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Kornilyev G.V., Paliy A.Ye., Rabotyagov V.D., Feskov S.A. Biologically active substances of aqueous-ethanolic extract of *Tagetes signata* Bartl. № 13152-8 'Vetvisty' specimen of Nikita Botanical Gardens collection // Bull. of the State Nikit. Botan. Gard. – 2016. – № 118. – P. 39-45.

The qualitative and quantitative composition of *Tagetes signata* Bartl. № 13152-8 'Vetvisty' specimen was investigated in terms of the research. It was established that among volatile substances there were aromatic (59%; p- vinylguaiacol prevails), aliphatic (23,7 %) and monoterpenoide (tagetenon content is 17,3%) compounds. Phenolic compounds were presented by flavonoids and their glycosides (rutin, quercetin-3-O-galactoside, quercetin-3-O-glycoside), and hydroxycinnamic acids (caffeic, ferulic). The ascorbic acid (14,54) and carotenoids (5,19 mg/100 g) were identified as well. On the whole, the specimen *T. signata* № 13152-8 "Vetvisty" can be considered as a sources of biologically active substances such as p- vinylguaiacol, flavonoid glycosides, ascorbic acid and carotenoids.

Key words: *Tagetes signata* Bartl.*; specimens; aqueous-ethanolic extract; volatile substances; phenolic substances; vitamins.*

PHYTOMONITORING

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LOWER LAYER ORNAMENTAL PLANTS OF ARBORETUM IN NIKITA BOTANICAL GARDENS AND THEIR GROWTH AND STATUS DEPENDING ON ILLUMINATION CONDITIONS

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Introduction

Investigation of shade tolerance of ornamental plants, peculiarities of their light conditions plays a big role for matching of cultivars and crop combinations projecting ladscape compositions. Shade-tolerant plants have wide ecological amplitude; concerning light, good illumination favors their better growth, but at the same time they adapt to weak light easily. As a rule they are divided into more and less shadow-tolerant. Those trees and bushes that grow on open areas and don`t stand continuous shade can be classified as less shadow tolerant (light-requiring) arboreal crops. Photosynthesis gets the highest point if good sun illumination. This group includes: birch, willow, larch, aspen, walnut, locust, pine, ash. More shadow tolerant arboreal plants are presented by trees and bushes standing some shadow, but intensively growing under conditions of good illumination: box tree (*Buxus),* arrowwood *(Viburnum), Euonymus Japonicus,* cherry laurel, Japan laurel (*Aucuba japonica*),

hazel (*Corylus)* and etc. [3, 7]. Lower layer plants should be studied especially, as they grow under conditions of microclimate, created by environment. That`s why expansion of species and form composition of arboreal and shrub plants in landscaping projecting long-term green plantations, resistant to abiotical and biotical factors is an urgent and rather important problem.

In this way the study purpose was to investigate state and growth of ornamental plants from lower layer allowing for illumination to mark out species, promising for landscaping on South coast of the Crimea.

Objects and methods of the research

Researches were carried out in Upper and Lower Arboretum of Nikita Botanical Gardens (NBG). Seven species of ornamental plants with individual characteristics of water regime, drought-resistance and shadow tolerance were chosen as model objects for investigations: *Pittosporum heterophyllum* Franch. (питтоспорум разнолистный), *Buxus sempervirens* L., *Euonymus japonica* Thunb., *Chimonanthus praecox* (L.) Link, *Viburnum tinus* L., *Cornus mas* L., *Laurocerasus officinalis* M. Roem. Principal phenological development phases of study cases are different (table 1). Table 1 revealed that *Euonymus japonica* Thunb., *Chimonanthus praecox* (L.), *Cornus mas* L. started the earliest vegetation (vegetative budding) – the 1st decade of February – the 2nd decade of March.

