USE OF CROP WATER STRESS INDEX FOR MONITORING WATER STRESS IN SOME SINANTHROPIC PLANT SPECIES

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Abstract. The water stress indicator (crop water stress index, CWSI) is a measure of the transpiration rate of a plant, influenced by the leaf and air temperature difference from the plant's vicinity and the air pressure deficit of the water vapors from the atmosphere. The experiments were realized in July-August 2008 and 2009 for six species in the cities Pitesti, Mioveni and Maracineni: *Cichorium intybus* L., *Conyza canadensis* (L.) Cronq., *Erigeron annuus* L. (Pers.), *Lactuca serriola* Torn., *Polygonum aviculare* L. and *Echinochloa crus-galli* (L.) Beauv. For those species we calculated the CWSI to estimate the water stress on the selected plants in the urban environment conditions. The analyzed species were exposed to a less accentuated water stress while vegetating in the soil and to a more intense one they were grown in the asphalt cracks. *Cichorium intybus* had the smallest CWSI value (0.26) while *Lactuca serriola* the highest one (0.44).

Keywords: ambient stress, anthropic conditions, diagnosis possibilities

INTRODUCTION

The utilization of the crop water stress index (CWSI) is preferred in agriculture, being one of the best indicators for the irrigation programming and management [9, 14, 15, 18, 20, 22 - 24, 28] and for the harvest estimation crops [10, 11, 13, 20, 29, 30]. The CWSI calculation was done for the apple orchards from Pitesti-Maracineni [20], for the ornamental plants and the walnut [25, 26] and for the orange [27]. CWSI was also utilized for the wheat's crop water stress evaluation [6] and of the corn [13]. Studies have been made and the CSWI was also calculated for potato [3], watermelon [5] and soybean [19]. CWSI was also used for the appreciation of the meadows' crop water stress. There were, also, investigated the relation between CWSI and evapotranspiration of two grass species *Festuca arundinacea* and *Dactylis glomerata* [4]. In other studies [25] were determined the low basal line (LBL) for cultivated plants such as: *Medicago sativa, Fraxinus velutina glabra* and *Prunus cerasifera* and the low basal line (LBL) for the CSWI calculation at cotton [7]. In the same time, new methods for determining the low basal line (LBL) and upper basal line (UBL) at corn and soybean [19] were developed. In 1993 was determined the CWSI at *Cynodon dactylon* [16] and was established that the values of this index were strongly influenced by the net radiation. CWSI was also correlated with the plant's water's potential [14, 18, 21], with the ground's water availability [7, 23] and with the leaf's conductance at *Vitis vinifera* [17]. The method for the evaluation of wheat CWSI was modified [31] comparative with the method previously established [14], through the utilization of an artificial leaf's temperature, without transpiration (imitation leaf). Other authors proposed the *Medicago sativa* CWSI calculation [8], through measuring the stomatal conductance of the leaves [2].

MATERIAL AND METHODS

The experiments for the appreciation of the crop water stress at sinanthropic plants (determination of CWSI) were realized in July-August 2008 and July-August 2009, on six species of sinanthropic plants: *Cichorium intybus* L., *Conyza canadensis* (L.) Cronq., *Erigeron annuus* L. (Pers.), *Lactuca serriola* Torn., *Polygonum aviculare* L. and *Echinochloa crus-galli* (L.) Beauv. The temperature of the leaf (of the plant) was measured with a termohigrometer with an infrared thermometer (Mannix EM8857PI), oriented at an angle of 45° from the plant at a distance of 15-20 cm, 10 readings being done, between 12^{00}-14^{00}, during the cloudless days of July-August.

