

Figure 2 Bio-filter for nitrate levels reducing [4]

MATERIAL AND METHODS

The method is schematically presented in the next figure (fig. 3). The formula recommended for the calculation of distance between drains, in controlled drainage regime, is a variation of Hooghoudt formula for drainage design, in a modified form initially proposed by Fox in 1956 and corrected to actual form by Ernst in 1975. This method uses Dupuit-Forchheimer assumptions of horizontal flow, Skaggs demonstrating that it is adequate for flow modeling in the case of subirrigation. [3, 6]

In the application of this approach, we assume that vertical flow is constraint by a restrictive barrier, in its interior the saturated hydraulic conductivity being lower than soil's hydraulic conductivity above barrier. This barrier is as impermeable layer and it is used in the restrictive sense of saturated hydraulic conductivity. [3, 6]

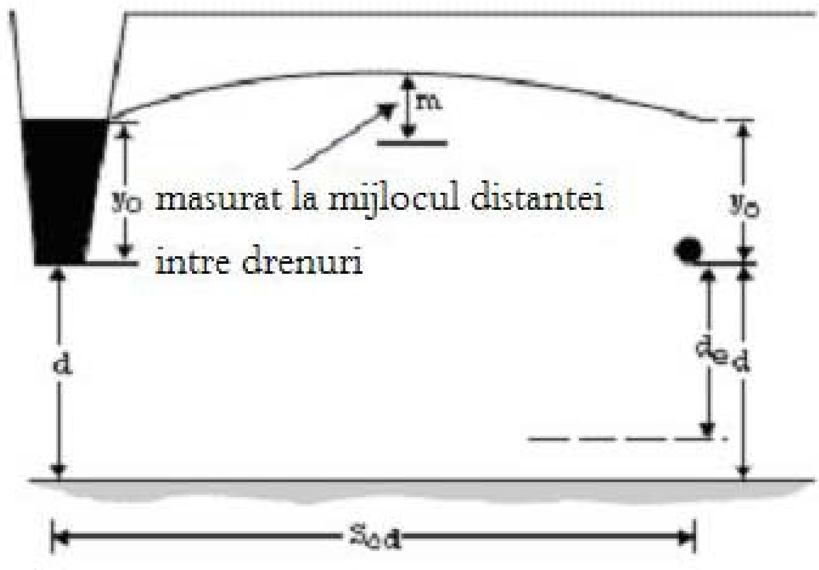

Fig. 3 The scheme of distance between drains calculation in controlled regime [6]

$$S_{cd} = \sqrt{\frac{4K_e(2h_0 + m)}{q}}$$

$$h_0 = d_e + y_0$$

where S_{cd} represents the distance between drains necessary for controlled drainage, K_e is the equivalent hydraulic conductivity; m is the distance from drains line level to the water-table level measures at the middle of distance between drains; d is the distance from drains bottom to the impermeable layer; q is the drainage coefficient; d_e is the equivalent distance from drains bottom to the impermeable layer where:

$$d_e = \frac{d}{1 + \frac{d}{S_{cd}}\left[\frac{8}{\pi}\ln\frac{d}{r_e} - 3.4\right]}$$

r_e is the effective radius, considered lower than drain radius and considered for entrance resistance due to a finite number of openings in drain tube. Skaggs computed the values for r_e and presented them in tables.

Adapting the formula for the calculation of distance between drains for controlled drainage to Romanian terminology we obtained the following expression:

$$L^2 = \frac{4K(2d_e + h + \frac{d_{dren}}{2})}{q}$$

This equation can be resolved with iterations using the table with the values of equivalent soil layer of Hooghoudt.

One of the American standards in the field of drainage, EP 479, propose the utilization of some modeling software instead of selecting depths and distances between drains for the situation of designing a controlled drainage system. The method used for computing the distances between drains for a controlled drainage system implies mathematic formulas used by DrainMod program. For the calculation of distances between drains in controlled regime, EP 479 standard proposes the following equation [5]:

$$L^2 = h_0 4K_L M \frac{2 - \frac{M}{D}}{ET}$$

where L is the distance between drains; K_L is the effective horizontal hydraulic conductivity; M is the difference between the water level measured over drains and water level measures at the middle of distance between drains; $h_0 = y_0 + d_e$ is the distance from the water level above drains and the impermeable equivalent soil layer; y_0 is the depth from water level above drains to the drains centre; d_e is the depth from drains centre to the impermeable equivalent soil layer; D is the depth from water level above drains to impermeable layer; ET represents the evapotranspiration.

