REGULARITIES OF WATER RETENTION PROCESS BY FIR-TREE NEEDLE SAMPLES

Mazurkin P.M., Popova A.O.
Mari state technical university, Yoshkar-Ola, Russia

For accuracy increase of the analysis of water retention ability of ramule needle samples collected from accountable fir-tree in various geodesic directions, and also evaluation of ecological conditions it is offered to use a criterion - time of full desiccation in needle samples. The needle sample weighing up to the constant room air-dry mass allows to determine water retention cycle time and mean plant sample deliquification rate. The offered method of ecological territory evaluation by accountable fir-tree needle mass dynamics, besides on an mean sample deliquification rate, allows to reveal tree groups. In the following the evaluation of effects on territory enclosing group of measured accountable fir-trees is executed.
Keywords: fir-tree, verticil, ramule, needles, mean deliquification rate, forest and urban territory, ecological evaluation

The growing trees are enabled to assimilate a plenty of impurities, intertropical in the atmosphere. Therefore during ecological monitoring [3] of environment use of tree sustainability parameters [1], in particular regularities of desiccation by fir-tree needle samples is possible.

Inaccuracy of the analysis of a water loss by fir-tree needle samples is defect of known methods of an estimation of desiccation by fir-tree needles. Thus the samples cut from an accountable fir-tree in different geodesic directions, isn't taken as whole chains. The reason is that the specific places at fir-tree verticils for sampling as ramules are not determined. It doesn't allow to conduct the analysis of environmental situation around of an accountable fir-tree on the statistical data, obtained in laboratory conditions on measurements of needle samples from ramules of each accountable fur-tree verticils legibly space-stabilized.

In brochure [1] the proposed criterion is needle moisture mass halves loss time. However, termination of needle sample weighings after loss more than 50 % of their initial mass results in impossibility of determination of such water retention process dynamics parameters both an initial mass of a moisture in sample, first passage time of a room air-dry mass and mean deliquification rate of sample. Thus, the existent methods of desiccation estimation don't allow to measure parameters of water retention and desiccation processes, and also to conduct analysis of water retention ability of needle samples on the obtained data.

The purpose of the article - to show the basic regularities of water retention and desiccation by fir-tree needle samples, and on their basis briefly to state a technique of an ecological evaluation of territory of its habitat.

For consummation of the purpose in view the following problems were decided:

1) statistical characteristics of water retention process by separate ramule needle samples collected from an accountable fir-trees, growing on forest territory, that is in ecologically clean conditions of development and growth of forest trees are determined;

2) statistical characteristics of water retention process by ramule needle samples collected from an accountable fir-trees, growing on central square of Yoshkar-Ola, that is in conditions of foulness of fir-trees by the atmosphere are determined;

3) regularities of water retention by fir-tree needle samples are determined.

For environmental investigation of territories the fir-trees *Picea abies* [2] were taken. On territory of scientific-experimental forestry enterprise of Mari state technical university (46 compartment, 1 subcompartment, and distance from auto-road more than 50 m) four small fir-trees in the age of 15-20 years were selected. The trees were selected in proportion to increase of distance from a road (increasing number). On an accountable fur-tree verticil, then limb inside verticil in-

cluding measurement of a geodesic direction of its stem were selected, after basic sample as one ramule from the extremity of stem was snipped. For the analysis of water retention ability of needles after snipping each ramule was put into container as paper packets for transportation. In laboratory conditions on all cut ramules needles were separated from a stem, needle samples were pitted into paper open boxes for air drying. Each sample was multiply weighed including drying in room conditions up to achievement of a constant mass. The measurements of a needle sample mass were conducted on scales Vibra AJ-420 CE to within 0,001 ($\pm$ 0,0005) g.

On each accountable fir-tree limbs were selected in four cardinal directions. From limbs for the analysis of water retention ability of needles ramules were snipped from the stem extremity approximately at the height 1,3 m from a root trunk collar. Besides samples were collected out of vegetation period in January, 2009.

In room conditions desiccation, contained in needle samples, was measured on the dynamics of needle mass. Besides at the first day the weighing was conducted in each hour at the first 6 hours after snipping, then through each three hours. At following days of the first week weighings were conducted also through each three hours, then some days the measurements were executed two - three times in day, further during several days - once per day, and then once in some days and at the end of experiences once per one week. Besides the measurements were conducted, while the sample mass didn't achieve constant significance for oscillation within weighing error.

On territory of Yoshkar-Ola centre the similar experiments for study of water retention by needles of fir-trees growing in conditions of potent pollution were conducted. For realization of experiences three sample areas were selected:

1) compartment № 1 - area near a building of theatre named after Shketan on square named after Lenin on the one hand and auto-road along the street Komsomolsky - with other;

2) compartment № 2 - area near central entrance into bulk № 1 of Mari state technical university, where the accountable fir-trees stand in one line, besides crowns of fir-trees are densely closed, and from eastern direction of area the parking lot is situated;

3) compartment № 3 is situated along a street Sovetsky across sports complex Ubileyny, besides the tree № 1 on this sample area grows at traffic light on intersection of a street named after Panfilov from a street Sovetsky.

