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The mesostructure of the photosyntetic cell system of the picea ajanensis ((Lindl. Et Gord.) Fisch ex Carr.) to an action of drought and shade in the pot experiment as simulated conditions

Keywords*: coniferous, mesophyll, adaptation, photosynthesis.*

Annotation*: This paper has to presents the results of investigation of the influence of stress factors. Soil drought and shade are to exert influence on the production and the structural and functional characteristics of Picea ajanensis needles. The action of stress factors is a cause significant of adaptive adjustment of the photosynthetic apparatus Ajan spruce, providing cost-effective use of limited resources, light and moisture. In the process of adaptive rearrangements in conditions of drought photosynthetic apparatus has formed the xeromorphic type with high potential assimilation abilities, that is contributed to the successful adaptation to the action drought.*

Introduction

Picea ajanensis is the dominating breed of the Primorye region on the Far East Russia. The woods dark coniferous forests are formed by this breed have the big extent of an area: from noth-east borders of the euro-Asian continent to islands of Japan and Korea (Манько, 1987).

Features of ecology of a fur-tree is high moisture and shade tolerance in valley habitats on rehumidified, low dewater soils. The wide area of habitats of a picea ajanensis fur-tree should affect is adaptive plasticity, however limits of tolerance and mechanisms of adaptation of this fur-tree to action stressfactors remain poorly studied.

Experiences on cultivation of 3-5 years plants at the various lighting has made of the Russian researcher, it has shown, that a strong shade (10 % from full illumination) operates adversely on development young trees, and lead to the high of plants decease.

In ekologo-physiological researches of the P. ajanensis, which made to the Primorye Territory, decrease in photosynthesis and efficiency of needles under wood bed curtains is defined at light exposure of 10 % from greatest possible (Чернышев, 1973). To the contrary, on cuttings down the needles hiest lengths and width are formed a increases of the density stomatal (Вернигора 2002, 2008), diameter of pitch courses, raises photosynthesis (Ворошилова, 1977; Базунова, 1977; Базунова, etc., 1977). In Kalinichenko's works (Калиниченко, 1977) there is shown, that the P. ajanensis is capable is long to transfer a soil drought at high humidity of air. In works of Chernishev the effect «negative transpiration» for the given kind is described, growing in mountains Sihote-alin reserve (Чернышев, Коляда, 1982, Чернышев, 1995), allowing plants to worry modes of a soil drought. In the conditions of vegetative experience at 50 % decrease watering action of a soil drought causes to decrease

in growth of top runaways, photosynthetic efficiency of needles, the chlorophyll maintenance (Козина, etc., 2011; Титова, Козина, 2008).

A number of authors suggests were to use anatomic characteristics as tests at selection of plants on stability to action to various ecological factors (Цельникер, 1978; Мокроносов), equally, as well as for an ecological estimation of comfort of habitats in situ (Бурундукова, etc., 2008; Хроленко и др, 2012).

It is known, that the method of the mezostructures analysis, developed by the academic A.T. Mokronosov (Мокроносов, 1978) allows is to receive the detailed information on structural adaptation. Parametres of mesostructure of sheet are closely connected with its photosynthetic activity, direct correlation of the total area of membranes of cages and green plastid with intensity of assimilation CO_2 (Nobel &Walker, 1985; Patton and Jones, 1989).

Influence of ecological factors on mesostructure of the photosynthetic device of grassy and deciduous wood plants is in detail investigated by authors (Мокроносов, 1978; Горышина, 1989; Цельникер, 1978) in their works it is shown specificity of structurally functional mesophyll reorganizations in depends on illumination, temperature, humidity. Adaptation in "stressful" and "physiological" ranges of action of the ecological factor has an opposite orientation: reduction of intensity of highlight in borders of a "physiological" range conducts to increase in the area of leaves, the sizes of chloroplast, to the chlorophyll maintenance - as a result, to increase in efficiency of use of highlight at photosynthesis and homeostasis preservation producing capacity. In a "stressful" range reaction of plants is directed on a survival and an exit from under actions the stressfactor - there is a reduction of the area of leaves, the sizes of cages and chloroplasts, decrease in the expense of organic substance on growth of leaves and strong distension a stalk (Цельникер, 1978). Literary data on mesostructure of Far East coniferous are individual and single.