Table 1

Development phenophases of some ornamental plants in NBG-NSC gardens

Cultivar	Vegetative start (vegetative budding)	Blooming		Growth termination (crown bud setting)
		start	finish	
Eunymus japonica Thunb.	1st d. of February – the 2nd d. of March	3rd d. of June – 1st d. of July	2nd d. of July	2nd d. of June
Chimonanthus praecox (L.) Link	1st d. of February – 2nd d. of March	3rd d. of November – 1st d. of December	1st d. of January	1st d. of June – 1st d. of July
Viburnum tinus L.	1st d. of March – the 1st d. of April	3rd d. of March	3rd d. of April – 1st d. of May	2nd d. of July – 1st d. of August
Cornus mas L.	1st d. of February – the 2nd d. of March	1st d. of March	2nd d. of April	3rd d. of June – 1st d. of July
Laurocerasus officinalis M. Roem.	1st d. of April – the 2nd d. of May	1st d. of April – 2nd d. of May	3rd d. of April – 2nd d. of May	3rd d. of May – 3rd d. of June
Pittosporum heterophyllum Franch.	1st d. of April	1st d. of May	3rd d. of May	1st d. of June – 3rd d. of July
Buxus sempervirens L.	1st d. of March – 1st d. of April	3rd d. of March	2-3rd d. of April	2nd d. of May
Notes: d. - decade				

Laurocerasus officinalis M. Roem. presented the latest vegetation. *Viburnum tinus* L., *Buxus sempervirens* L., *Pittosporum heterophyllum* Franch. took intermediate place. Therefore, study cases covered almost the whole vegetative period, which continues 210 days on South Coast of the Crimea (SCC).

Early growth termination was fixed for *Buxus sempervirens* L. (setting of the crown bud was determine factor) – 2nd decade of May. A bit later *Laurocerasus officinalis* M. Roem. and Eunymus japonica Thunb. finished their growth (the end of May – June). *Chimonanthus praecox* (L.) Link., *Pittosporum heterophyllum* Franch. and *Cornus mas* L.

growth termination happened in June-July. *Viburnum tinus* L. formed its crown bud in the 1st decade of August.

Ornamentality is mainly rated by terms and duration of blossoming if landscape compositions. Among study cases *Cornus mas* L., *Viburnum tinus* L., *Pittosporum heterophyllum* Franch. and *Chimonanthus praecox* (L.) Link revealed the most continuous blooming period (more than a month). Plants of the rest cultivars were blossoming not so long (2-3 weeks). Blooming period of study cases covered rather continuous period since November till December - *Chimonanthus praecox* (L.) Link , up to July - Eunymus japonica Thunb. Majority of cultivars were in blossom in March-May.

Most study cases of the lower layer (besides *Chimonanthus praecox* (L.) Link) grow in Upper park of NBG Arboretum (145-165 m above the sea level), *Chimonanthus praecox* (L.) Link locates in Lower park (115 m above the sea level). Microclimate of study areas is various [5]. Allowing for illumination factor they can be classified into three groups: 1st group of plants grows under shadowed conditions during entire ontogenesis (under coniferous exots), the second – on shadowed land during active vegetation in frost-free season (under foliage trees), and the 3rd group – on rather open areas. The first group included:

- *Pittosporum heterophyllum* Franch. – evergreen ornamental bush with common leathery nitid leaves, grows under *Atlas cedar* crown, 1 m from the stem;
- *Buxus sempervirens* L. – evergreen ornamental bush, locates within shared projective cover of *Atlas cedar*, *Laurus nobilis* and equally spaced with their stems, 2,5m.
- *Chimonanthus praecox* (L.) Link – ornamental bush, blooms in winter, oblong-elliptic leaves fall in winter. It grows under *Cupressus macrocarpa* crown (3,5 m from its stem).

