# RESEARCH REGARDING THE USE OF THE PICHE EVAPORIMETER FOR IRRIGATION SCHEDULING IN CUCUMBER UNDER POLYETILENNE TUNNEL CONDITIONS

**Bei Mariana Florica*, Domuța Cristian*, Cărbunar Mihai ***

*University of Oradea, Faculty of Environmental Protection, 26 Gen. Magheru St., 410048 Oradea, Romania, e-mail: domocosmariana@yahoo.com

***Abstract***

*The paper is based on the research carried out in Husasău de Tinca, North Western Romania, during 2007-2009.*

*Piche evaporimeter was installed in the middle of the polyetilenne tunnel and every morning the Piche evaporation was determined. The optimum water consumption was determined in two variants: 1) with mulch; 2) without mulch. To maintain soil moisture under polyetilenne tunnel condition at depth 0-50 cm between easily available water content and field capacity determined to irrigate with 3430 $m^3$/ha in 2007, with 2890 $m^3$/ha in 2008 and 3340 $m^3$/ha in 2009.*

*Water consumption of cucumbers under polyetilenne tunnel condition was influenced by climatic conditions and crop system with mulch. In the year with the highest daily temperature average was registered the highest water consumption, and in the variant without mulch the total water consumption was higher than the water consumption from the variant with mulch.*

*The crop coeficient ,,Kc" was determined like ratio between monthly water consumption of the cucumber and Piche evaporation from every month. The values of the crop coefficients had the specifical sizes for every month and variant. The average value of the crop coefficients ,,Kc" for the variant with mulch were smaller than the crop coefficient values determined in the variant without mulch.*

**Key words:** irrigation scheduling, Piche evaporimeter, crop coefficient, mulch, cucumber, polyetilenne tunnel

## INTRODUCTION

Irrigation scheduling represents measures that ensure the correct timing of irrigation (Grumeza et al., 1989). Operation is very important for field crops and for the shelter because the correct time of watering application ensures optimum and uniform supply with water at crops, while irrigation made earlier than necessary, determine the excess humidity for short periods of time, irrigation rate oversized and waste water and energy as well as negative consequences for the plant and soil. Delay of irrigation leads to installation hydric stress in soil and in the end to negative consequences on crop yields (Domuta, 2009, 2012).

Irrigation scheduling methods used worldwide are based on direct and indirect determination of timing watering application.

Direct methods are based on the control of the soil moisture using gravimetric methods, tension, neutron and electrometric method, etc. From this category of methods, the tension method is expanding, and this is facilitated by the construction of electronic tensiometer easy to use and very accurate. Also in the category of direct methods of irrigation scheduling are joining the methods based on physiological indicators (growth of the fruit, the pressure cell, cellular juice concentration, the growth of the stem, etc.) but

these methods are used more in the research domain and their extension in production is a problem of the future.

Indirect methods are based on the link between plants water consumption (directly determined) and reference evapotranspiration ($ET_0$). The reference evapotranspiration can be calculated through a variety of methods using climatic elements or can be measured using evaporimeters or lysimeters (Grumeza et al., 1993).

Internationally are known about 100 types of evaporimeters, but Piche evaporimeter is widely used in irrigation scheduling in France and other countries. In Romania it is well known; research regarding on using it are realized after 1966 in the network research fields for soil water balance conducted by Grumeza N., in the program: "Exploitation of irrigation and drainage system" from the Institute for Research Engineer, Irrigation and Drainage, Baneasa Girgiu. (Domuta et al., 2012).

## MATERIAL AND METHOD

The research was carried out in Husasau de Tinca in polyetilenne tunnel. In the field conditions the Piché evaporimeters are realized in a weather shelter, but under polyetilenne tunnel condition renounced of this, placing the two evaporimeters on a stand with a height similar with weather shelter. The support with two evaporimeters was installed at the center of polyetilenne tunnel.

Determination of Piche evaporation was made every morning at 8 o'clock and noted in a register.

In conducting of soil moisture regime was considered the maintenance of the water reserve on 0-50 cm depth between easily available water content and field capacity (Domuta Cr., 2010). Easily available water content was established at 2/3 (66%) of active moisture range. As consequence the soil moisture was determined 10 to 10 days using the gravimetric method.