The work problem included studying of structural adaptation of the photosynthetic device of saplings shade-tolerant watermesophyte of Picea ajanensis at action-shade and a soil drought in the conditions of vegetative experience.

Material and methods

Vegetative experience has been put in pawn in the beginning of May (08.05.09) in the conditions of a summer hothouse on Gornotajeznaja stations (mauntain-taiga station) of Far East Branch of the Russian Academy of Sciences under a film covering. Objects of researches ate 3-4 years Picea ajanensis. Plants grew up in identical ditches on volume in soil culture. The soil was wood brown gleization, was taken in territory of a accumbent forest a biological research station. Initial humidity soil of 65-70 % from a full moisture was capacity. Vegetative experience spent from May till september by two variants of experience: 1- the soil drought, 2- the shading and the control. The soil drought was created by decrease watering 50 %; light exposure decrease have executed a shading saplings 50-70 % from the control.

The period of a soil drought made 70 days, including 20 days without water in August, duration off saplings - 75 of days in active vegetation. On termination of growth of runaways and needles defined indicators of mesostructure both the photosynthetic device.

The mesostructure of the photosynthetic device is defined according of autors works (Мокроносов, Борзенкова, 1978; Горышина, 1989). Needles from three plants of each

variant of experience fixed in the 3,5 % glutaraldehyde water on the phosphatic buffer (pH 7.0).

Quantity chloroplast calculation in cages mesophyll, measurement of their sizes spent in microphotos crush preparations on light microscope Zeiss Axioskop-40 with chamber ZeissAxioCam (HRs) and package AxioVision ver. 4.8.3. The maseration tissues for measurement of the chloroplast sizes prepared on a water bath short-term heating (15-20 min.) needles in 5 % th solution chrome oxide (6) in 1N HCL at temperature-60-70^{0}C. Calculation of quantity of cages in unit of the area of sheet spent in Gorjaev's chamber, from maseration tissues about 10 needles the known area, which maserated in the water 50 % NaOH at short-term boiling.

For scoping and a surface of cages mesophyll picea ajanensis used following formulas. Settlement characteristics - an index of membranes of cell (IMC) and an index of membranes chloroplasts (IMCh), (CCCh) – a cellular capacity (volume) of chloroplasts follows:

IMC=N (cell) *S (cell), where N (cell)-number of cell in unit of the area of sheet, S (cell) - the area of a surface of mesophyll cell;

IMCh = N (chloroplasts) *S (chloroplasts), where N is the chloroplasts quantum in unit of the sheet area, S - the surface area chloroplasts;

CCCh=V/n, where V - capacity of chloroplasts, n – chloroplasts amount in a cell.

Reliability of distinctions between experience variants has estimated by criterion - the criterion Manna-Uitni. The statistical analysis has executed spent using package Statistica ver. 10.

Results and discussion

In table 1 data under characteristics of mesostructure of needles an undergrowth in the simulated conditions of a soil drought and artificial shade are cited.

Table 1.

Mesostructure characteristics of needles Picea ajanensis in the stress conditions.

Characteristics	The control	The shade	The drought
The area of needle, sm^2	1,51	1,36	2,08
The area projection of needles, sm^2	1,11±0,15	0,731±0,10	1,19±0,11
The quantity of cell, N $10^3/sm^2$	268,51±21	219,79±12	329,71±27
The volume of cell, μm^3 10^3	60,7±6,0	43,5±4,0	20,5±3,3
The cell area, μm^2 10^3	7,1±0,6	5,5±0,6	3,1±0,3
The chloroplasts quantity in cell, pcs	79,2±5,2	56,6±4,0	60,6±5,3
The chloroplasts quantity on area unit, pcs $10^6/sm^2$	1,77±0,3	2,51±0,7	4,43±0,8
The chloroplasts quantity on area needle, pcs 10^6	2,67	3,41	9,21
Volume chloroplast, μm^3	28,5±0,9	24,9±1,2	33,7±0,9
The area chloroplast, μm^2	45±1	50±1	2,6±0,6
IMC, sm^2/sm^2	21,9±3,3	15,9±1,9	24,9±1,0
IMCh, sm^2/sm^2	11,0±2,2	8,1±1,5	41±1
CCCh, μm^3	766±139	768±168	9,6±1,7