The second group of plants locates under crown of deciduous trees:

- *Eunymus japonica* Thunb. – valuable ornamental evergreen plant, grows under *Laburnum anagyroides* (1 m from the stem);
- *Viburnum tinus* L. – evergreen bush with middle-sized nitid and green leaves and corymbs of white flowers, grows in undercrown space, created by *Circassian walnut* and *Gleditschia triacanthos*, spaced from tree stems 1 and 2,5 m.
- *Laurocerasus officinalis* M. Roem. is a bush with common leathery evergreen leaves, from south, west and north-west surrounded by three trees of *Tilia cordata* spaced from the stems 3,5-4,5 m, while from north it is shadowed by outlying part of *Aesculus glabra* (buck-eye) crown;
- *Cornus* mas L. is a deciduous bush, growing under shadowed conditions [4].

The third group consists of plants belonging to cultivars mentioned above, but not subjected to shadowed conditions of growing.

Studying one-year amount of study cases growth was carried out applying methodic of phenological tree and bush observation [6]. Plant state was determined according technical inventory instruction of green plantations [7]. Light stream was measured by Yu-116 luxmeter allowing for recommendations by V.A. Alekseyev – having total illuminance during midday hours and minimum wind velocity [1].

Results and discussion

Growth investigation of chosen genotype revealed middle length of shoot for plants being under well (enough)-illuminated conditions, that is *Eunymus japonica* Thunb. and *Chimonanthus praecox* (L.) Link (16,5 and 18,8sm respectively), so they are the most intensively growing among study cases (table 2).

Table 2

One-year shoot length as an indicator of shadow tolerance and plant state depending upon growth conditions (2014-2015)

Cultivar	Illumination conditions	Plant state	Middle length of shoot, sm	Shoot being under shadowed conditions, sm	Shadow tolerance indicator
1	2	3	4	5	6
Eunymus japonica Thunb.	illuminated	good	16,5±0,8	10,2	0,38
	shadowed	satisfied	6,3±0,4		
Chimonanthus praecox (L.) Link	illuminated	good	18,8±1,5	13,5	0,28
	shadowed	satisfied	5,3±0,4		
Viburnum tinus L.	illuminated	good	12,6±0,8	5,2	0,59
	Shadowed	good	7,4±0,6		
Cornus mas L.	illuminated	good	13,2±1,1	9,3	0,30
	shadowed	satisfied	3,9 ±0,1		
Laurocerasus officinalis M. Roem.	illuminated	good	10,4±0,5	1,9	0,82
	shadowed	good	8,5±0,4		
Pittosporum heterophyllum Franch.	illuminated	good	11,0±0,2	6,9	0,37
	shadowed	satisfied	4,1±0,4		
Buxus sempervirens L.	illuminated	good	8,2±0,4	3,2	0,61
	shadowed	good	5,0±0,3		

Under conditions of total illuminance *Laurocerasus officinalis* M. Roem. and *Buxus sempervirens* L. presented worse amount of growth – 10,4 and 8,2 sm, so they are considered as weak-growing.

All study cases, growing on shadowed area, length of one-year shoot (on average for 2 years) consideredbly reduced in comparison with plants on well-illuminated areas, but decrease degree ranges (table 2). The most significant reduction of this parameter was fixed for *Chimonanthus praecox* (L.) Link and *Eunymus japonica* Thunb. – 13,5 and 10,2 sm less respectively or 72 and 62% in comparison with other study plants, so these cultivars experienced the most considerable inhibit of growth amount being under shadowed conditions. *Laurocerasus officinalis* M. Roem. and *Buxus sempervirens* L. didn`t reduce amount of growth so much (the lowest parameter). Length of one-year shoot being shadowed is 1,9 and 3,2 sm less (18 – 39% respectively), what indicates rather insignificant shade negative effect on shoot growth. The rest plants took intermediate place.

Correlation analysis of shoot growth amount and reduction degree of study cases being shaded revealed direct relation between average length of one-year shoots under conditions of illumination and degree of its reduction being shaded (r-0,91, n-7). It proves observations conducted before: plants with more intensive growth reduces amount of growth to the large degree being shaded and can be considered not so shade tolerance.

