ORIGINAL ARTICLE

# RESEARCH REGARDING THE WATER CONSUMPTION OF TOMATOES, GREEN PEPPER AND CUCUMBERS CULTIVATED IN SOLARIUMS

# CERCETĂRI PRIVIND CONSUMUL DE APA LA TOMATELE, ARDEII ŞI CASTRAVEȚII CULTIVAȚI ÎN SPAȚII PROTEJATE

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## ABSTRACT

In such conditions, saving water represents a very important aspect, both economically and socially. But in horticulture saving water must consider another very important aspect, that of providing food for a continuously growing population. So horticultors have the difficult task of obtaining big productions as well as saving water. Our research come to support the cultivators who grow tomatoes, green peppers and cucumbers in solariums. Determining precisely the water consumption of this species will create the possibility of avoiding both the excess and the lack of water of the tomatoes, green peppers and cucumbers grown in solariums, each of them having negative effects on production. Establishing the best water regime of this crop will lead to the application of optimum water quantities, at the right time and by the most efficient irrigation methods. This way, the cultivators will have the possibility of obtaining high productions, of superior quality, justified economically.

**KEYWORDS: irrigation, water consumption, water capitalization coefficients**

## REZUMAT

In aceste conditii, economisirea apei reprezinta un aspect foarte important, atat din punct de vedere economic cat si social. In horticultura, insa, cand se are in vedere economisirea apei trebuie sa se tina seama si de un alt aspect deosebit de important, acela al necesitatii de a produce hrana pentru o populatie in continua crestere. Ca urmare, horticultorilor le revine dificila sarcina de a obtine productii mari, in conditiile economisirii apei. Cercetarile noastre vin in sprijinul cultivatorilor de tomate ardei si vinete in solarii. Determinarea exacta a consumului de apa al acestor specii va creea posibilitatea de a evita atat excesul de apa cat si seceta in cazul celor trei culturi, ambele cu efecte negative asupra productiei. Stabilirea celui mai bun regim de irigare al acestor culturi va conduce la aplicarea cantitatilor optime de apa, la momentul potrivit si prin cea mai eficienta metoda de irigare. In acest fel, cultivatorii vor putea obtine productii ridicate, de calitate superioara, justificate din punct de vedere economic.

**CUVINTE CHEIE: irigare, consumul apei, coeficient de valorificare a apei**

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## DETAILED ABSTRACT

In the case of tomatoes, the experiments were made in the years 2000, 2001 and 2002 and in the cases of green peppers and cucumbers, the experiments were made in the years 1999, 2000 and 2001. On the diagonal of he solarium were placed 3 tensiometers which served for the measurement of the best time of wetting.

The irrigation water was administered by dripping, using for this purpose the T.P. 57.08.06. dripper in the cases of tomatoes and cucumbers, and by microsprinkling, using the microsprinkler MA-1, in the case of green peppers.

For determining the EP were used the direct method, based on the water balance in the soil and the indirect methods which are based on the Villele, Turk and Penman formulas.

The time of administering the wettings was determined with the help of the gravimetric method, based on drying the samples of soil in the drying oven and with the tensiometric method, with the help of the tensiometers placed on the diagonals of the crops.

Having known the REP and PEP values for the experimental crops, the K correction coefficients of PEP were obtained, for each month of the vegetation period during the 3 years and for each crop.

Knowing the water consumption of the crops and the obtained yields, by comparing these, we obtained the water capitalization coefficients (Wca), which shows the water quantity consumed by the plants to produce 1 kilogram of fruits.

## INTRODUCTION

The horticulture specialist who has very good knowledge about the water consumption of the crops has a few advantages, some of which are:

he can avoid the administration of small quantities of water, with obvious negative effects on plants and consequently with diminishing effects of the crop quantity and quality (MUREŞAN D. et al., 1992, NAGY Z., 1972, 1982);

he can also avoid the administration of grate quantities of water, error with negative effects both physiological and economical. The plants wet to intense can suffer from root asphyxiation whose immediate effect is the decrease of yield. A too high humidity in the phase of harvesting can lead to the cracking of fruits (for example: tomatoes), with profound negative effects on crops also a to intense evaporation at ground level leads to the increase of atmospheric humidity and thus, favourising diseases (*Phytophtora, Fusarium, Verticillium, Dydimella, Botrytis* etc.). Of course, all this water administrated in excess must be paid, having as a result the increase of production expenses and the decrease of profit (LUCA E., Z. NAGY, 1999);

knowing exactly the water consumption of the crops, the path of automatic irrigation by sprinkling and dripping, that, although requests a pretty high initial investment, is justified by the reduction of expenses with manual label forces.