The conditions of a soil drought we observed essential reduction of the sizes of mesophyll cell and increase in their quantity counting on unit of the area of a projection of needles. It has led to reduction of the area internal assimilation reduced a mesophyll surface (IMC). Plants of a shade, also, authentically differed from the control smaller number of green plastids in a cage and the size IMCh characterising volume of a cage corresponding one chloroplast. The soil drought suppresses chloroplastogenesis on the scale of a cage, but, in a consequence, structurally functional is reorganisations of mesofyll fabrics (reduction of volume of cages and has increased their quantities in unit of the area of sheet), there is a compensatory alignment of chloroplast number and sizes of a total surface of chloroplast membranes (IMCh) counting on unit of the area of a projection of needls in the control and in the conditions of a soil drought.

Observable structural reorganisations testify that in the conditions of a soil drought element of mesostructure of the photosynthetic device of the xeromorphic type are formed. From A.T.Mokronosov's works (Мокроносов, 1981) it is known, that adaptation of photosynthesis to action of factors of an environment is carried out on means of system structural and functional reorganisations at different levels of the organisation of the photosynthetic device. Thus it is known, that degree of a variation of signs appears that above, than above structural level of photosynthetic system. Structures of low usages (chloroplast, photosynthetic unit) are differ higher stability, than structures of higher order (sheet mesostructure, a plant, cenosis). We observed similar results in our experience. In the conditions of a soil drought at a young P. ajanensis tree the sizes of chloroplasts have changed slightly while the size of cages has decreased in 3 times, the size of indexes IMCh and CCCh has gone down in 2-2,5 times. Water deficiency is strongly suppresses a stretching of cages, parvicellular is the reason of

increase in number of cages on unit of the area of sheet, thus quantity of green plasted on unit of the area of sheet in the variant shade does not change, remains at the same level, as well as in the control that testifies to ability of a fur-tree to form in the conditions of a soil drought photosynthetic the device with high photosynthetic abilities (Tab. 3). Earlier similar paradoxical fact has been noted in the experiences spent on a potato. It has been shown, that at oppressed of water deficiency of plants amount chloroplasts on unit of the area of sheet and potential photosynthetic activity of sheet was even essentially above, than at optimum watering (Мокроносов, 1981).

In the shade stress has caused reduction in 1,5 times of length needle, reduction of chloroplasts number in a cage in 1,4, and increase in their volume. Decrease in volume of the cell and IMC at shade conditions has occurred to a lesser degree, than at action of a soil drought. The general number of chloroplasts calculated on one needle has decreased in 2,8 times in the variant 2, while in the variant 1, practically has not changed. In the shade conditions sciomorphic lines of needles mesostructure of a seedling P. ajanensis were amplify, but quantitative changes of parametres of cages are expressed to a lesser degree, than at action of a soil drought.

Light is the leading factor in formation of the photosynthetic device. The shade resistance plants have a specific sciomorphic structure of sheet allowing effectively using of headlights of low intensity. Sciomorphic lines are in detail investigated at grassy plants and deciduous trees. They include following signs are a thin sheet plate, the large cell of mesophyll and small chloroplasts concentration in a cell and sheet, large chloroplasts (Горышина, 1989).

