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DYNAMICS OF METABOLIC CHANGES IN LEAVES OF ABORIGINAL AND INTRODUCED SPECIES OF THE GENUS *QUERCUS* L. IN CULTURE OF DNIPRO CITY BOTANICAL GARDEN

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Features of dynamics of the soluble proteins content and catalase activity in leaves of six species of the oaks-introducents cultivated in a botanical garden of Dnipro city in comparison with a indigenous species of pedunculate oak (*Quercus robur* L.) are investigated during vegetative period. Distinctions in speed of proteins accumulation, catalase activity among investigated species of introducents and in comparison with *Quercus robur* L. has been established as well. It is revealed that species of the Oak genus introduced in the steppe zone of Ukraine adapt to transferring of unfavourable conditions of droughty summer by similar biochemical reorganizations, but at expressed individual reaction of each studied kind of an oak is distinguished.

Introduction, *Quercus robur* L., *Quercus rubra* Du Roi., *Quercus dentata* Thunb., *Quercus castaneifolia* C.A.M., *Quercus petraea* Liebl., *Quercus macranthera* Fisch. et Mey., leaves, *light-soluble proteins, catalase activity*

Species of the genus *Quercus* L. are concerned to be one of the finest wood, are very important forest-forming cultures, possess high decorative quality and are widely used in planting of greenery in settlements [2, 3, 5]. The pedunculate oak is a native species in flora of the steppe zone of Ukraine and possesses good frost- and drought-resistance, but at the same time it growth is very slowly and is infested by mealy dew and green oak roller moth [6]. Therefore expansion of wood plants assortment at the expense of introduction of other species of oaks with higher economic-significant and decorative properties is actual [1]. The greatest part of alien crops which are used in the conditions of an open ground in Ukraine, originate from East Asia, the Caucasus and the North America. At the same time mechanisms of their stability in the conditions of the steppe zone of Ukraine are studied insufficiently except some works [8–10].

The aim of this work is to study metabolic features in leaves of different introduced species of the Oak genus in the vegetative period in the steppe zone of Ukraine.

Materials and methods

The object of a research are leaves of six species of oaks from a collection of a botanical garden of Oles Honchar Dnipropetrovsk National University (DNU): *Quercus robur* L. – pedunculate oak, *Quercus rubra* L. – red oak, *Quercus dentata* Thunb. – dentate oak, *Quercus castaneifolia* C.A.M. – chestnut-leaved oak, *Quercus petraea* Liebl. – sessile oak, *Quercus macranthera* Fisch. et Mey. – largely-anther oak. Samplings of leaves of oaks were collected in June, July and September, 2015.

Antioxidant enzyme activity and content of lightly-soluble proteins were determined in the supernatants obtained by centrifugation (7,000 g for 20 min at 4 °C) of crude extracts (100 mg of fresh leaves homogenized with 0,1 M TRIS-HCl buffer, pH 7.4 contained 0,1 % polyvinylpyrrolidone, 250 mM saccharose, and 1 mM $MgCl_2$). Catalase (CAT) activity was evaluated according to Goth [12] by measurement at 410 nm of optical density of reactive mixture containing 0,2 ml sample, 0,1 % H_2O_2, and 4 % ammonium molibdate. The result was calculated through the calibration graph and expressed in mM H_2O_2/g FW. The content of lightly-soluble proteins (LSP) was determined according to Bradford [11]. All determinations of the biochemical parameters characterizing the oak leaves required five replicates. Data representation means values and standard deviations (±SD). The differences were considered as statistically significant at $P<0,05$.

Results and discussion

Among the oaks concerning six species, none has revealed signs of oppression, plants are characterised by normal vegetative growth with the exception of *Q. castaneifolia* at which slight freezing of branches was observed.

Ecological features of oaks which grow in conditions of a collection of a botanical garden of Dnipro National University, are presented at table 1.