The list of advantages offered by the exact knowing of water consumption of the crops is, of course, much longer, but we consider that those described above are sufficient enough to convince us of the utility of our research.

## MATERIAL AND METHOD

In the case of tomatoes, the experiments were made in the years 2000, 2001 and 2002, in solariums covered with polyethylene foil from the University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, România. On the edges of the solarium was left a protection zone of 45 cm wide, the width of protection zone from both edges of the solarium being of 2 m. On the diagonal of he solarium were placed 3 tensiometers which served for the measurement of the best time of wetting. The irrigation water was administered by dripping, using for this purpose the T.P. 57.08.06. dripper.

The experimental crop in the case of green pepper was placed, also, inside the UASVM Cluj-Napoca, România, but in the solarium-greenhouses covers with glass. For this experiment, made during the years 1999, 2000 and 2001, hybrids of green pepper were used. In this case, also, were assured protection zones on both lateral sites and edges, and on the diagonal of the solarium were placed 3 tensiometers. The irrigation of the green pepper was made by microsprinkling, using the microsprinkler MA-1.

Our experiments regarding the cucumber were made in 1999, 2000 and 2001, in the solariums covered with glass from the UASVM Cluj-Napoca, România. As in the cases of the other two crops, protection zone were assured on the edges and laterals of the crop. The tensiometers from the solarium's diagonal were also present, and irrigation water was distributed by the same drippers T.P. 57.08.06.

The water consumption of any crop, so of our crops, refers to 2 main aspects:

- evaporation at ground level, that is an unproductive loss, a useless water consumption but inevitable, from which the plant "gains" nothing;
- perspiration of the plants, that is a productive loss, through which the plant regulates its inner temperature. The plants lose by perspiration, which takes place at the stoma level, very large quantities of water, requesting quantities of hundreds of litres of water for the synthesis oh one kilogram of dry substance.

The water consumption of a crop, based on the 2 mechanisms of water loosing is called evapoperspiration (EP).

For determining the EP were used several methods:

- the direct method based on the water balance in the soil:

$Ri + Pv + \Sigma m + Af = Rf + REP$, where:

Ri – the initial stock of water in the soil (in the beginning of the vegetation period)

Pv – precipitation during the vegetation period (in our case, having crops placed in protected areas, where the water coming from precipitation doesn't reach, Pv = 0)

Σm – irrigation norm (the sum of the wetting norms)

Af – the contribution of the freatic waters to the existing water (in our case, the freatic water are found at a depth higher then 5 m, so Af = 0)

Rf – the final water stock in the soil (at the end of the vegetation period)

REP – real evapoperspiration

- the indirect methods are based on the Villele, Turk and Penman formulas. Some factors used in these methods, such as incoming radiation, air temperature and relative humidity of air were obtained from the meteorological center of the society "Apele Române" Cluj-Napoca and respectively by determination with termohydrograph in the solarium of UASVM Cluj-Napoca.

In the cases of the Villele formula, used in the determination of the potential evaporation perspiration (PEP), the global radiation (Rg) is exclusively used:

$PEP = 0,67 \cdot (Rg / 60) - 0,2$

For the calculation of water consumption through the Penman method, the following formula is being used:

$PEP = (Ea + H \cdot \Delta / \gamma) / (1 + \Delta / \gamma)$, where:

PEP – the potential evaporation perspiration

Ea – the water evaporation

H – the net radiation at the surface of the soil or of the water (mm water/day)

$\Delta / \gamma$ – constant depending on the temperature

The last indirect method that has been used for determining the water consumption is the Turk method. In the opinion of this last scientist, the PEP depends less on the vegetal species and more on the climatic conditions of the period when the evaporation perspiration produces. The PEP calculation formula is:

$PEP = (0,13 \cdot t) x (Ig + 50) / (t + 15)$ [mm/decade], where:

t – the air temperature under shelter (°C)

Ig – the corrected global radiation, average decade value (cal/cm$^2$)

0,13 – the coefficient for the relative humidity of the air over-passing 50%.