All compartments are directly situated near urban main roads, besides compartment № 3 is situated along auto-road and at the same time intersection is disposed from its southwest direction, and along compartment № 2 the parking lot is placed.

On each area also four fir-trees, from which ramules were snipped for study of water retention of their needles, were selected. Age of trees is 25-30 years. The samples were collected out of vegetation period in February, 2008. The analysis technique of desiccation by needle of fir-trees growing in pollution conditions is similar to an assay techniques of desiccation by needle of trees growing in a forest. Its difference was consisted only that from the extremity of a stem of a lateral wing three ramules were snipped, as for realization of experiment the less sensitive laboratory scales ELB 600 to within 0,05 g were used. Besides the measurements of needle sample mass were conducted under the following scheme: per the first day - in each three hours, in following some days - 2-3 times in day, and then during two weeks - once in day and further once per one week, while the needle sample mass didn't achieve constant significance.

The needle sample mass measurement data were subjected to statistical processing in a software envelope Curve Expert 1.3.

By identification water retention dynamics model as formula was revealed:

$$m = m_m + m_d = m_{m0} \exp(-a_1 t^{a_2}) + m_d , \quad (1)$$

where m - variable mass of sample during air drying process, g; m_m - variable mass of a moisture in sample, g; m_{m0} - initial mass of a moisture in sample after snipping, g; m_d - mass of dried needles, g; t - drying time from the moment of sample snipping, days.

In a fig. 1 the graph of water retention and desiccation by needle sample collected from ramule cut from the southern cardinal direction of an accountable fir-tree № 1 (compartment № 1) is represented.

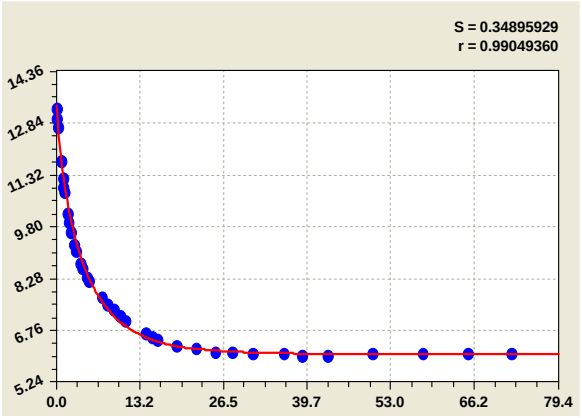

Fig. 1. The graph of dynamics of a moisture in needle sample collected from cut ramule of fir-tree № 1 from the southern cardinal direction

The dynamics graphs of water retention and desiccation by needle samples collected from ramules cut from other an accountable fir-trees are similar.

The first component m_m of biotechnical regularity formula (1) shows, that the process of air drying occurs by the death distribution in general form, and the second component m_d - that desiccation will be realized up to some constant significance of sample moisture mass [4, 5].

In a fig. 2 collected needle sample mass dynamics scheme is represented.

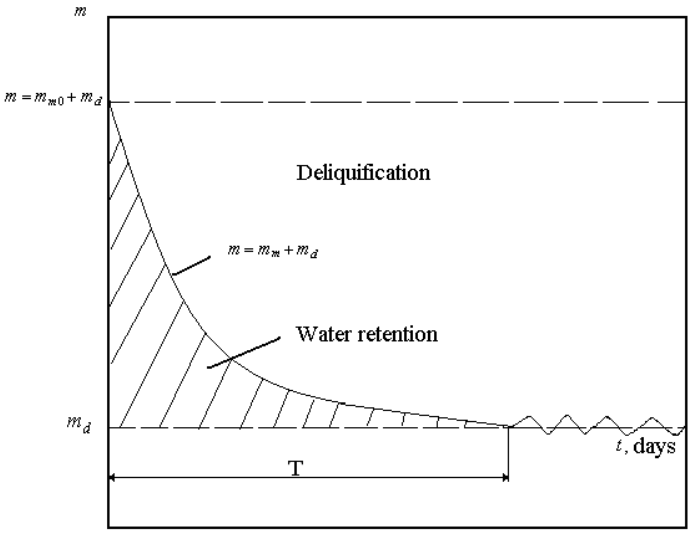

Fig. 2. Dynamics of a mass of needle sample from ramules of an accountable fur-tree

After snipping of ramule the initial mass of needle sample is composed of the initial mass of a moisture m_{m0} and dry needle mass m_d. During drying the moisture mass in sample is decreased by the exponential death distribution, and it in each time of a desiccation consists of the sum of a mass of a moisture, retained by cells m_m and mass of dry needles m_d. The moisture mass decreasing rate in the beginning is high, specially at the first six hours after snipping of ramule, and then it decreases. The needle mass decreases up to constant significance and then there is its oscillation around it in connection with a modification of room moisture.

