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FRACTIONAL COMPOSITION OF WATER IN LEAF TISSUES OF SPECIES AND FORMS OF THE GENUS *ULMUS* L.

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Optimal conditions of growth and development of species and forms of the genus *Ulmus* depend on many factors, primarily on the water regime of plants. Optimal water supply is important for rhythmic functioning of physiological processes and optimization of plant productivity [1, 2].

Changes in water exchange occurring in the process of wilting under laboratory conditions are similar to the conditions of open ground during the drought season. However, the indicated method of wilting is not a direct method for assessing drought tolerance, but rather a comparative method. This is due to the fact that it does not take into account the role of the root system, the activity of which in natural conditions is essential. To study the water regime of plants, the laboratory method of wilting is effective, since it is much more efficient than the field method and does not require many years of observation and presence of drought [1, 4, 6].

In order to compare in more detail the drought tolerance of species and forms of the genus Ulmus, the total water content in their leaves was analyzed, fractional analysis of plant water composition was performed, relative turgescence, water deficit and water retention capacity of leaves were determined, which more widely illuminated the response of each taxon to a lack of moisture. These indicators were determined according to the method of M. D. Kushnirenko et al. [5].

As a result of research of dynamics of total water content in leaves of species and forms of genus *Ulmus* it was established that this index is unstable and gradually decreases till the end of vegetation period. Thus, in June it was 58.9-67.9%, in July – 57.6-65.5%, in August – 54.5-62.2%. The highest content of total water in average by variants was noted for ornamental form *U. g.* “Rubra” (65.2%), although a significant difference with the water content of species of the genus *Ulmus* (61.4-63.8%) and the weeping form of U. g. “Pendula” (63.7%) was not observed in contrast to the other two forms. The lowest rate was noted in the ornamental forms of U. g. “Albo-variegata” (58.9%) and U. g. “Crispa Pyramidalis” (57.3%), which clearly differed from the species of the genus *Ulmus* and the forms *U.g.* "Pendula" and *U. g.* “Rubra”.

During the study period, the total water content decreased with each month. Thus, for three months the greatest decrease of water in leaf blades was recorded in

U.minor – 7.4%, and the least loss – in *U. g.* “Pendula” and *U. g*. “Albo-variegata” (5.1%).

A study of the dynamics of water retention capacity of leaves of species and forms of the genus Ulmus showed that large water losses occur during the first two hours and the largest losses occur one day after the beginning of wilting. On average, during a day, the least amount of water was lost through leaves of *U. pumila* – 34.9%, and the greatest – through leaves of the weeping form *U. g*. “Pendula” – 36.8%.

Table 1

Indices of water retention capacity of leaves of species and forms of the genus *Ulmus*

Species, forms	Water loss every two hours, %							Average percentage, %
	2	4	6	8	10	12	24	
U. pumila	11,4	20,7	27,3	37,1	43,0	46,7	58,6	34,9
U. glabra	12,5	22,4	28,5	38,2	43,9	47,6	59,3	36,1
U. laevis	12,3	22,1	29,3	38,0	43,7	47,1	59,2	35,9
U.minor	11,9	21,6	27,6	37,6	43,4	46,9	58,7	35,4
U. g. ‘Pendula’	14,6	22,8	28,4	38,5	44,6	49,3	59,7	36,8
U. g. ‘Albo-variegata’	10,2	19,2	27,1	36,4	45,3	48,0	58,5	35,1
U. g. ‘Rubra’	13,9	21,9	29,2	37,8	44,0	47,8	59,3	36,2
U. g. ‘CrispaPyram.’	11,5	20,9	27,3	37,3	43,2	46,6	58,7	35,3
HIP_{05}	*0,6*	*1,1*	*1,4*	*1,5*	*1,6*	*1,8*	*1,8*	–

During the first two hours, the greatest amount of water (14.6% and 13.9%) was lost through the leaves of *U. g*. "Pendula" and *U. g*. "Rubra", and the least – from the leaves of *U. g*. “Albo-variegata” and U. *pumila* – 10.2% and 11.4%, respectively.

It was found that the dependence of water loss rate on time in species and forms of genus Ulmusmae is high inverse correlation (r = 0,9), which is described by the regression equation: $y = –2,0305x - 17,138$, where y - water loss, %; x - time, h. (Fig. 1).