A new parameter of shade tolerance was introduced to determine degree of one-year shoot length being shaded. It can be calculated by ratio of one-year shoot length in shade to the same parameter but under conditions of illumination. Than more shade tolerance than less differences in amount of growth under both conditions (shade and total illumination), than more shade tolerant a plant is.

On average during two-years observations the highest point of shade tolerance was fixed for *Laurocerasus officinalis* M. Roem. (0,82), lower - *Viburnum tinus* L. and *Buxus sempervirens* L. (about 0,59-0,61). Therefore these cultivars can be considered raher shade

tolerant growing in certain conditions, in comparison with other study cases. *Chimonanthus praecox* (L.) Link and *Cornus mas* L. revealed the lowest shade tolerance which ranges 0,28-0,30, and so they are considered weak shade tolerant. *Eunymus japonica* Thunb. *Pittosporum heterophyllum* Franch. took in this line intermediate place, as they had almost similar parameters of shade-tolerance (0,37-0,38); they are medium-shade tolerant.

According to shade-tolerance study plants were arranged in descend order as follows: *Chimonanthus praecox* (L.) Link → *Cornus mas* L. → *Eunymus japonica* Thunb. → *Pittosporum heterophyllum* Franch. → *Viburnum tinus* L. → *Buxus sempervirens* L. → *Laurocerasus officinalis* M. Roem. This line corresponds to shade tolerance parameters, presented in the article [4].

These results are preliminary which characterize plants under certain conditions. These cultivars rate should be kept on for 2-3 years if to get more correct data. Shade tolerance can be used for other cultivars as well.

Rating of study plant common state revealed that high illumination favored better state according to chosen scale (table 2). They were strong, well-developed with dense foliage evenly spread across branches, leaves have got common size and color, no signs of disease or persts damages, no stem of skeletal branches damages as well. Being shaded majority of plants had satisfactory condition. Growth slowdown, uneven crown development, decrease of leaves, insignificant mechanical damages and hollows on trunks pointed that fact. But *Viburnum tinus* L., *Laurocerasus officinalis* M. Roem. and *Buxus sempervirens* L. didn`t get any signs of inhibition being shaded and developed rather well. It proves their relative shade-tolerance under certain ecological conditions.

Dynamics of illumination regime is possible to follow at figures 1, 2, 3, 4 and 5. The highest parameters of illumination were fixed for cultivars, located on open areas. The lowest – for plants being shaded by high trees. Maximum illumination of 32000 Lx reduces till 947 Lx for plants on shaded areas. Low illumination plays role of limiting factor in study cases development (table2).