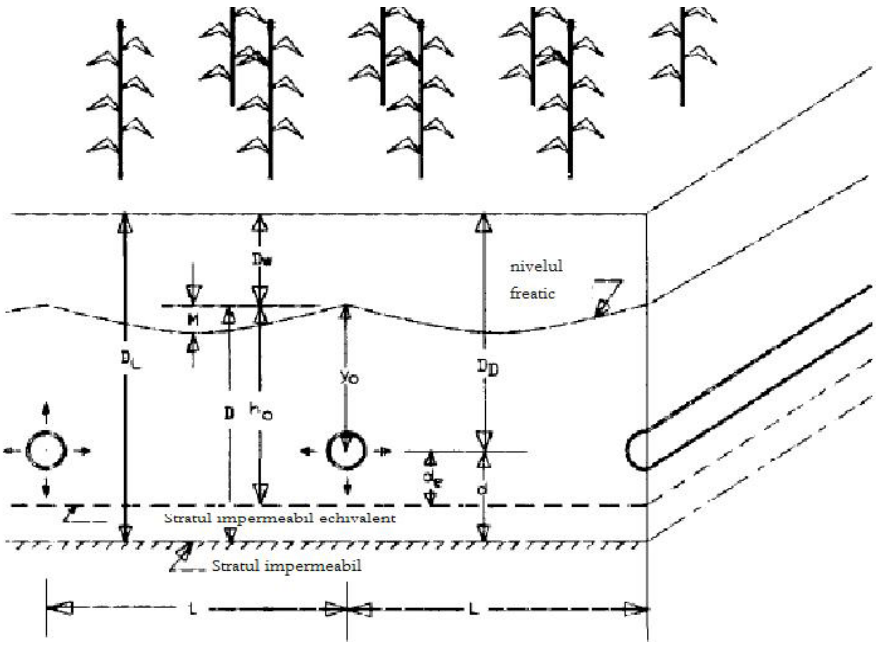

Fig. 4 The scheme of calculation of distance between drains in controlled regime according to EP 479/ ASAE [5]

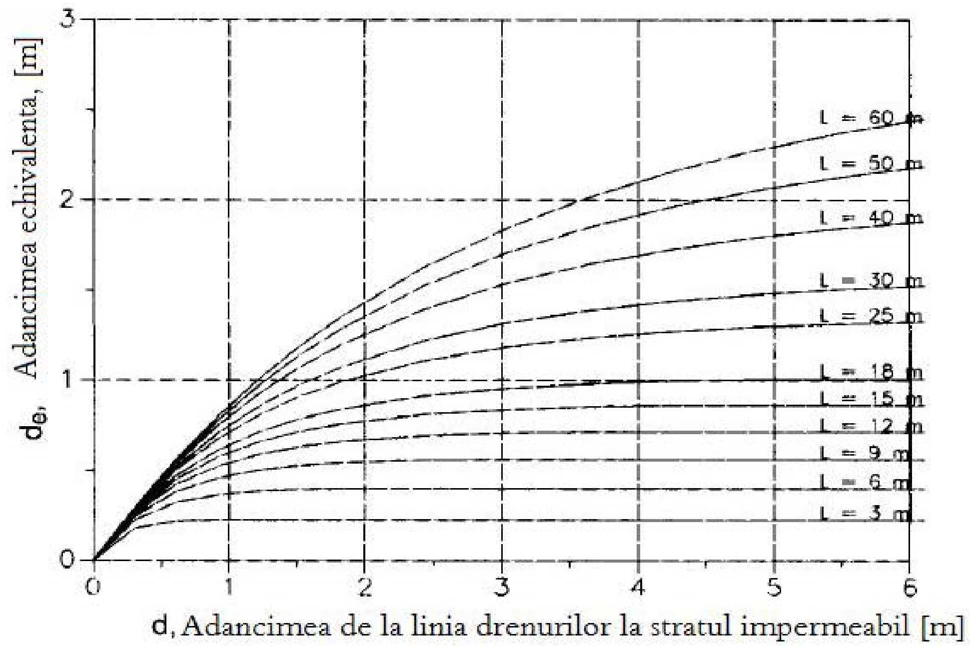

Fig. 5 Diagram representing the relation between equivalent depth and the depth from drains line to impermeable layer necessary for the calculation of distance between drains in controlled regime [5]

RESULTS AND DISCUSSIONS

In the following table I'm presenting the results obtained in calculation of distances between drains in controlled regime by using the EP 479 US standard.