The time of administering the wettings was determined with the help of 2 methods:

- the gravimetric method, based on drying the samples of soil in the drying oven. The soil samples are picked up on the diagonal of the solarium, at the different depths: 0 – 25 cm, 25 – 50 cm, 50 – 75 cm, 75 – 100 cm. The soil is introduced in the metallic phiols, with lids, with an exact known tare, and the are weighted in the shortest time, before part of the water contained by the soil will evaporate. The phiols with soil are introduced in the drying oven at 120 °C, for 8 hours, then they are immediately weighted before absorbing the water vapors from the atmosphere. The difference between the weight of the wet soil and the weight of the dry soil represents exactly the lost water from the soil during its drying in the oven; comparing this difference to the weight of the dry soil, we can find out the water content of the soil, and, at need we administer the wetting before the soil humidity goes under the minimum limit.

## RESULTS AND DISCUSSIONS

Having known the REP and PEP values for the experimental crops, the K correction coefficients of PEP were obtained, for each month of the vegetation period during the 3 years and for each crop, based on the formulas:

$$K = \frac{\text{REP of the crop}}{\text{PEP after Villele, Penman or Turk}}$$

(tables 1,2,3)

Having known the values of the K correction coefficients of PEP, it is enough to know the PEP of the vegetation period to be able to calculate the water consumption of the respective crop and to establish precisely the wetting norm.

Knowing the water consumption of the crops and the obtained yields, by comparing these, we obtained the water capitalization coefficients (Wca), which shows the water quantity consumed by the plants to produce 1 kilogram of fruits.

Wca = water consumption (m$^3$/ha) / average yield (kg/ha)

Table 4 contains our results regarding the water capitalization coefficient in the cases of the 3 crops:

Table 1: The K correction coefficients of the PEP for each month for tomato culture

| Year | Indicators | IV | V | VI | VII | VIII | IX |
|---|---|---|---|---|---|---|---|
| 2000 | REP ($m^3$/ha) | 563,1 | 853,3 | 1054,7 | 1321,8 | 714,5 | 335,6 |
| | PEP Villele ($m^3$/ha) | 524,1 | 734,0 | 864,2 | 914,5 | 934,4 | 523,4 |
| | PEP Turk ($m^3$/ha) | 1437,2 | 1334,8 | 1644,0 | 1634,9 | 1341,5 | 987,2 |
| | PEP Penman ($m^3$/ha) | 1024,2 | 1331,4 | 1334,5 | 1347,0 | 1434,5 | 834,0 |
| | K – Villele | 0,62 | 0,95 | 1,04 | 1,05 | 0,96 | 0,84 |
| | K – Turk | 0,35 | 0,56 | 0,62 | 0,66 | 0,64 | 0,54 |
| | K - Penman | 1,32 | 1,46 | 1,34 | 2,06 | 2,94 | 7,83 |
| 2001 | REP ($m^3$/ha) | 339,6 | 708,7 | 855,0 | 1025,5 | 859,3 | 444,7 |
| | PEP Villele ($m^3$/ha) | 532,1 | 762,0 | 855,0 | 967,5 | 952,4 | 523,2 |
| | PEP Turk ($m^3$/ha) | 1038,8 | 1390,0 | 1396,0 | 1507,0 | 1492,0 | 875,0 |
| | PEP Penman ($m^3$/ha) | 257,1 | 506,1 | 649,7 | 507,2 | 306,4 | 56,6 |
| | K – Villele | 0,64 | 0,93 | 1,00 | 1,06 | 0,94 | 0,85 |
| | K – Turk | 0,33 | 0,51 | 0,63 | 0,68 | 0,60 | 0,51 |
| | K - Penman | 1,32 | 1,40 | 1,36 | 2,02 | 2,92 | 7,86 |
| 2002 | REP ($m^3$/ha) | 580,1 | 828,3 | 1074,6 | 1151,8 | 792,5 | 394,6 |
| | PEP Villele ($m^3$/ha) | 882,0 | 809,1 | 1029,0 | 1131,5 | 830,8 | 627,0 |
| | PEP Turk ($m^3$/ha) | 1413,0 | 1357,8 | 1494,0 | 1670,9 | 1199,7 | 900,0 |
| | PEP Penman ($m^3$/ha) | 360,0 | 499,1 | 555,0 | 548,7 | 452,6 | 315,0 |
| | K – Villele | 0,66 | 1,02 | 1,04 | 1,02 | 0,95 | 0,63 |
| | K – Turk | 0,41 | 0,61 | 0,72 | 0,69 | 0,66 | 0,44 |
| | K - Penman | 1,61 | 1,66 | 1,94 | 2,10 | 1,75 | 1,25 |