The water vapor's pressure deficit from the atmosphere (V_{pd}) was calculated by using the equations established by other authors [12, 14, 20]. For calculation the CSWI, the low basal line and upper basal line were calculated first. The low basal line was determined in 2009, during the cloudless days, when the air temperature recorded a maximum of 35.6°C, on plants which were well supplied with water for two days before performing the recordings, between 8^{00}-14^{00}. The difference between the leaf temperature (T_c) and air temperature (T_a), respectively T_c-T_a, was then graphically represented in opposition to the water vapor tension from the atmosphere (Vpd), and the basal line was obtained through a linear regression (Y=a+bx) a T_c-T_a (Y) in opposition to Vpd (x), using the method of the smallest squares. The upper basal line was determined by cutting the plant, tying it in its initial place, and after a day, during which the plant ceases to transpire, the temperature difference specific to this line was measured. The plants' crop water stress index was calculated through determining the relative distance between the low basal line, which represents the water "non-stress" conditions and the upper basal line which represents the lack of transpiration. It was calculated for each measured temperature at the ratio of: a – distance between the localization of a point (represented by a pair of values T_c-T_a, Vpd) and LBL and b – distance between LBL and UBL, in such a way that the CWSI is equal to a/b [12].

The applied statistical method of analysing the experimental data was the variation analysis for polifactorial experiences, and DUNCAN was the test used to determine the statistical significance for the confidence level of α=0.05. The utilized calculation and analysis program of the statistical data in the mentioned works was SPSS version 14, under Windows.

RESULTS

In Fig. 1, the low basal line is represented for six calculated species of sinanthropic plants, for the first time, at these species.

The high values of the water vapor pressure deficit of up to 6 kPa are due to the high temperatures at the asphalt's surface (45°C) recorded at the moment of performing the determinations.

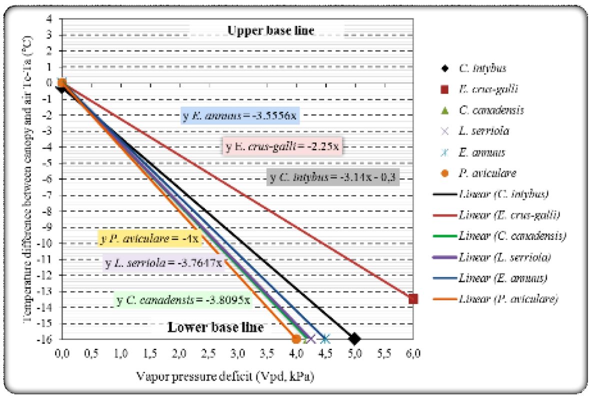

Figure 1. The Lowest Basal Lines LBL for six sinanthropic plants.

For calculation the CWSI, the intensity of the relation established between the difference of the leaf and air temperature and the pressure deficit of the water vapors for each investigated species was represented graphically (graphs were drawn having as horizontal axis Vpd and as vertical axis Tc-Ta) (Fig. 2-7). The space between the low basal line LBL and the upper line UBL represents the domain of this index. The line's slope corresponding to the LBL lines is more inclined at the *Polygonum aviculare* species and more reduced at the *Echinochloa crus-galli* species.

In the case of the *Polygonum aviculare* species, the individuals raised in the asphalt's cracks are more water stressed compared with the individuals grown on soil, regardless of location: the CWSI values have oscillated between 0.37 and 0.86 in the conditions from Pitesti, in the asphalt and between 0.40 and 0.98 in the conditions from Mioveni, in the asphalt, comparative with the maxim values of 0.47, in the conditions of soil vegetation (Fig. 2).

And in the case of the *Erigeron annuus* species, the individuals met in the asphalt's cracks, particularly in Pitesti seem to be strongly water stressed, the CWSI value ranging between 0.54 and 1. The CWSI values at this species, in the situation in which the individuals grow in asphalt cracks, are bigger in comparison with all the other analyzed species, met in the same substrate, which proved that the species rarely grows in asphalt cracks (Fig. 3).

In the case of the *Lactuca serriola*, in the conditions offered by the asphalt, especially at Mioveni, the CSWI records higher values, between 0.57 and 1 (Fig. 4).

The same tendency of accentuating the water stress also manifested at the *Conyza canadensis*, in the conditions of plant vegetation in the asphalt, especially

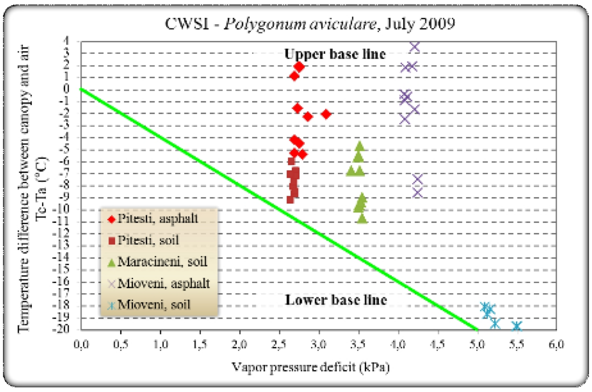

Figure 2. CWSI at *Polygonum aviculare*.