As it is visible in a fig. 2, the square under the graph shows process of water retention on the formula (1). And the process of sample deliquification is defined by square above the graph, therefore of desiccation dynamics is characterized by a difference $m_0 - m$ and formula:

$$m_0 - m = m_{\text{в}0}(1 - \exp(-a_1 t^{a_2})) . \quad (2)$$

Let's mark, that the time T also can be directly be defined on the table date of measurement dynamics. However significance of initial moisture mass in sample m_{m0} can be defined only after identification of biotechnical regularity (1) concerning new experiment results.

For all samples mean deliquification rate is expected on expression:

$$\overline{V} = m_{m0} / T , \quad (3)$$

where $\overline{V}$ - mean deliquification rate, g/day; T - first passage time of a room air-dry mass m_d, days. Both and this ecological parameter also characterizes mean rate of water retention by sample, however term «deliquification rate of needle sample» is more preferential. The derivative from the formula (2) will give a variable plant deliquification rate.

In table 1 the significances of mean deliquification rate $\overline{V}$ of needle samples collected from cut ramule from all accountable fir-trees are represented.

In tab. 1 there are lines. They mean that there are no breathful limbs on accountable fir-trees № 2 and № 3 on urban compartment № 2 from the southern cardinal direction. Also in table 1 it is possible to note, that some fir-trees growing in Yoshkar-Ola, have pronounced differences in significances of mean deliquification rate of needle samples (for example, trees on a urban compartment № 2). It happens that the indicated accountable trees in the present geodesic directions densely are closed by limbs of adjacent trees.

In a fig. 3 the graph, on which mean deliquification rates of needle samples from accountable fir-trees from northern cardinal direction on an urban compartment № 3 are shown, is represented. Besides the trees on the present sample area by the northern direction are situated near an auto-road, and are disposed in a line in proportion to increase of distance from intersection with intensive automobile movement. Numbers of trees are accepted in proportion to increase of distance from intersection. As it is visible from points in a fig. 3, the significance of deliquification rate for fir-trees from northern cardinal direction on a urban compartment № 3 reaches maximum significance on some distance from intersection with intensive automobile movement and further again decrease.

Therefore point of maximum concentration of pollutants also is situated on some distance from extremity of an auto-road.

Table 1. Mean deliquification rate by needle samples from cut fir-tree ramules

Tree number	North	East	South	West
Forest compartment				
1	0,026	0,014	0,034	0,026
2	0,019	0,024	0,030	0,022
3	0,013	0,011	0,020	0,019
4	0,020	0,022	0,025	0,010
Urban compartment № 1				
1	0,170	0,086	0,164	0,115
2	0,087	0,070	0,153	0,140
3	0,030	0,053	0,058	0,051
4	0,048	0,073	0,072	0,046
Urban compartment № 2				
1	0,091	0,100	0,046	0,066
2	0,062	0,087	-	0,081
3	0,062	0,170	-	0,069
4	0,033	0,042	0,123	0,083
Urban compartment № 3				
1	0,058	0,030	0,077	0,064
2	0,111	0,066	0,052	0,110
3	0,033	0,057	0,048	0,050
4	0,020	0,059	0,055	0,055

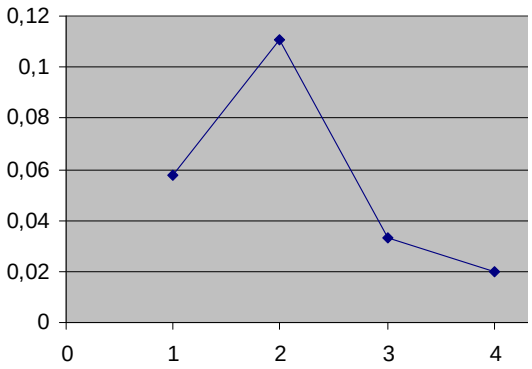

Fig. 3. Dynamics of mean deliquification rate for needle samples from northern cardinal direction of fir-trees on a urban compartment № 3

During analysis of the obtained significances of mean deliquification rate of needle samples on a t-Student′s test for want of 5-percentage significance the substantial differences for different sample compartments were revealed. Results of a comparison show that the significances of deliquification rate are essentially differ for needle samples of ramules cut from different accountable fir-trees.

On the basis of experiment results it is possible to make following conclusions:

1) The parameter of a mean deliquification rate can be applied for an ecological evaluation of pollutant effects on an environment because of a high sensitivity of needle samples to deliquification after snipping of ramules from fir-tree verticils;

2) The maximum significance of deliquification rate of needle samples collected from accountable fir-trees, is on some distance from a traffic intersection, that it is possible to use for an evaluation of emission status from automobile transportation, therefore it is necessary to put in experiments the parameter of distance from extremity of an auto-road;

2) By dint of a mean deliquification rate for needle samples from accountable fir-trees it is possible to reveal ecological conditions of forest and urban fir-tree growth.

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