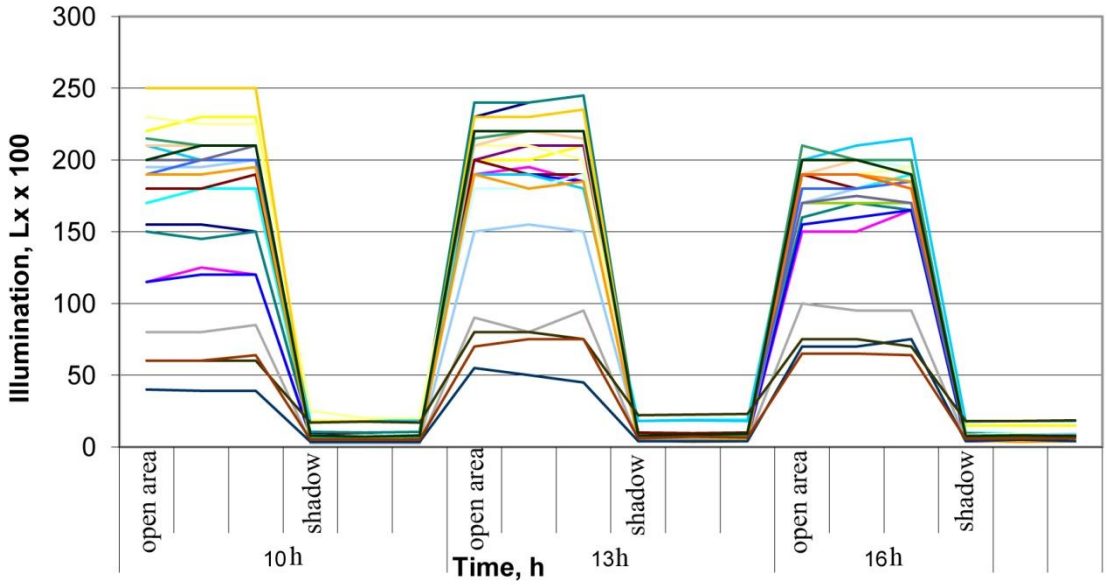

Fig.1 *Eunymus japonica* Thunb. Illumination 18.06.15-07.08.15

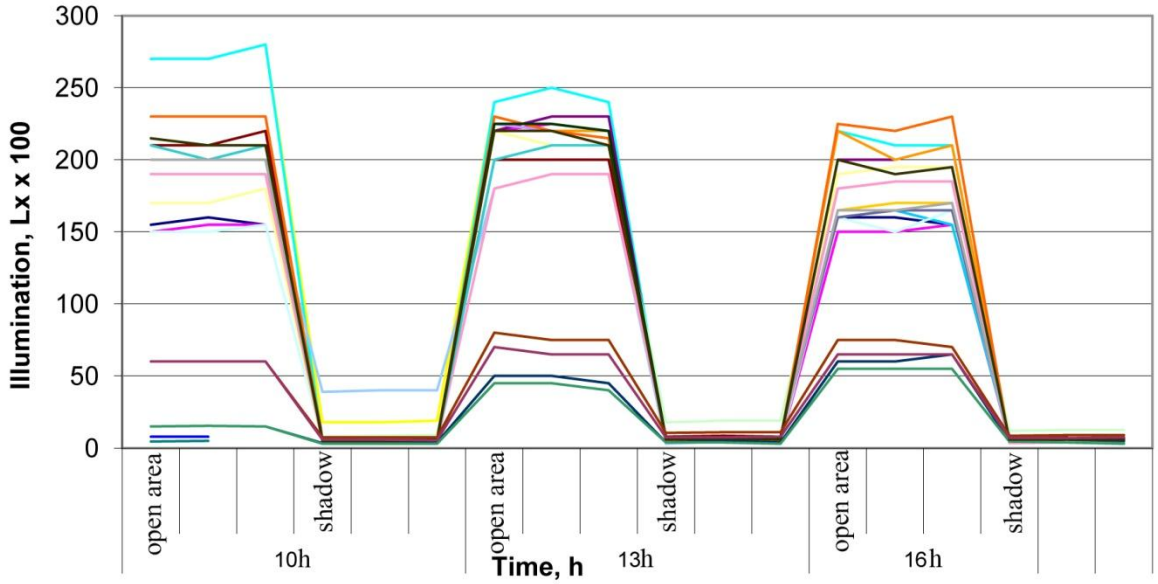

Fig.2 *Chimonanthus praecox* (L.) Link illumination during 18.06.15-07.08.15

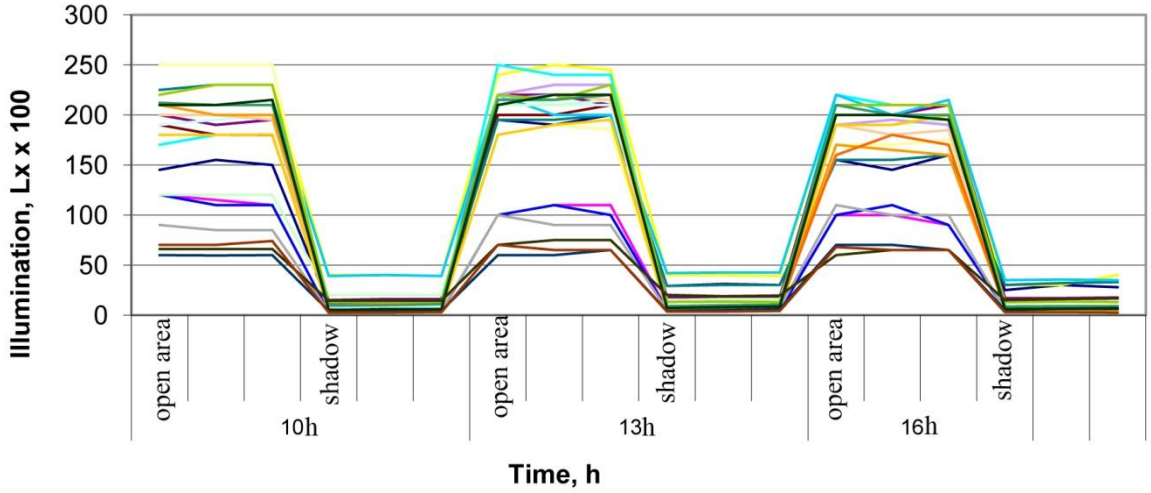

Fig.3 *Viburnum tinus* L. illumination during 18.06.15-07.08.15

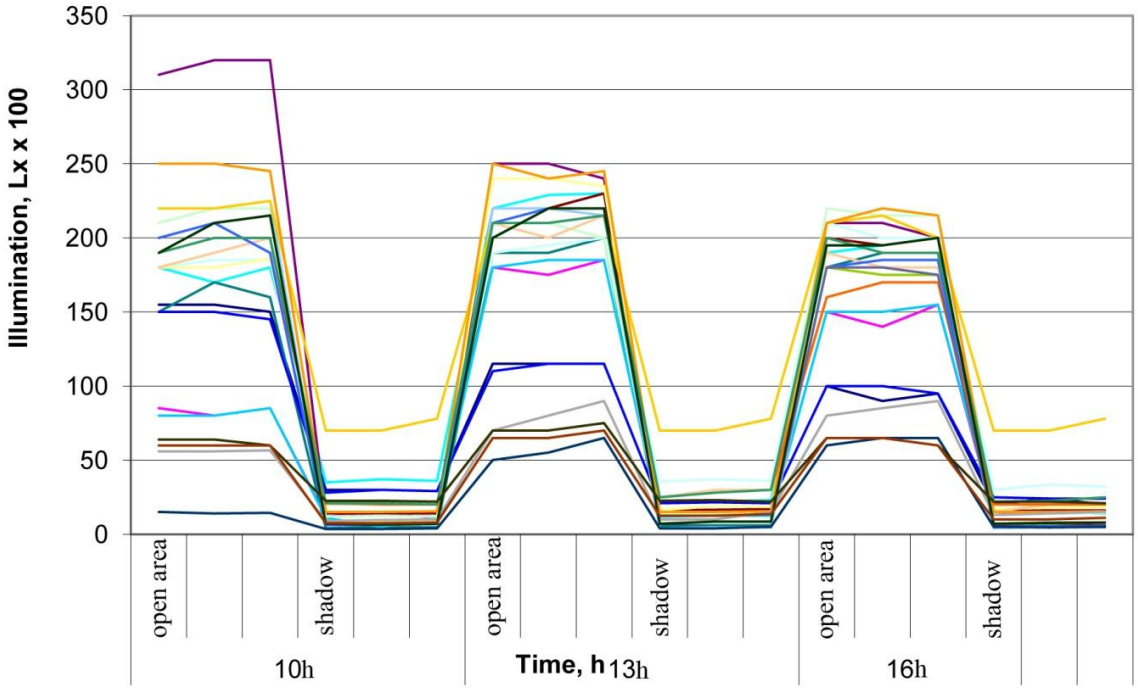

Fig.4 *Cornus mas* L. illumination during 18.06.15-07.08.15

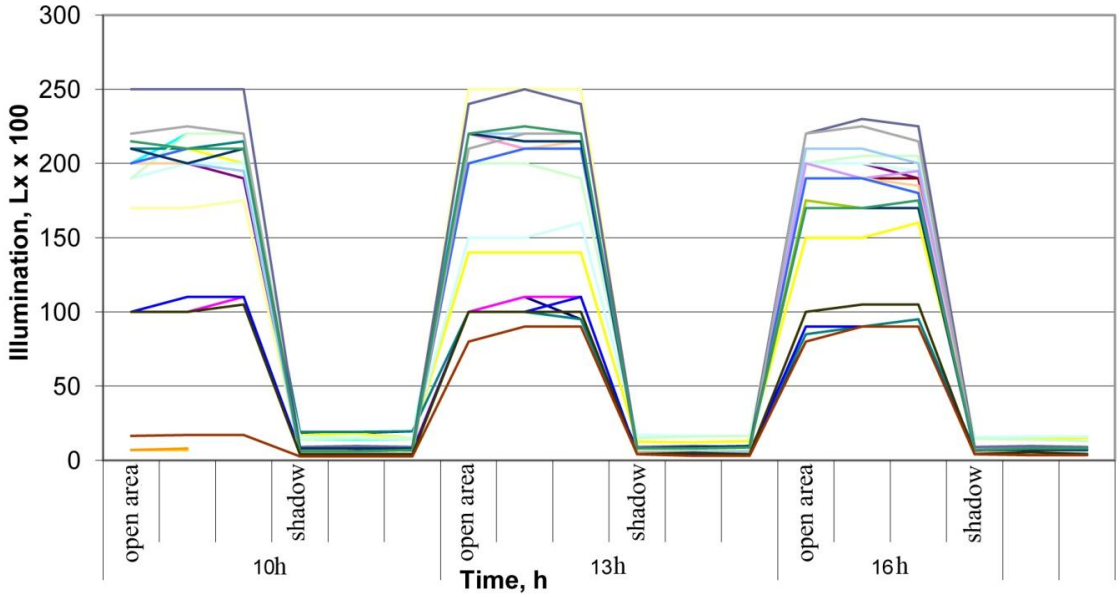

Fig.5 *Laurocerasus officinalis* M. Roem. illumination during 18.06.15-07.08.15

Illumination parameter is characterized with cyclicity for all study cultivars. In the midday parameters take higher points comparing with morning and evening, while morning factors are lower than evening. Such a dynamics is typical for both, plants growing in the shade or on open garden areas.

