SUMMARY OF PhD THESIS

THE STUDY OF WATER CONSUMPTION AND IRRIGATION REGIME AT THE LETTUCE CULTIVATED IN PROTECTED AREAS

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INTRODUCTION

When crop requirements towards water cannot be assured through natural means as precipitations, in a protected system, watering gains a great importance. Watering scheme implies prevention of the soil humidity deficit for a certain crop and for certain soil conditions, by estimating the first watering, as to be an efficient one, or the date of the last watering, as to avoid the negative effects of humidity stress (RITCHI et al., 1990).

The decision to water crops should be taken while considering all the aspects that refer to soil, water, plant, climatic factors and the equipment used to obtain maximum yielding of the crop, as: soil capacity to retain water, quality of the irrigation water, volume of the applied water and watering frequency (CARRIJO et al., 1999).

Proper irrigation management requires a systematic evaluation of the energetic state of soil water, not only as to determine the quantity of water that is necessary, but also to establish watering moments. The amount of soil water should be kept between certain limits, so that water is available to plants and eluviations are avoided (MORGAN et al., 2001).

Both water deficit and water excess influence production. As a cellular constituent and a presence in various physiologic processes of the plant, water is directly linked to the nutrients absorption process (MAROUELLI et al., 1996).

Generally, vegetables have higher water consumption, when comparing them to other crop plants and a strong negative response in production quality and quantity, when not properly irrigated. Water use efficiency can be attained only when knowing the needs for water of the irrigated crop, the watering moment, the quantity of water required at a certain irrigation moment (watering rate) and throughout the whole vegetation period (watering scheme).

RESEARCH PURPOSE AND OBJECTIVES

The research purpose of this PhD thesis, was to determine water consumption and the watering scheme for lettuce, cultivated in a protected area, while aiming to attain early crops of high quality, at low specific costs.
Every producer should be able to estimate the amount of necessary water, use it rationally, exploit correctly irrigated fields and crop watering techniques in order to meet yield and harvest quality goals at the lowest production costs.

Hence, the following objectives were proposed for this paper:

- studying the reaction of lettuce plants under the influence of micro sprinkler irrigation and drip irrigation;
- studying the development of lettuce plants at different values of the active humidity interval;
- determining the elements of irrigation scheme for this crop;
- determining water consumption for lettuce cultivated in protected areas;
- determining water consumption for lettuce cultivated in protected areas;
- establishing watering efficiency upon lettuce through determinations of the water exploitation coefficient;
- establishing the most useful irrigation method for lettuce cultivated in protected areas, in order to obtain big and quality yields;
- watering influence upon some morphologic characters of the lettuce;
- evaluating the economic efficiency of lettuce cultivated in protected areas;

**ORGANIZATION AND LOCATION OF EXPERIENCE**

Experiments regarding water consumption and watering schemes studies for lettuce, were carried out between years 2004 and 2006, at The University of Agricultural Sciences and Veterinary Medicine, Cluj-Napoca, Faculty of Horticulture, inside the greenhouses belonging to Vegetable Growth discipline.

Researches concerning water consumption and irrigation scheme for lettuce grown in protected area, were conducted in two experimental cycles (spring and autumn) in each year, within trials that added in two factors, one of them having two and the other one three graduations.

Experimental factors and their graduations were:

**Factor A: watering method, with following graduations:**

- $a_1$: drip watering
- $a_2$: microsprinkler watering

**Factor B: watering moment, with following graduations:**
b₁ - at 60% from the active humidity interval
b₂ - at 70% from the active humidity interval
b₃ - at 80% from the active humidity interval

The experiment contains two factors, of 2x3 kinds, resulting 6 experimental variants.

Within the experiments, two new watering methods were chosen: through drip and through microsprinkles, aiming to save irrigation water and labour, and to obtain stable, high yields.

**EXPERIMENTAL METHODS USED**

Establishing main hydrophysical parameters, characterizing the soil from the agrochemical point of view and framing the experimental plots according to a texture category, was done following the methods of the ICPA system.

Statistical interpretation of the data was carried out using the variance analysis method and in order to appreciate the significance of the differences the multiple comparison test was applied (Duncan).

To determine water consumption of the lettuce cultivated in protected area, a direct method, soil water balance method and three indirect methods: Thornthwaite method, Balney-Criddle method and Hargreaves-Samani method (using the original ecuation and the one modified by Trajkovic (2007)) were used, the last three methods being reliant on air temperature. In order to determine water consumption through direct method, soil water reserve was accurately established at the beginning and at the end of the vegetation period, using the gravimetric method.