The three years studied were different regarding to air temperature. The highest average temperature for the period from June - September was registered in 2007, 20.6 ° C, followed by 2009 with 20.2 º C and in 2008 with 19.8 º C. In all this three years the average values for the period from June - September were higher than the multiannual average of the years 1931 – 2006. (Table 1).

*Table 1*

Average monthly temperature, Husasău de Tinca, 2007 – 2009

| Year | Month | | | | Average |
|---|---|---|---|---|---|
| | VI | VII | VIII | IX | VI - IX |
| 2007 | 22.2 | 23.6 | 22.3 | 14.4 | 20.6 |
| 2008 | 21.0 | 20.9 | 22.0 | 15.4 | 19.8 |
| 2009 | 19.8 | 23.1 | 22.2 | 15.5 | 20.2 |
| Multiannual average 1931 - 2006 | 19.3 | 20.8 | 20.9 | 16.2 | 19.3 |

## RESULTS AND DISSCUSIONS

The optimum irrigation regime of cucumbers for maintaining of the soil water reserve between easily available water content and field capacity on 0-50 cm depth was ensured by irrigation rate of 3430 $m^3$/ha in 2007, of 2890 $m^3$/ha in 2008 and 3340 $m^3$/ha in 2009. Number of irrigation rate was 12 in 2007 and 2009 and 10 in 2008. The average value of irrigation rate on studied period was 3220 $m^3$/ha (Table 2).

*Table 2*

Irrigation regime used in cucumber for maintaining the water soil reserve at watering depth (0-50cm) between easily available water content and field capacity under polyetilenne tunnel conditions, Husasău de Tinca, 2007-2009

| Year | Month | | | | | | | | VI - IX | |
|---|---|---|---|---|---|---|---|---|---|---|
| | VI | | VII | | VIII | | IX | | | |
| | Σm | n | Σm | n | Σm | n | Σm | n | Σm | n |
| 2007 | 870 | 3 | 920 | 3 | 1010 | 4 | 630 | 2 | 3430 | 12 |
| 2008 | 650 | 2 | 600 | 2 | 850 | 3 | 790 | 3 | 2890 | 10 |
| 2009 | 500 | 2 | 950 | 3 | 1090 | 4 | 800 | 3 | 3340 | 12 |
| Average | 673 | 2 | 823 | 3 | 983 | 4 | 740 | 3 | 3220 | 12 |

Σm – irrigation rate ($m^3$ water/ha)

n – number of irrigations

Monthly irrigation rates used are directly correlated with air temperature. In June, the highest value of irrigation rate was used in 2007 (870 $m^3$/ha), in July 2009 (950 $m^3$/ha), August 2009 (1090 $m^3$/ha) and in September in year 2009 (800 $m^3$/ha). On average on the study period and in every year, the highest value of the irrigation rate and the largest number of irrigations were used in August.

With the indirect method, the values of the reference evapotranspiration ($ET_0$) were obtained, which is converted to water consumption using crop coefficients "Kc".

The crop coefficients "Kc" are obtained by a specific methodology through the reporting of optimum daily water consumption to the daily average reference evapotranspiration (Grumeza et al. 2005, Domuta et al., 2010).

Sampling of soil from 10 to 10 days and maintaining the water reserve between easily available water content and field capacity assured an optimum water regime of plants was obtained (Domuța Cr., 2012).

At the beginning and the end of each month the soil samples were taken from a depth of 0-150 cm, thus ensuring the optimum conditions needed to calculate the optimum real consumption ($ETR_{opt}$) of the crops (Bei Mariana et al, 2010). Calculations of soil water balance are presented in tables 3, 4, 5.