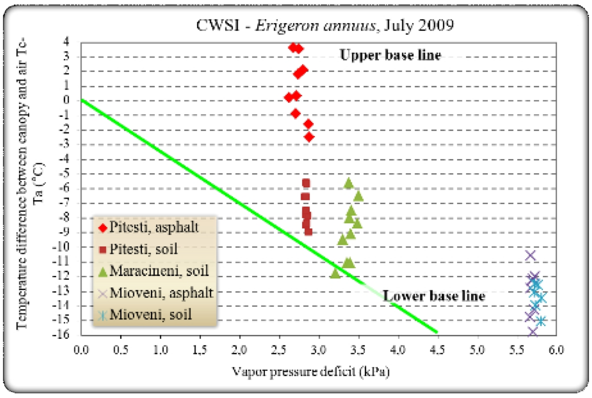

Figure 3. CWSI at *Erigeron annuus*.

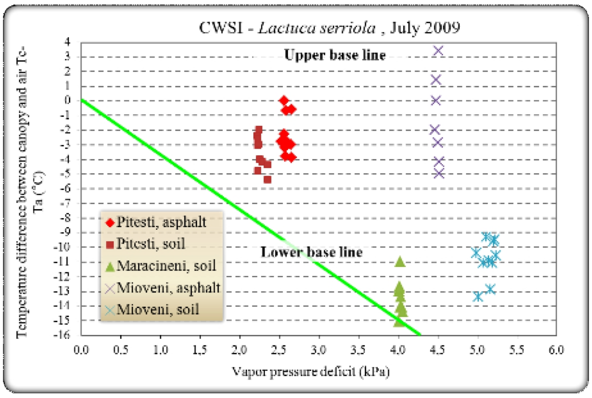

Figure 4. CWSI at *Lactuca serriola*.

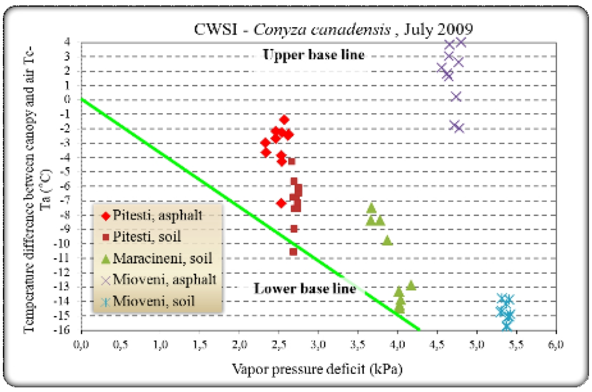

Figure 5. CWSI at *Conyza Canadensis*.

in the city of Mioveni, situation in which the CSWI calculated values were between 0.73 and 1 (Fig. 5).

At *Echinochloa crus-galli*, the water stress was more pronounced, when the plant was seen growing in the asphalt cracks of Pitesti (CWSI between 0.15 and 0.85) (Fig. 6). At this species, the CWSI values are, in general, smaller comparative with the other analyzed species, seemingly less water stressed.

At *Cichorium intybus*, Pitesti asphalt conditions intensify the water stress, CWSI values ranging between 0.20 and 1 (Fig. 7).