Table 2: The K correction coefficients of the PEP for each month for green pepper culture

| Year | Indicators | IV | V | VI | VII | VIII | IX |
|---|---|---|---|---|---|---|---|
| 1999 | REP ($m^3$/ha) | 324,3 | 726,7 | 792,7 | 934,7 | 735,4 | 335,4 |
| | PEP Villele ($m^3$/ha) | 1134,9 | 1234,5 | 1634,5 | 1334,7 | 1134,7 | 613,4 |
| | PEP Turk ($m^3$/ha) | 352,4 | 834,6 | 734,9 | 724,0 | 734,5 | 536,4 |
| | PEP Penman ($m^3$/ha) | 364,2 | 531,4 | 634,2 | 634,8 | 332,4 | 129,5 |
| | K – Villele | 0,35 | 0,43 | 0,55 | 0,67 | 0,52 | 0,56 |
| | K – Turk | 0,82 | 0,97 | 1,53 | 1,25 | 0,93 | 1,97 |
| | K - Penman | 0,87 | 0,73 | 1,15 | 0,81 | 1,83 | 3,43 |
| 2000 | REP ($m^3$/ha) | 470,7 | 650,6 | 1033,8 | 939,4 | 697,5 | 331,6 |
| | PEP Villele ($m^3$/ha) | 1196,0 | 1276,8 | 1697,0 | 1390,3 | 1134,7 | 618,9 |
| | PEP Turk ($m^3$/ha) | 561,1 | 715,2 | 961,7 | 782,5 | 697,1 | 352,8 |
| | PEP Penman ($m^3$/ha) | 388,0 | 595,8 | 686,0 | 645,9 | 401,9 | 137,0 |
| | K – Villele | 0,39 | 0,51 | 0,61 | 0,67 | 0,61 | ,054 |
| | K – Turk | 0,84 | 0,91 | 1,07 | 1,19 | 1,00 | 0,94 |
| | K - Penman | 1,21 | 1,09 | 1,51 | 1,44 | 1,74 | 2,42 |
| 2001 | REP ($m^3$/ha) | 303,3 | 729,8 | 791,9 | 925,4 | 714,8 | 374,8 |
| | PEP Villele ($m^3$/ha) | 1014,0 | 1547,0 | 1336,0 | 1378,6 | 1254,2 | 938,0 |
| | PEP Turk ($m^3$/ha) | 351,4 | 807,6 | 756,9 | 773,0 | 722,3 | 508,1 |
| | PEP Penman ($m^3$/ha) | 350,0 | 591,8 | 663,0 | 631,8 | 396,3 | 136,0 |
| | K – Villele | 0,30 | 0,47 | 0,59 | 0,67 | 0,57 | 0,51 |
| | K – Turk | 0,86 | 0,90 | 1,51 | 1,20 | 0,99 | 1,93 |
| | K - Penman | 0,87 | 0,73 | 1,19 | 0,82 | 1,81 | 3,49 |