*Table 3*

Soil water balance ($m^3$/ha) in cucumber without mulch and with mulch under polyetilenne tunnel conditions, Husasău de Tinca, 2007

| Variant | Period | | No. of days | Initial reserve | Irrigatin rate | Total in soil | Final reserve | Total water consumption | Daily water consumption $m^3$/ha |
|---|---|---|---|---|---|---|---|---|---|
| | From | To | | | | | | | |
| Without mulch | 19.06 | 01.07 | 11 | 4170 | 870 | 5040 | 4626 | 414 | 37.6 |
| | 01.07 | 01.08 | 31 | 4626 | 920 | 5546 | 3897 | 1649 | 53.2 |
| | 01.08 | 01.09 | 31 | 3897 | 1010 | 4907 | 3007 | 1900 | 61.3 |
| | 01.09 | 30.09 | 30 | 3007 | 630 | 3637 | 2500 | 1137 | 37.9 |
| | 19.06 | 30.09 | 103 | 4170 | 3430 | 7600 | 2500 | 5100 | 49.5 |
| With mulch | 19.06 | 01.07 | 11 | 4210 | 870 | 5080 | 4691 | 389 | 35.4 |
| | 01.07 | 01.08 | 31 | 4691 | 920 | 5611 | 4042 | 1569 | 50.6 |
| | 01.08 | 01.09 | 31 | 4042 | 1010 | 5052 | 3198 | 1854 | 59.8 |
| | 01.09 | 30.09 | 30 | 3198 | 630 | 3828 | 2700 | 1128 | 37.6 |
| | 19.06 | 30.09 | 103 | 4210 | 3430 | 7640 | 2700 | 4940 | 47.9 |

*Table 4*

Soil water balance ($m^3$/ha) in the cucumbers crop with or without mulch under polyetilenne tunnel conditions, Husasău de Tinca, 2008

| Variant | Period | | No.of days | Initial reserve | Watering | Total in soil | Final reserve | Total water consum. | Daily water consum. $m^3$/ha |
|---|---|---|---|---|---|---|---|---|---|
| | From | To | | | | | | | |
| Without mulch | 17.06 | 01.07 | 13 | 4210 | 650 | 4860 | 4363 | 497 | 38.2 |
| | 01.07 | 01.08 | 31 | 4363 | 600 | 4963 | 3720 | 1243 | 40.1 |
| | 01.08 | 01.09 | 31 | 3720 | 850 | 4570 | 2970 | 1600 | 51.6 |
| | 01.09 | 30.09 | 30 | 2970 | 790 | 3760 | 2878 | 882 | 29.4 |
| | 17.06 | 30.09 | 105 | 4210 | 2890 | 7100 | 2878 | 4222 | 40.2 |
| With mulch | 17.06 | 01.07 | 13 | 4180 | 650 | 4830 | 4337 | 493 | 37.9 |
| | 01.07 | 01.08 | 31 | 4337 | 600 | 4937 | 3703 | 1234 | 39.8 |
| | 01.08 | 01.09 | 31 | 3703 | 850 | 4553 | 3025 | 1528 | 49.3 |
| | 01.09 | 30.09 | 30 | 3025 | 790 | 3815 | 2969 | 846 | 28.2 |
| | 17.06 | 30.09 | 105 | 4180 | 2890 | 7070 | 2969 | 4101 | 39.1 |

In all three years studied the water reserve determined at establishment of cucumbers crop, both variant with or without mulch was below of field capacity (5611 $m^3$/ha). Final water reserve was above the wilting point (2168 $m^3$/ha). Number of days of water balance period was 103 in 2007, 105 in 2008 and 99 in 2009.

In this three experimental years were registered higher values of total water consumption in the variant without mulch, compared with variant with mulch, the relative differences being of 3.2% in 2007, 2.9% in 2008 and 3.1% in 2009.

In the variant without mulch the cucumbers used a larger quantity of water from soil reserves.

*Table 5*

Soil water balance ($m^3$/ha) in the cucumbers crop with or without mulch under polyetilenne tunnel conditions, Husasău de Tinca, 2009

| Variant | Period | | No. of days | Initial reserve | Watering | Total in soil | Final reserve | Total water consum. | Daily water consum. $m^3$/ha |
|---|---|---|---|---|---|---|---|---|---|
| | From | To | | | | | | | |
| Without mulch | 24.06 | 31.07 | 38 | 3970 | 1450 | 5420 | 4010 | 1410 | 37.1 |
| | 01.08 | 31.08 | 31 | 4010 | 1090 | 5100 | 3370 | 1730 | 55.9 |
| | 01.09 | 30.09 | 30 | 3370 | 800 | 4170 | 2964 | 1206 | 40.2 |
| | 14.06 | 30.09 | 99 | 3970 | 3340 | 7310 | 2964 | 4346 | 43.9 |
| With mulch | 24.06 | 31.07 | 38 | 4010 | 1450 | 5460 | 4100 | 1360 | 35.8 |
| | 01.08 | 31.08 | 31 | 4100 | 1090 | 5190 | 3540 | 1650 | 53.2 |
| | 01.09 | 30.09 | 30 | 3540 | 800 | 4340 | 3140 | 1191 | 39.7 |
| | 14.06 | 30.09 | 99 | 4010 | 3340 | 7350 | 3140 | 4210 | 42.5 |