Table 1 – The stability of different species of oaks in the conditions of a botanical garden

Oaks species	Drought-stability	Frost-stability
East and North Europe		
Q. robur L.	drought-stable	very frost-stable
Quercus petraea Liebl.	very drought-stable	sufficiently frost-stable
The Caucasus		
Q. castaneifolia C.A.M.	drought-stable	insufficiently frost-stable
Q. macranthera Fisch. et Mey	drought-stable	frost-stable
East Asia		
Q. dentata Thunb.	insufficiently drought-stable	sufficiently frost-stable
North America		
Q. rubra L.	drought-stable	very frost-stable

The level of drought resistance of oaks is possible to arrange in such order: *Q. petrea = Q. castaneifolia > Q. robur = Q. macranthera > Q. rubra > Q. dentata*, and according to the winter hardiness level the order is following: *Q. robur = Q. rubra > Q. macranthera > Q. petrea = Q. dentata > Q. castaneifolia.* Thus, the most drought-resistant are sessile and chestnut-leaved oaks, and drought-unsteady – dentate oak. Pedunculate and red oaks are frost-steady, and chestnut-leaved oak is unstable.

As it is generally known, proteins play significant role in growth processes and for the adaptation to unfavourable factors of environment including low winter and high summer temperatures [4, 7, 14]. As the analysis of data shows, the peak of the protein content in leaves of all studied oaks falls by July, level of it fluctuated in limits from 0,45 (red oak) to 0,79 % (pedunculate oak) (table 2).

Table 2 – Change of the lightly-soluble proteins content in leaves of different species of oaks in the vegetative period

Oaks species	The content of proteins, %		
	june	july	september
Quercus petraea Liebl.	0,43 ± 0,009	0,61 ± 0,035	0,17 ± 0,010
Q. castaneifolia C.A.M.	0,34 ± 0,007	0,55 ± 0,008	0,17 ± 0,006
Q. macranthera Fisch. et Mey	0,15 ± 0,019	0,61 ± 0,017	0,18 ± 0,014
Q. robur L.	0,36 ± 0,006	0,79 ± 0,045	0,13 ± 0,002
Q. rubra L.	0,34 ± 0,007	0,45 ± 0,016	0,09 ± 0,017
Q. dentata Thunb.	0,31 ± 0,005	0,62 ± 0,007	0,20 ± 0,009

The differences in the content of light-soluble proteins in June was marked in comparison with a native species (*Q. robur* L.), as the most adapted for local conditions: two species (red and chestnut-leaved oaks) have shown insignificant decrease in this indicator (on 5,6 %), *Q. macranthera* and *Q. dentata* – more essential (on 58,3 and 13,9 %).

The lowered content of protein in leaves in comparison with an pedunculate oak during the most droughty period of plants growth was marked at all introduced species in July. The level of LSP decrease varied depending on an oak species in limits from 21,5 (*Q. dentata*) to 43 % (*Q. rubra*). The raised content of proteins in September have shown practically in all introduced species, except red oak, and, especially, *Q.dentata* in which increase of LSP is fixed on 53,9 %. Decrease in level of proteins (on 30,8 %) in leaves of red oak is registered unlike in other species.

Rates of accumulation/disintegration of proteins in leaves of the studied species essentially differed during the different periods of growth and development of plants. Thus, the increase of protein from June to July in species with very high drought resistance was at level 40 (ordinary oak) and 62 % (red oak) while the sharp increase of this indicator (by 4,1 times) was marked in leaves of largely-anther oak. Reduction of the protein content by September at these species was approximately identical (by 3,2–3,6 times).

A little bit another principle is registered for species with average drought resistance (pedunculate and red oaks) in which the content of proteins raised in the first phase by 2,2 and 1,3 times correspondingly, and reduction of LSP content in a phase of preparation for the autumn-

winter period occurred most sharply: by 6,1 and 5,0 times correspondingly. Speed of accumulation and desintegration of proteins in leaves of *Q. dentata*, as unstable to droughty conditions, differed from other species. Thus, during the first period protein level raised by 2,0 times (approximately as in oaks with average stability), and in the second – by 3,1 times (as in oaks with high stability to a drought).