Table 3: The K correction coefficients of the PEP for each month for cucumber culture

| Year | Indicators | VI | VII | VIII | IX |
|---|---|---|---|---|---|
| 1999 | REP ($m^3$/ha) | 1325,2 | 1365,4 | 1523,5 | 1235,4 |
| | PEP Villele ($m^3$/ha) | 1446,5 | 1665,5 | 1245,6 | 834,0 |
| | PEP Turk ($m^3$/ha) | 932,0 | 1145,5 | 865,2 | 545,6 |
| | PEP Penman ($m^3$/ha) | 495,2 | 545,2 | 534,2 | 345,0 |
| | K – Villele | 0,67 | 0,84 | 1,22 | 1,44 |
| | K – Turk | 0,87 | 1,28 | 1,75 | 2,22 |
| | K - Penman | 1,85 | 2,64 | 3,02 | 4,15 |
| 2000 | REP ($m^3$/ha) | 1248,3 | 1124 | 1683 | 1316 |
| | PEP Villele ($m^3$/ha) | 1436,0 | 1670,9 | 1199,0 | 900,0 |
| | PEP Turk ($m^3$/ha) | 999,0 | 1131,5 | 830,8 | 627,0 |
| | PEP Penman ($m^3$/ha) | 482,0 | 548,7 | 452,6 | 315,0 |
| | K – Villele | 0,54 | 0,67 | 1,37 | 1,46 |
| | K – Turk | 0,89 | 0,99 | 1,97 | 2,10 |
| | K - Penman | 1,81 | 2,05 | 3,62 | 4,18 |
| 2001 | REP ($m^3$/ha) | 1263,5 | 1385,4 | 1514,0 | 1247,9 |
| | PEP Villele ($m^3$/ha) | 1440,0 | 1689,5 | 1258,6 | 855,0 |
| | PEP Turk ($m^3$/ha) | 901,0 | 1100,5 | 874,2 | 564,0 |
| | PEP Penman ($m^3$/ha) | 480,0 | 533,2 | 502,2 | 303,0 |
| | K – Villele | 0,65 | 0,82 | 1,20 | 1,46 |
| | K – Turk | 0,82 | 1,26 | 1,73 | 2,21 |
| | K - Penman | 1,87 | 2,60 | 3,01 | 4,12 |

Table 4: Water consumption, average yields and water capitalization coefficient

| Crop | Year | Water consumption ($m^3$/ha) | Average yields (kg /ha) | Water capitalization coefficient |
|---|---|---|---|---|
| Tomatoes | 2000 | 4580,4 | 78564 | 0,0583 |
| | 2001 | 4232,8 | 78420 | 0,0544 |
| | 2002 | 4821,9 | 78890 | 0,0615 |
| Green peppers | 1999 | 4078,2 | 37954 | 0,1074 |
| | 2000 | 4123,6 | 37470 | 0,1106 |
| | 2001 | 3840,0 | 36540 | 0,1054 |
| Cucumbers | 1999 | 4327,5 | 53147 | 0,0814 |
| | 2000 | 4271,0 | 52640 | 0,0812 |
| | 2001 | 4302,0 | 53250 | 0,0814 |

Table 5: The water quantity necessary to tomato, green pepper and cucumber plants to produce 1 kg of fruits and recommended irrigating norms

| Crop | Year | The water quantity necessary to produce 1 kg of fruits (l water /1 kg fruits) | Recommended irrigating norms ($m^3$/ha) |
|---|---|---|---|
| Tomatoes | 2000 | 58,3 | 4400-5000 |
| | 2001 | 54,4 | |
| | 2002 | 61,5 | |
| Green peppers | 1999 | 107,4 | 4000-4200 |
| | 2000 | 110,6 | |
| | 2001 | 105,4 | |
| Cucumbers | 1999 | 81,4 | 4200-4500 |
| | 2000 | 81,2 | |
| | 2001 | 81,4 | |

## CONCLUSIONS

Following the experiments we've undertaken, a series of results have been obtained, based on which we could calculate the water quantity necessary to tomato, green pepper and cucumber plants to produce 1 kg of fruits. The interpretation of these results is presented in table 5.

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