In the covering sources of the total water consumption of cucumbers under polyetilenne tunnel the irrigation had the higher values, in the variant without mulch being 67% in 2007 to 68% in 2008 and 77% in 2009. In the variant with mulch, the irrigation rate participated in total water consumption was higher of 69% in 2007, 70% in 2008 and 79% in 2009 (Table 6).

*Table 6*

Analysis of the mulch influence on total water consumption in cucumber under polyetilenne tunnel conditions, Husasău de Tinca , 2007 - 2009

| Year | Variant | Total water consumption | | Covering sources of water consumptions | | | |
|---|---|---|---|---|---|---|---|
| | | | | Soil reserve | | Irrigation | |
| | | $m^3$/ha | % | $m^3$/ha | % | $m^3$/ha | % |
| 2007 | Without mulch | 5100 | 100 | 1670 | 33 | 3430 | 67 |
| | With mulch | 4940 | 96.8 | 1510 | 31 | 3430 | 69 |
| 2008 | Without mulch | 4222 | 100 | 1332 | 32 | 2890 | 68 |
| | With mulch | 4101 | 97.1 | 1211 | 30 | 2890 | 70 |
| 2009 | Without mulch | 4346 | 100 | 1006 | 23,5 | 3340 | 77 |
| | With mulch | 4210 | 96.9 | 870 | 21 | 3340 | 79 |
| Average | Without mulch | 4556 | 100 | 1336 | 29 | 3220 | 71 |
| | With mulch | 4417 | 96.9 | 1197 | 27 | 3220 | 72 |
| | Difference | -139 | -3.1 | -139 | -2 | - | +1 |

The daily values obtained during the study are presented in table 7.

*Table 7*

Daily Piche evaporation (mm) under polyetilenne tunnel conditions, Husasău de Tinca, 2007-2009

| Average of the daily evaporation Piche (mm) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| June | | | July | | | August | | | September | | |
| 2007 | 2008 | 2009 | 2007 | 2008 | 2009 | 2007 | 2008 | 2009 | 2007 | 2008 | 2009 |
| 6.76 | 6.11 | 6.33 | 7.81 | 7.13 | 7.64 | 6.34 | 5.57 | 5.62 | 3.07 | 3.27 | 3.10 |

Another necessary element for irrigation scheduling using indirect methods is daily water consumption. As previously mentioned, it was determined by the soil water balance method based on the soil moisture control. Decade determination of the soil moisture at depth of 0-50 cm assured the maintaining of water reserve between easily available water content and field capacity ensuring optimum water supply of plants and obtaining of optimum values for water consumption of cucumbers with mulch and without mulch variant.

Daily average values are specific for each months of the vegetation period and in generally are lower in variant without mulch (Apahidean Al.S, et al., 2001).

Both variant with and without mulch, the highest average value of daily water consumption was registered in August (Table 8).

*Table 8*

Optimum water consumption in cucumber from the variant with and without mulch under polyetilenne tunnel conditions, Husasău de Tinca, 2007 - 2009