**RESULTS AND CONCLUSIONS**

After watering according to the irrigation scheme, at three different moments, it can be observed, that, wetting numbers grew while the humidity level of the soil arose, in correspondence with the watering moment established and where water was supplied through drip irrigation, the wetting number was twice as big as the one reached due to microsprinklers irrigation. The number of wettings was smaller for microsprinklers irrigation, as water rates were almost double in compassion to drip irrigation ones. In fall,
the wetting number was reduced, but still the variants wetted through drip were more frequently wetted.

Irrigation rates applied to lettuce crops, during the three experimental years, varied dependent on the watering method and the level of humidity maintained in soil. In each year, water rates were bigger for micro sprinkles variants and lower for drip variants. Where the amount of water is concerned, the wetting moment had a significant role, because variants frequently wetted had bigger water rates than the ones wetted through the same method, but not at the same frequency.

The water rate of 80% from the active humidity interval distinguishes itself from the rest, through maximal values, both for drip irrigation (between 1674 and 1890 mc/ha) and micro sprinklers irrigation (between 2160 and 2295 mc/ha), applied in spring cycle.

Water rates applied in autumn crops, are lower, with maximal values in 2004 autumn: 1512 mc/ha through drip irrigation and 1890 mc/ha through microsprinklers irrigation.

During vegetation period, salads water consumption oscillated in accordance to the development state of the crop, water rates and watering methods, recording low values at the beginning and at the end of the vegetation period and maximal values at the middle of the vegetation period, which corresponds with the period of heads development.

The influence of climatic conditions brings differences between the average water consumption of the two crop cycles. In each of the three experimental years, water consumption recorded in spring is bigger than the one recorded in autumn.

Where the total water consumption is concerned, during spring crops, the highest values were recorded in 2005: between 1198 m$^3$/ha and 1975 m$^3$/ha for drip irrigation and 1913 m$^3$/ha and 2401 m$^3$/ha for micro sprinklers irrigation, respectively.

In the second crop cycle, in autumn, lettuce total water consumption recorded maximal values in 2004, at an 80% water rate from the active humidity interval, with 1558 m$^3$/ha at drip irrigation and 1952 m$^3$/ha at microsprinklers irrigation.

Reference evapotranspiration values, excluding the Hargreaves-Samani method with the original ecuation, exceed away the values of real evapotranspiration in the lettuce crop irrigated through drip. Comparing it to the average consumption on
microsprinklers, reference evapotranspiration obtained through Thornthwaite, Blaney-Criddle and Hargreaves-Samani methods, with the modified ecuation, has values that are closer to the real one.

The watering method had a decisive influence upon water valorization coefficient. Variants wetted through drip had bigger yields and water consumption was lower than the case of variants wetted through microsprinklers, so, the water valorization coefficients from variants wetted through microsprinkler were with almost 40% higher than the ones wetted through drip.

Water exploitation coefficients decreased while diminishing wetting frequency at variants wetted by using the same method. This can be explained by better water management of the variants wetted at a reduced frequency, in comparison to the ones frequently wetted, which rather ‘wasted’ water.

The index for water valorization efficiency in a salad crop, expressed in kg of vegetal product for each m$^3$ of water applied through irrigation, reaches higher values when water rates remain at a minimum of 60% from the active humidity interval, both for drip and microsprinkler irrigation.

In the first crop cycle, during spring time, a strong correlation can be observed between lettuce yields and total water consumption, the correlation coefficient being noticeably significant with a value of $r=0.94$, when irrigation occurs through drips, and very significant with a value of $r=0.97$, when irrigation occurs through microsprinklers. Yields were determined by water consumption up to 89% at salad irrigated through drips ($R^2=0.89$), and up to 93% at lettuce watered through microsprinklers ($R^2=0.93$).

Between the analyzed parameters of the autumn crop, the correlation is lineal, noticeably significant and the value of the correlation coefficient is $r=0.95$, both for the lettuce watered through drips and the one watered through microsprinklers, this indicating yields close dependence on the water consumption of the crop. Lettuce yield of the autumn was 90% determined by water consumption for both of the methods.

Though higher yields and water economy were achieved through drip irrigation, the economic efficiency was not maximal. The upper price of the system itself and of the labour did not allow the achievement of a profit superior to the microsprinklers method.
This last method justifies itself economically, as yields, though lower, were enough to determine a higher gain.

**RECOMMENDATIONS**

From a qualitative point of view, in what lettuce heads are concerned, drip irrigation is recommended, because it assures control upon the quantity of applied water, as well as quality yield, due to the fact that not the entire surface is moistened, the water reaches the soil directly, in the root area, and the leaves remain dry, which reduces the percent of rotten wasted plants. This method is also recommended when higher yield are desired, no matter the costs.

From an economical point of view, microsprinklers irrigation is recommended. Though the yields are lower using this method, they are enough to determine a higher gain.

In the matter of proper wetting moment, it is recommended a water rate of 80% from the active humidity interval, in which case yields are noticeable higher than in the case of 60% or 70% rates from the active humidity interval.