LEPL "BATUMI SHOTA RUSTAVELI STATE UNIVERSITY"

Faculty of Natural Sciences and Health Care Department of Biology

Department of Biology

Nana Abashidze

„Ecobiomorphological and Biochemical Peculiarities of some exotic species of Batumi Botanical Garden in the Adjara seaside"

(Submitted for the degree of Doctor of Biology)

Specialty: **Plant Biodiversity**

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Scientific Supervisors::

F. Chaidze - Academic doctor of biology

Scientific Coordinator:

A. Kalandia - Propessor of BSU

Reviwers:

Nani Gvarishvili - Phd Dr. of Biology, Associate Professor of Batumi Shota Rustaveli State University

Irakli Mikeladze - Phd Dr. of Biology, Senior scientist of Institute Phytophatology and Biodiversity of Batumi Shota Rustaveli State University

Nana zarnadze - Phd Dr. of Biology, The overview Professor

The Dissertation thesis is going to be defended on March 5, 2021 ... , at the dissertation council meeting of faculty of Natural Sciences and Health Care, Batumi Shota Rustaveli State University.

Adress: № 35 Ninoshvili Str., Batumi 6010, the second Building of the University, room № 55. www.bsu.edu.ge.

The overview Professor: **Nana Zarnadze**

Introduction

Actuality of the Research; The plant introduction and maintenance of exotic species diversity have always been an important priority of the Batumi Botanical Garden. The exotic species introduction works have been going on in the garden since its establishment. The introduction of such trees and plants in through the subtropical zone of the Black Sea, in particular in Adjara, is associated with the 80s of the nineteenth century. Initiators of such works were: I. Veru, M. D'Alphonse, E. Tatarinov, A. Solovtsev, G. Olinsky, B. Stoyanov, A. Korsakov, the Founder of the Garden I. Klingen and others. A Georgian decorator Jason Gordeziani, who had a higher agronomic education in Europe and later worked as an agronomist-decorator of the Royal Garden of Great Britain, had an important role in the process of creating this garden, Batumi seaside park and ornamental tree-plant nurseries arranged around Batumi at that time. He is the first director of the garden, who came by the invitation of A.Krasnov and gained the worldwide recognition, which was manifested by the erection of his bronze bust in the central part of the Batumi Seaside Park, moreover, one of the central squares of the Batumi Botanical Garden was named after Jason Gordezian.

The study of the ecobiomorphological and biochemical peculiarities of exotic plants, introduced from different continents and countries in the garden, still continues, as one of the scientific-theoretical bases for the introduction of plants, which is an essential part to identify new plant species and introduce them in various fields of agriculture.

The prophylactic measures allow producing of various medicinal-prophylactic products, they strengthen as important function of the exotic plants as the protective function of organ is. So far, this is an important task for this research of observing exotics plants. The ingredients of this protective function include: essential oils, vitamins, dietary fiber, minerals, polyunsaturated fatty acids, amino acids, proteins, peptides, organic acids, phenolic compounds (antioxidants) and others.

Aim of the Research, Purpose and Objective; the aim of the research is to study the ecobiomorphological and biochemical peculiarities of some exotic plants introduced in Batumi

Botanical Garden. As far as, one of the main objectives of the Botanical Gardens is to create collections of the botanical species, characterize them under studies, study bio-ecological peculiarities, name growth and development features, identify possibilities of generative - vegetative propagation and essential oil in studying species, determine comparative characters of the natural distribution areas of the studying species and the soil-climatic conditions of the Adjara seaside;

Scientific Novelty; it must be emphasize that, some growing species in the Batumi Botanical Garden have been studied for the first time. Their bio-ecological and biochemical peculiarities have been analyzed and studied according to their seasonal dynamic growth and development; also, effective methods of propagation and the content of essential oils have been elaborated.

Objects of the Research Venue and Methodology: based on the above, the aim of the research is to study the ecobiomorphological and biochemical peculiarities of some exotic plants introduced in Batumi Botanical Garden. Also, estimating the results of their adaptation in the Adjara seaside and setting development measures. 2 groups of exotic plants (11 species and two varieties) identified as research objects.

The first group includes 6 types of essential oil - Aromatic Species and 2 varieties:

1. Yellow, Canary- or Golden Sassafras - *Doryphora sassafras* Endl.
2. Star-Anise - *Illicium verum* Hook. F.
3. Manuka, Broom Tea-Tree - *Leptospermum scoparium* J.R.Forst. & G.Forst.
4. Manuka, Broom Tea-Tree var. chapmannii-*Leptospermum scoparium var. chapmannii* Dorrien. Smith.
5. Manuka, Broom Tea-Tree var. *nichollsii* -*Leptospermum scoparium var. nichollsii* (Dorr. Sm.)Ewart
6. Lindera, Chinese Spicebush - *Lindera communis* Hemsl.
7. Magnolia, Banana Shrub - *Magnolia figo* (Lour.) DC.
8. Brazilian peppertree - *Schinus terebinthifolia* Raddii.