| Year | Variant | Month | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | June | | July | | August | | September | |
| | | $m^3$/ha/ day | % | $m^3$/ha /day | % | $m^3$/ha/ day | % | $m^3$/ha/ day | % |
| 2007 | Without mulch | 37.6 | 100 | 53.2 | 100 | 61.3 | 100 | 37.9 | 100 |
| | With mulch | 35.4 | 94.1 | 50.6 | 95.1 | 59.8 | 97.6 | 37.6 | 99.0 |
| 2008 | Without mulch | 38.2 | 100 | 40.1 | 100 | 51.6 | 100 | 29.4 | 100 |
| | With mulch | 37.9 | 99.2 | 39.8 | 99.3 | 49.3 | 95.5 | 28.2 | 95.9 |
| 2009 | Without mulch | 37.1 | 100 | 37.1 | 100 | 55.9 | 100 | 32.4 | 100 |
| | With mulch | 35.8 | 96.5 | 35.8 | 96.5 | 53.2 | 95.2 | 31.7 | 97.8 |
| 2007-2009 | Without mulch | 37.6 | 100 | 43.5 | 100 | 56.3 | 100 | 33.2 | 100 |
| | With mulch | 36.4 | 96.7 | 42.1 | 96.7 | 54.1 | 96.1 | 32.5 | 97.9 |
| | Difference | -1.2 | -3.3 | -1.4 | -3.3 | -2.2 | -3.9 | -0.7 | -2.1 |

Crop coefficient "Kc" is determined as the ratio between optimum daily water consumption of crop and daily reference evapotranspiration, daily Piche evaporation in this case.

The values of the crop coefficients "Kc" from the variant without mulch are bigger than the values of the crop coefficients "Kc" from the variant with mulch. (Table 9)

By multiplying the daily Piche evaporation in this day with coefficient "Kc" for that month, in the table above, were obtained daily water consumption in the day was obtained. Subtracting this amount from the amount of the daily water reserve in the beginning of day was obtained the value of soil water reserve registered at the end of the day. If the water reserve is under easily available water content, the irrigation must start.

Establishing this way the timing of irrigation, it is simple, and compared to theoretical calculations has the advantage that it using measures elements - Piche evaporation – under polyethylene tunnel conditions, gives extra rigor for irrigation of cucumbers crop and provides significant water savings. Regarding of gravimetric determination of soil moisture, using Piche evaporimeter in the timing of watering application has advantages does not require soil sampling, weighing and drying them (Brejea, 2012).

*Table 9*

The crop coefficients „Kc" for transformation of the Piche evaporation in optimum water consumption in cucumber with and without mulch in polyetilenne tunnel conditions, Husasău de Tinca, 2007-2009

| Year | Variant | Month | | | |
|---|---|---|---|---|---|
| | | June | July | August | September |
| 2007 | Without mulch | 0.56 | 0.68 | 0.97 | 1.23 |
| | With mulch | 0.53 | 0.65 | 0.94 | 1.22 |
| 2008 | Without mulch | 0.62 | 0.56 | 0.93 | 0.89 |
| | With mulch | 0.61 | 0.55 | 0.89 | 0.86 |
| 2009 | Without mulch | 0.59 | 0.49 | 0.99 | 1.05 |
| | With mulch | 0.57 | 0.47 | 0.95 | 0.96 |
| 2007 - 2009 | Without mulch | 0.59 | 0.58 | 0.96 | 1.06 |
| | With mulch | 0.57 | 0.56 | 0.93 | 1.01 |

For an accurate the irrigation scheduling with Piche evaporimeter are necessary accurate data regarding on soil hydrophysics indices (field capacity, wilting point, easily available water content) an accurate assessment of daily Piche evaporation, data regarding of "Kc" coefficients resulting from research field. The method allows a high degree of automatization, monthly data can be completed on the computer, can be achieved programs computer that provide automatic closure of the irrigation system (Domuta, 2012).

## CONCLUSIONS

The research carried out in the polyetilenne tunnel from Husasău de Tinca, North Western Romania during 2007-2009 determined the following conclusions:

- to maintain the soil moisture under polyetilenne tunnel conditions on 0-50 cm depth between easily available water content and field capacity the irrigation rate used were of 3430 $m^3$/ha in 2007, of 2890 $m^3$/ha in 2008 and 3340 $m^3$/ha in 2009;
- water consumption for cucumbers from polyetilenne tunnel was influenced by climatic conditions and crop system with mulch. In the year with the highest average of daily temperature was registered highest water consumption and in the variant without

mulch the total water consumption was higher than the values determined in the variant with mulch;

- irrigation scheduling based on use of Piche evaporimeter required daily Piche evaporation determinations. Their value had the highest in July. To convert Piche evaporation in optimum daily water consumption of cucumbers were calculated coefficient "Kc" as ratio between optimum daily water consumption and Piche evaporation. These coefficients values are specific to each month of the growing stage. In average over the studied period in variant with mulch, the coefficient "Kc" values are lower than the values determined in the variant without mulch.