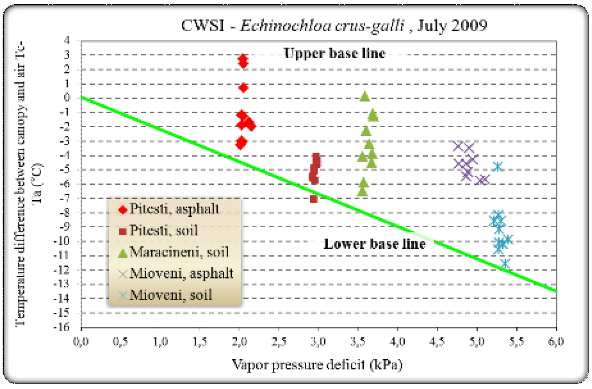

Figure 6. CWSI at *Echinochloa crus-galli.*

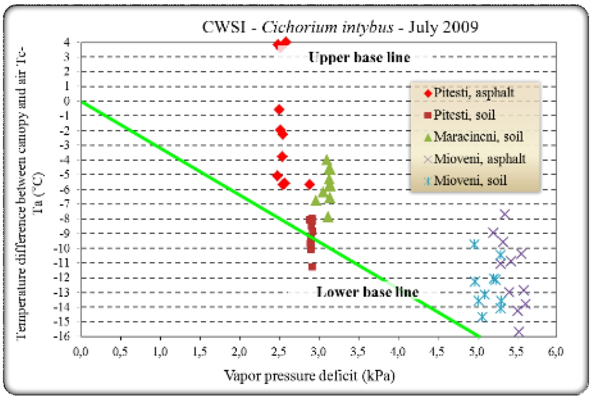

Figure 7. CWSI at *Cichorium intybus.*

DISCUSSIONS

At first, there were calculated the LBL low basal lines in order to determine the CWSI for six sinanthropic plant species: *Conyza canadensis, Erigeron annuus, Cichorium intybus, Lactuca serriola, Polygonum aviculare* and *Echinochloa crus-galli*. The lines slope that corresponds to the LBL lines for the six species are different. The bigger the slope is, the more intense the plants transpire in the zone of bigger water vapor pressure deficiency. The smaller the slope is, the lesser the plant's sweat, being better adapted to high temperatures.

The straight line slope in accordance with the LBL is more inclined at *Polygonum aviculare* species (which transpire more intensely in an area of higher water vapor pressure deficits) and less inclined at *Echinochloa crus-galli* species which transpire less [1], being much better adapted to high temperatures. Another possible explanation could be offered by the fact that it is a type C_4 species and thus presents adaptations which assures it a bigger efficiency in the utilization of water [1]. In C_4 plants the transpiration is more reduced comparative with photosynthesis [1], when the stomata close, that being considered as an efficient adaptation to hot conditions in the environment.

Compared with the LBL values for other species (*Medicago sativa*, *Fraxinus velutina glabra*, *Prunus cerasifera*) [25] and other environmental conditions, for the apple [20], the low basal lines LBL, calculated by us for six species of sinanthropic plants, have the slopes, respectively aligned at the origin, y, much more accentuated. If at the alfalfa the LBL descends until 8°C difference on the OY axis [8, 12], in the conditions of some pressure deficiencies of 4.5 kPa, at the species analyzed by us, the LBL lines descend until a 16°C difference on the OY axis, in the conditions of some pressure deficit of the water vapors of 5 kPa. In Pitesti, UBL reached 4°C in July 2009 when the measurements were made.

The highest value of CWSI was calculated on the average of the places in which the determinations were conducted, at *Lactuca serriola* (0.44) species, while the lowest value at *Cichorium intybus* (0.26) species; the CWSI values are the cause of water deficits which characterized July and August 2008, deficits partially covered by rainfall.

CWSI recorded higher values at plants which grow in the asphalt (0.56, Pitesti, in the asphalt) compared to plants which grow in the soil (0.20, Pitesti, in the soil), considering that the medium temperature values recorded on the asphalt surface were by 4.4-4.7°C higher and the air humidity by 4.8-11.5% lower.

At all analyzed species, the individuals which grow in the asphalt cracks are more water stressed, having higher CWSI values. For example at *Polygonum aviculare* species, CWSI varied between 0.40 and 0.98 at individuals found in Mioveni, in the asphalt, compared to individuals which vegetate in the soil.

From the analysis and interpretation of corroborated data with those of consulted specialized literature, we can draw the conclusion that CWSI values were bigger when the species were met in the conditions which vegetation in asphalt cracks. These conditions implied high temperatures at asphalt surface, quick evaporation of the water from precipitations and most often the impossibility of its infiltration. That fact outlines the natural adaptation potential of sinanthropic species to the environment in which they live.

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