The second group includes 5 types of Medicinal and Fruit-Decorative Species

1. Five-leaf Akebia - *Akebia quinata* (Houtt.) Decne.
2. Chinese Mulberry – *Maclura tricuspidata* Carriére
3. Black Cherry - *Prunus serotina subsp. capuli* (Cav. ex Spreng.)McVaugh.
4. Cattley Guava - *Psidium cattleianum* Afzel. ex Sabine.
5. Six-leafed Stauntonia - *Stauntonia hexaphylla* Decne.

To achieve the goal, we set up the following tasks:

- Characterizing and comparing of the natural distribution areas of the research species and the soil-climatic conditions of the Adjara seaside;
- Determining the possibilities of adaption the introduced species to new environmental conditions and analyzing obtained results;
- Studying ecobiomorphological peculiarities of the research objects and determining the specificity of the process of phonological phases;
- Studying generative peculiarities of the research objects;
- Determining content of the essential oil in leaves, fruit, seeds, flowers of the research objects.

Research Methodology; Different methods have been applied for different purposes in this research: the Mayer Photo-climatic analogue method (Mayer, 1909) for determining the degree of adaptation of introductions; I. Serebryakov (Serebryakov; 1971; 120-165); I. Beideman (Beideman; 1974; 55); N. Nesterovich (Nesterovich; 1950; 130), A.Gursky (Gursky; 1951: 303) methods for studying the rhythm of growth & development, the timing of fruiting and studying of sprouts biology; I. Elagin (Elagin; 1974, 95) method for clarification of the phenological phases of plants; F. Urbach method (Urbach; 1975; 94) for calculating the percentage of sprouting and flourishing; the "Decorative Dendrology" of M.Tkavadze (Tkavadze; 1990; 5-12) for determining the biometric indicators, the dispersion analysis for mathematical-statistical processing of experimental material (V.Dospekhov; 1985; 351) and Biological method (Gerasikin; 2010, 206) for determining the viability of the rowing material (Standard;1954, 42).

The Hydro-distillation, titration, gas chromatography and mass spectrometric methods have been applied for quantitative and qualitative analysis of essential oils in the studied species.

Material-Technical Bases; the phonological observations of objects under this research were conducted on the specimens growing in the open soil plots of the Batumi Botanical Garden. The propagation works were accomplished in the orangery of the exotic plant department of the Garden. According to the purpose of this research and to determine the content of essential oils in the studying species, there have been conducted an experimental research in the regional chromatographic center of western Georgia.

The dissertation is represented on 141 printed pages, consists 3 chapters, 11 sub-chapters, with 17 tables and 48 colored photos, 160 title lists of references. The main text includes: introduction, literature review, analysis of the results, experimental part, conclusion and recommendations and the list of literature references. The bibliography consists of 160 works by domestic and foreign authors, of which 36 are Georgian, 124 are in foreign languages.

Literature Review; the first chapters of the dissertation analyzes the results of literature and refers the material research. There are also, some discussions about characterization of the soil-climatic conditions of the Batumi Botanical Garden and the area of natural habitat of the studying plants; the regularities of plant introduction, the list of methods used during the studying period; the dissertation is supplied with the list of the literature reference as well.

Chapter I Results Analysis and Outcome of Studying, Botanical-Morphological Characterization of the Exotic Species And Dendrometric Indicators

2 species out of 13 exotics plants growing in the Batumi Botanical Garden have been chosen for the research purpose, they are referred as following; evergreen lianas: *Akebia quinata* and *Stauntonia hexaphylla*. Also, 7 species: *Doryphora sassafras*, *Illicium verum*, two varieties of *Leptospermum scoparium (Leptospermum scosparium var. chapmannii, Leptospermum*

scoparium var. nichollsii), Psidium cattleianum, Schinus terebinthifolia, which are evergreen

Species	Family	Origin	Life Form	Use

woody exotics. And, two species: *Maclura tricuspidata*, *Prunus serotina subsp. capuli,* which is a deciduous woody exotic plant. The Latin names of research objects, life form, status, and natural distribution area are given in Table №1 and Dendrometric parameters, year of introduction are given in Table № 2.