The results of the research support the possibility of the Piche evaporimeter irrigation scheduling of the cucumber from polyetilenne tunnel both in the variant with mulch and in the variant without mulch. The method is based on the soil water balance on 0-50 cm depth and the use of the specifically crop coefficient "Kc" for transformation of the Piche evaporation in the optimum water consumption of the cucumber both in the variant with mulch and without mulch.

## REFERENCES


1. Apahidean Al.S. et al., 2000, Legumicultură generală vol. I, Ed. Risoprint, Cluj-Napoca.
2. Apahidean Al.S. et. al., 2000, Legumicultură generală vol. II, Ed. Risoprint, Cluj-Napoca.
3. Apahidean Maria, Al.S. Apahidean, 2000, Legumicultură specială, Ed. Risoprint, Cluj-Napoca.
4. Apahidean Al.S. et al., 2001, Legumicultură generală, Ed. Academic Pres, Cluj-Napoca.
5. Bei Mariana, Apahidean S.Al., Domuța C., 2010, Determining the water consumption of cucumbers grown in solariums in the western part of Romania, Universitatea de Ştiinţe Agricole şi Medicină Veterinară Iaşi, Simpozion Ştiinţific anual cu participare internaţională – Horticultură –Ştiinţă, Calitate, Diversitate şi Armonie.
6. Bei Mariana, Apahidean S.Al., Domuța C., 2010, Determining the irigation regime and the water consumption for cucumber crops grown in solarium, Journal of Horticulture, Forestry and Biotechnology, Vol. 14(2).
7. Bei Mariana, Apahidean S. Al., Cărbunar M., 2010, The influence of some tehnological elements upon the production of organic cucumbers cultivated in solariums, Journal of Horticulture, Forestry and Biotechnology, Vol. 14(2), ISSN 2066-1797, pag. 321-324.
8. Brejea R., 2012, Practicum de tehnologii. Ed. Universităţii din Oradea
9. Butnariu H., Indrea D., Petrescu C., Savițchi P., Pelaghia Chilon, Ruxandra Ciofu, Popescu V., Radu Gr., Stan N., 1992, Legumicultura, E.D.P., Bucureşti.
10. Domuța C. (coord.) et al., 2008, Asolamentele in sistemele de agricultura Ed. Univ. din Oradea
11. Domuța C., 2009, Irigarea culturilor. Editura Universităţii din Oradea.
12. Domuța C. (coord.) et al., 2012, Irigarea culturilor în Câmpia Crişurilor. Ed. Univ. din Oradea
13. Domuta Cr., 2010, Materii prime vegetale. Ed. Univ. din Oradea
14. Domuța Cr., 2011, Subasigurarea cu apă a porumbului, soiei şi sfeclei de zahar din Câmpia Crişurilor. Ed. Univ. din Oradea
15. Domuța Cr., 2012, Cercetările privind irigarea soiei în Câmpia Crişurilor. Ed. Universităţii din Oradea.
16. Grumeza N., Alexandrescu I., Ionescu P., 1979, Tehnica irigării culturilor hortiviticole. Ed. Ceres, Bucureşti.
17. Grumeza N. şi colab., 1989, Prognoza şi programarea aplicării udărilor în sistemele de irigaţii. Editura Ceres, Bucureşti.
18. Grumeza N., Dragomirescu O., 1993, Irigaţii prin picurare. Ed. Ceres, Bucureşti.

19. Grumeza N., Klepş Cr., 2005, Amenajările de irigații din România. Editura Ceres Bucureşti.
20. Indrea D., Apahidean Al., 1995, Ghid practic pentru cultura legumelor. Ed. Ceres, Bucureşti.
21. Indrea D., Apahidean Al., 1997, Cultura legumelor timpurii. Ed. Ceres, Bucureşti.
22. Jovicich E., Cantliffe D., J., Simonne E., H., Stoffella P. J., 2007, Comparative water and fertilizer use efficiencies of two production systems for cucumbers, Acta Horticulturae