Catalase is one of the most active enzymes, wich regulates the content of hydrogen peroxide in plants, preventing its toxic action, and also plays an important role in processes of ageing [13]. Dynamics of catalase activity in leaves of the studied oaks was characterized by increase of indicators in July almost in all species, except *Q. dentata* and *Q. castaneifolia* in which the activity peak was observed in June (table 3).

Table 3 – Activity changes of catalase in leaves of different kinds of oaks during the process of vegetation

Species of oaks	Catalase activity, мМ H_2O_2 /g FW		
	june	july	september
Quercus petraea Liebl.	0,85 ± 0,004	1,12 ± 0,021	0,11 ± 0,02
Q. castaneifolia C.A.M.	1,75 ± 0,037	1,27 ± 0,010	0,14 ± 0,04
Q. macranthera Fisch. et Mey	0,30 ± 0,038	1,12 ± 0,013	0,17 ± 0,02
Q. robur L.	0,23 ± 0,007	0,86 ± 0,008	0,25 ± 0,05
Q. rubra L.	1,06 ± 0,013	1,53 ± 0,004	0,14 ± 0,01
Q. dentata Thunb.	1,76 ± 0,015	1,11 ± 0,014	0,64 ± 0,02

The analysis of data shows, that in June and July activity of a native species was the least in comparison with its greatest activity in June inherent to *Q. castaneifolia and Q. dentata* (by 7,6 and 7,7 times correspondingly, than to *Q. robur*).

In July this difference decreased, but nevertheless remained high enough: from 30 to 80 % correspondingly, than for the native species. By September sharp decrease in activity of enzyme in all species, except *Q. dentata*, in which this indicator in comparison with ordinary oak has been raised by 2,6 times, is registered. The decrease of enzyme activity in all other oaks in comparison with a local species was up to standard of 32–56 %.

The analysis of the received data shows, that practically in all investigated species of oaks catalase activity changes in the process of

ontogenesis: smaller activity in June is replaced by higher in July, and in the end of vegetation there is its essential falling. *Q. castaneifolia* and *Q. dentata* show an exception: gradual decrease in activity of enzyme from June by September was observed.

Thus, species of the Oak genus introduced in the steppe zone of Ukraine, adapt for transferring of droughty conditions in summer in the same way, as a local species *Q. robur*, similar biochemichal reorganizations in which concern dynamics of the protein content and activity of antioxidant enzyme – catalase concerns, and also peroxidase [10] but with the expressed individual reaction of each studied species of oaks. It can be the certain proof of adaptedness of introduced species of oaks to the conditions of the droughty period of the steppe zone of Ukraine. At the same time the increase in the protein content and catalase activity is noticed at such species as *Q. castaneifolia* and *Q. dentata* in September that it is possible to consider as the undesirable fact as higher late metabolic activity can reduce success of preparation of plants to the autumn-winter period.

Conclusions

1. Indicators of the content of soluble proteins in leaves of introduced oaks testify their smaller synthesis in comparison with *Q. robur* L. in a phase of active growth and development of plants (except of sessile oak at which higher protein content was marked in leaves in June). The preparation of introduced species to the autumn-winter period was characterised by a higher accumulation of soluble proteins in leaves in comparison with a local species, except of red oak.

2. It has been established that catalase activity changes in the process of vegetation in all investigated species of oaks: smaller activity in June is replaced by higher in July, and in the end of vegetation there is its essential falling. The gradual decrease in activity of enzyme from June to September was observed in leaves of *Q. castaneifolia and Q. dentata*.

3. It has been shown that the protein content increases and catalase activity at leaves of such species as chestnut-leaved and dentate oaks is noticed in September that it is possible to consider this as the undesirable fact as higher late metabolic activity can reduce success of preparation of plants to the automn-winter period.

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