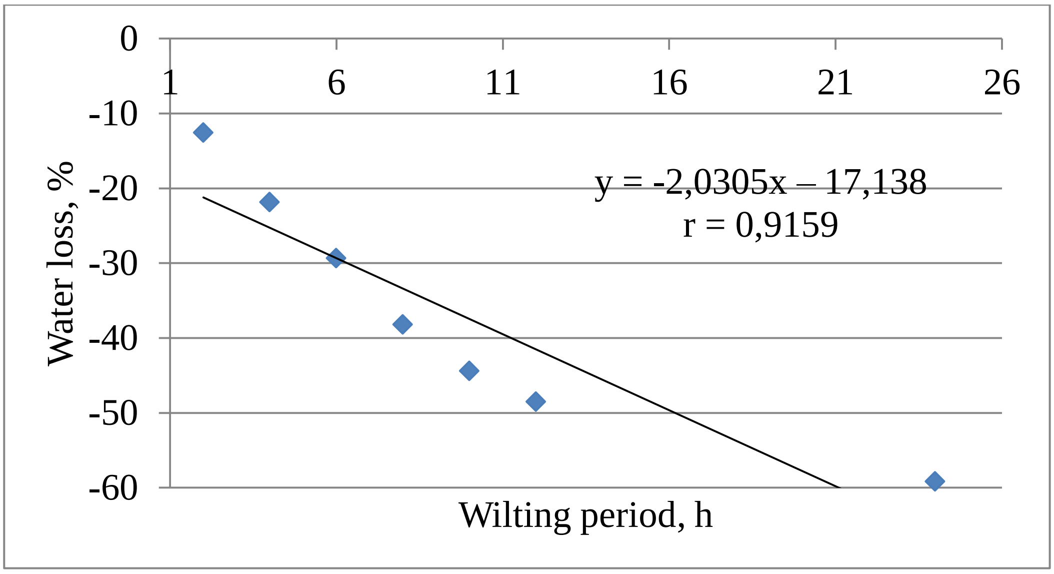

Fig. 1. Correlation dependence between water loss rate of species and forms of the genus *Ulmus* and time

It is possible to reveal water regime trends in more detail by fractional analysis of plant water composition. Labile or mobile water in a cell is a factor of rapid response to external conditions and an important component of intracellular environment where metabolic processes take place. Bound by osmotically active substances, water makes plants resistant to adverse environmental conditions, namely soil and atmospheric drought. The mobility of water molecules and, consequently, their activity, is reduced due to their binding by particles of hydrated colloids, hydrated molecules and ions [3, 4, 6, 8].

The fractional composition of water determines the degree of water retention capacity of leaf tissues. The so-called apoplastic ("free") water, which is located in leaf intercellular air space, evaporates most easily and quickly. Under unfavorable hydrothermal conditions, during wilting, leaf tissues first of all lose such easily mobile water. In this case, the rate of water loss and its value will be higher, and the resistance of tissues to dehydration is estimated as low. High resistance to dehydration is provided by high content of symplastic ("bound") water – colloidally bound in hydrate shells of cytoplasmic biopolymers [1, 2, 7].

Studies have shown that the content of bound water in most species and forms of Ulmus genus exceeds the content of free water by 2-4.5 times, indicating the significant role of bound water in plant adaptation to growing conditions. During calculation of fractional water composition, it was taken into account that the total water content in tissues, i.e. – the sum of bound and free water is 100%. As a result of determining the total level of water loss, it was identified that the studied species differ significantly in the total amount of water, therefore, when conducting a comparative analysis on fractional composition of water, it was advisable to go to the absolute values of its loss with recalculation of the proportion of water content in a certain ratio (Table 2). In this connection, the quantitative content of water fractions and their influence on adaptation were determined. Thus, the proposed method of calculation of water fraction composition shows objective data on plant adaptation and the influence of water fractions on formation of drought tolerance.

Table 1

Fractional composition of water in the tissues of leaves of Ulmus species and forms, %

Ulmus species and forms	Bound water content, %	Free water content, %
U. pumila	51,5	11,4
U. glabra	48,2	20,3
U. laevis	50,1	12,2
U.minor	40,2	14,3
U. g. 'Pendula'	44,7	22,4
U. g. 'Albo-variegata'	36,5	15,6
U. g. 'Rubra'	44,8	12,3
U. g. 'CrispaPyramidalis'	42,1	20,9
HIP_{05}	*2,2*	*0,8*

U. *pumila* and U. *laevis* are characterized by the maximum content of bound water fraction, which is 51.5% and 50.1%, respectively, and the minimum content of free water – 11.4% and 12.2%. This provides their high water retention capacity and low water yield rate. The minimum content of bound water was found in leaves of ornamental form *U. g*. "Albo-variegata" – 36.5% and the maximum free water content in *U. g.* "Pendula" – 22.4%. In addition, it was found that the rate of water loss of certain species is uniform to such an extent that it is impossible to distinguish the rate constants of symplastic and apoplastic water loss. Probably, the total rate of water loss is approximate to the rate of symplastic water loss, since the free water fraction is almost absent, which accounts for the low rate of water loss in these species and confirms their characteristic as drought-resistant species. The ratio of content of free and bound water fraction in leaves of species and forms of the genus *Ulmus*.

The overall level of water loss by leaves ranges from 52.1% to 68.5% with predominance of high values of water content (Fig. 2). In spite of this, it is reasonable to distinguish a group of species with low and higher levels of water loss. The low level of water loss is characterized by U.*minor* (54.5%), *U. g*. "Albo-variegata" (52.1%) *and U. g*. "Rubra" (54.3%). Such indices are a normal adaptation mechanism for plants that have evolutionarily adapted to arid environmental conditions and are able to maintain physiological processes during drought with a low level of tissue water loss. Other studied species and forms differ in the average level of water loss by leaves – in the range from 62.3% to 68.5%, which emphasizes belonging of representatives of the genus *Ulmus* to the mesophytes.

The ratio of different water fractions in leaf tissues characterizes the water retention capacity of a plant. Thus, free water located in intercellular tissues and cell membranes transpires faster than colloid-bound water in the inner cell environment [98]. First of all, free water is transpired, so the dynamics of water loss is variable over the time of the experiment with a higher rate of water loss at the beginning and a lower one at the end.

So, according to the level of total water content, water deficit and fractional analysis of water composition of plants in leaves, it was found that species and forms of genus Ulmus are medium- and high-drought tolerant. Rate and water loss by leaves of representatives of the genus are adapted to growing conditions. The studied species and forms of the genus Ulmus have a balanced water regime, which increases their prospects for use in landscaping the Right-Bank Forest-Steppe of Ukraine.

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