Table 1

Area	M (m)	K_L (m/day)	d_e (m)	h_0 (m)	D (m)	ET(m/day)	L(m)	L(m) Ernst
Caras-Severin County								
Ticvanu Mare	0,25	1,99	0,95	1,55	2,2	0,035	12,89	44-45
Pescarie	0,25	0,29	0,55	1,15	2,2	0,035	4,31	13-14
Fineata	0,25	0,07	0,25	0,85	2,2	0,035	1,79	4-5
Timis County								
Margina	0,25	0,1635	0,45	1,05	2,2	0,04	2,81	9
Faget	0,25	0,355	0,6	1,2	2,2	0,04	4,51	15-16
Folea	0,25	0,06	0,3	0,9	2,2	0,04	1,6	3-4
Sere Lovrin	0,25	0,02	0,2	0,8	2,2	0,04	0,87	1
Arad County								
Felnac I	0,25	0,1	0,4	1	2,2	0,03	2,51	5
Felnac II	0,25	0,16	0,5	1,1	2,2	0,03	3,33	7
Chisineu Cris	0,25	0,098	0,4	1	2,2	0,03	2,51	4-7
Bihor County								
Tileagd	0,25	0,011	0,1	0,7	1,2	0,03	0,68	0,5
Cheresig	0,25	0,05	0,3	0,9	1,2	0,03	1,64	0,6
Ciumeghiu	0,25	0,07	0,3	0,9	1,2	0,03	1,94	3,5
Satu Mare County								
Turulung	0,25	0,366	0,7	1,3	2,4	0,025	6,01	11
Doba	0,25	0,0045	0,1	0,6	1,5	0,025	0,44	0
Carei	0,25	0,078	0,3	0,8	1,1	0,025	2,13	3
Maramures County								
Ulmeni	0,25	0,3335	0,6	1,2	2,2	0,02	6,11	2
Satu Lung	0,25	0,0946	0,45	1,05	2,2	0,02	2,98	6
Salsig	0,25	0,197	0,4	1	1,9	0,02	4,32	2
Pribilesti	0,25	0,03175	0,25	0,85	1,9	0,02	1,54	3
Tamaia	0,25	0,0946	0,3	0,9	1,1	0,02	2,68	1
Suciu de Jos	0,25	0,09485	0,05	0,65	0,7	0,02	2,19	4
Scalaseni	0,25	0,0759	0,3	0,9	1,4	0,02	2,56	3

As it can be observed from the previous table, the distances between drains in controlled regime are generally between 2 and 4 times smaller than the distances between drains computed in permanent regime with Ernst formula.

There are some situations when can appear different errors in computing the distances between drains for controlled systems. One of these situations supposes the design of a subirrigation system in the conditions of assuming that the spaces between drains, from the respective area, are optimum computed. We can make one sufficient comment that rarely we can discuss about optimum spaces between drains. [5]

A much complicated situation implies the computation of vertical hydraulic conductivity and the assuming the idea that this vertical hydraulic conductivity is equal with the horizontal hydraulic conductivity. This situation may appear in the immediate layer from land surface worked by agricultural machines, a layer which is continuously worked and relative homogeny. [5]

A third situation exists when the lateral hydraulic conductivity is measured by auger-hole method but without penetrating the impermeable layer or when the depth until the permeable layer is not exactly determined. [5]

CONCLUSIONS

The calculation of distance between drains, in controlled regime, by using EP 479 standard is a fast calculating method but which doesn't offer the safety of some viable results given being the problems complexity which are approached and the typology and the number of errors which may appear in computing the distances between drains.

I recommend on this way the utilization of this method for computing the distances between drains in controlled regime but only for an approximate calculation following to verify the obtained results with the help of some specialized programs.

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