Conclusions

1. It was determined that shoot length of bush plants growing on sunlit areas, was significantly higher in comparison with bush plants growing in the shade.

2. Parameter of shade tolerance was suggested in terms of this research. Study cultivars were arranged in increasing order according to this factor: *Chimonanthus praecox*

(L.) Link→ *Cornus mas* L. → *Euonymus japonica* Thunb. → *Pittosporum heterophyllum* Franch. → *Viburnum tinus* L. → *Buxus sempervirens* L. → *Laurocerasus officinalis* M. Roem.

3. On open areas plants of all study cases are possible to use in landscaping on SCC. For shaded places *Viburnum tinus* L., *Buxus sempervirens* L. *Laurocerasus officinalis* M. Roem. are more preferable as the most shade-tolerant cultivars.

4. Illumination parameter is characterized with cyclicity. Its dynamics is typical for both, plants growing in the shade or on open garden areas. In the midday parameters take higher points comparing with morning and evening, while morning factors are lower than evening.

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The article covers analysis results of annual shoot growth and status of ornamental plants belonging to seven cultivars growing in Arboretum lower layer of Nikita Botanical Gardens. Correlation of annual shoot growth and illumination, that was revealed in terms of the research, makes it possible to differentiate plant cultivars according to shade tolerance; this data permits to recommend them for cultivation in a certain region on South Coast of the Crimea allowing for its microclimatic characteristics.

Key words: *ornamental plants; shoot growth; shade tolerance; phytomonitoring.*