Plants of different functional types have similar reaction for shade mesophyll, which is expressed in decrease in integrated parametres - the general surface of cell and green plastids, but thus degree and structural mechanisms of these changes essentially differ. So at representatives for pattern competition type of ecological strategy (S-type) change of conditions of growth in lagest degrees influences change of quantity of cell, while at plants with stress-tolerant (S-strategists) type of ecological strategy on change of their sizes. According to classification of Grime for the trees for competitive type of ecological strategy is characteristic. Naturally to expect, that the tree Picea ajanensis are acclimation should pass as S-strategists. Specificity of adaptation of shade resistance saplings and photophilous deciduous trees is in detail investigated in J. Tselniker's work, in a wide range of conditions of consecration (variants: 0,5 %, 4 %, 8 %, 18 %, 50 %, 90 % from light exposure on an open place.). Comparison of mesostructure characteristics of sheet of a P. ajanensis saplings, observed in the control with literary data on mesostructure of leaves of shade fastness saplings and photophilous kinds of trees in the conditions of 50-90 % of light exposure from the maximum has revealed essential distinctions in mesostructure of needles and leaves. First of all, it was a concerns the sizes and quantity of mesophyll cell: cell quantity of mesophyll counting on unit of the area of sheet at a little-tree of experiment Pices more low in 40 times than at shade resistans, and it was in 80 times than at photophilous deciduous kinds. The cell volume was at 15-20 times more, number of chloroplasts was in the cell 2,5 -3 times above. Distinctions in plastids structure the device are less expressed such characteristics as: volume, number of chloroplasts on unit of the sheet area, indexes IMCh & CCCh neighbours with

shade resistant saplings deciduous breeds had similar characteristics. Reaction on the shade was similar also.

In our experience with a tree of light exposure in the control have made 47 - 70%, and in a variant with shade prepared 11-20 % from full solar illumination. The shade has provided light exposure decrease in a variant 2 approximately in 5 times and has led to suppression of cell fission and chloroplast reconstitution, number of chloroplasts in a cell and sizes of indexes IMC and IMCh have decreased in 1,3-1,5 times. In experiences (Цельникер, 1987) at illumination decrease in limits of "a physiological range" from 90 % to 18 % from light exposure on an open place observed similar quantitative reorganisations of mesostructure of lighted. So at light resistant breeds at light exposure decrease on the average in 5 times size of indexes IMC and IMCh were to decrease in 2-2,5 times, and at shade resistant plants in ready smaller degree - in 1,3-1,5 times, as well as in our experiences with a P. ajanensis. Hence, the degree reaction of resistant shade plants deciduous and coniferous C-strategists essentially differ from photophilous C-strategists. Naturally to expect, that experiment trees acclimation should pass as S-strategists, that is in general and observed during experiment, thus it is necessary to note and elements S-strategists - reduction of volume mesophyll cell and the chloroplast quantities in a cell, increase in the sizes of chloroplasts. Probably, that adaptation of the photosynthetic device of a research tree is a relic kind occurs on compound C-S to type.

For shade persistent plants deciduous breeds transition from a "physiological" condition to "stressful" comes at intensity of headlight of 4-5 % then the chloroplasts number in unit of the area of sheet decreases to 11-15 million (Цельникер, 1987). Mesostructure indicators in experience with shade for objects P. ajanensis come nearer, but do not reach sizes of a "stressful" range, the number of chloroplasts counting on unit of the area of a projection of needles in the shade variant makes-16,2 million.

Thus, action stressfull factors of water deficiency and shade are caused by essential adaptive reorganisations of the photosynthetic device of fog, there are providing economic use of the limited resources of light and a moisture. Character of structurally functional reorganisations and level of reaction of the P. ajanensis young-tree on shade is not typical for the C-strategist as has lines as competitive and stress-tolerant of strategy, can be defined, how intermediate a C-S variant. The low values of indexes IMC and IMCh in shade conditions are authenticated about approximation to approach to "a stressful range" light exposure and consequently weak rehabilitation ability of the shaded saplings. Less rigid influence of a drought on a youg-tree of picea ajanensis is revealed. In the course of adaptive reorganisations in the conditions of a soil drought the photosynthetic device of xeromorphic type with high potential with the anabolism abilities, which have provided successful rehabilitation at removal of stress action is picked.

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