	Species	Family	Year of Introduction	Age	Quantity	Height/M/Average/	Stem Diameter-on 1,3 M./cm/Average/	Canopy Circumference/ M/Average/
1	*Akebia quinata*	*Lardizabalaceae*	1913	106	2		6 x 7	
2	*Maclura tricuspidata*	*Moraceae*	1937	82	15	4	16 x 20	5×3
3	*Doryphora sassafras*	*Atherospermataceaea*	1978	42	1	4,5	7 x 9	4 x 3,20
4	*Illicium verum*	*Schisandraceae*	1959	61	1	4	12 x 13	3 x 2,80
5	*Leptospermum scoparium*	*Myrtaceaea*	1912	107	35	4, 50	13x14	3,75 x 2,80
6	*Leptospermum scoparium var. chapmannii*	*Myrtaceaea*	1912	107	25	5, 15	11x 13	5,40 x 3, 46
7	*Leptospermum scoparium var. nichollsii*	*Myrtaceaea*	1912	107	20	3	21x 20	3,7 x 2,6
8	*Lindera communis*	*Lauraceae*	1958	61	3	3,7	7x23	5,08 x 7,75
9	*Magnolia figo*	*Magnoliaceae*	1903	116	17	5	10 x 9	9,0 x 1 ,00
10	*Prunus serotina subsp. capuli*	*Rosaceae*	1972	47	5	5	21x 29	8 x 3
11	*Psidium cattleianum*	*Myrtaceaea*	1978	41	40	2	35,0 × 40	2 × 3
12	*Schinus terebinthifolia*	*Anacardiaceae*	1973	46	1	7	50 x 55	7,3 x 8,6
13	*Stauntonia hexaphylla*	*Lardizabalaceae*	1913	106	1		5 x 7	-------

Table 1. Status, Life form and Origin of the of Research Species

Akebia quinata (Houtt.) Decne.	Lardizabalaceae	Japan, Korea, China	Evergreen Liana	Healing, food
Doryphora sassafras Endl.	Atherospermataceae	New South Wales	Evergreen Tree	Healing
Illicium verum Hook. F.	Schisandraceae	China	Evergreen Tree	Healing
Leptospermum scoparium J.R.Forst &G. Forst.	Myrtaceae	New Zealand	Evergreen tree or Shrub	Healing.
Leptospermum scoparium v. chapmannii Dorien. (Smith.)	Myrtaceae	New Zealand	Evergreen tree or Shrub	Healing.
Leptospermum scoparium v. nicholIsii (Dorr.Sm.)Ewart	Myrtaceae	New Zealand	Evergreen tree or Shrub	Healing.
Lindera communis Hemsl.	Lauraceae	South China	Evergreen tree or Shrub	Healing,
Maclura tricuspidata Carriére	Moraceae	China, Himalaya, India	Deciduous Tree	Healing, food
Magnolia figo (Lour.) DC.	Magnoliaceae	South China	Evergreen Tree	Healing
Prunus serotina subsp. capuli McVaugh.	Rosaceae	Peru, Venezuela	Deciduous Tree	Food
Psidium cattleianum Afzel.ex Sabine	Myrtaceae	South America	Evergreen tree or Shrub	Food
Schinus terebinthifolia Raddii.	Anacardiaceae	Brazil, Argentina	Evergreen Tree	Food, Healing
Stauntonia hexaphylla Decne.	Lardizabalaceae	Southern Japan, Korea	Evergreen Liana	Food, Healing

Table 2. Dendrometric Data Obtained through Observations.

Throughout the research, there is given detailed description of botanical-morphological and general biological characterization of each species in their natural habitats (based on reference literature) and in the Batumi Botanical Garden (based on the direct observations and descriptions). Here, in Table №2, there is provided dendrometric data obtained through observations.

Picture 1. *Akebia quinata* (Houtt.) Decne.

Picture 2. *Akebia quinata* fruiit

Flowering in Batumi Botanical Garden

Picture 3. *Maclura tricuspidata* Carriére Fruiting in Batumi Botanical Garden

Picture 4. *Leptospermum scoparium* Forst. Flowering in Batumi Botanical Garden

Picture 5. ***Leptospermum scoparium var. nichollsii*** (Dorr. Sm.)Ewart . flowering in Batumi Botanical Garden

Picture 6. *Magnolia figo* (Lour.)DC. flowering in Batumi botanical Garden

Picture 7. *Prunus serotina subsp. capuli* McVaugh fruiting in Batumi Botanical Garden

Picture 8. ***Psidium cattleianum*** Afzel. Ex Sabine fruiting in Batumi Botanical Garden

Picture 9. ***Stauntonia hexaphylla*** **Decne fruits**

Growth and Development Peculiarities of Exotic Species

Studying of the growth and development peculiarities of exotic species, especially introduced species related to the climatic conditions, has an utmost significance, inasmuch as, the seasonal development of plants is an integral indicator of their adaptation. We have been studied the growth and development peculiarities of 13 species in relation to the climatic conditions for five years (2015-2020) on the basis of phonological observation.

The process of vegetative-generative development observations have been conducted through the study of each phonological phase. During the vegetative development: swelling and spreading of vegetative buds; beginning and end of sprout growth (I, II …); sprout wooding; germination, opening/spreading, reaching final size and massive leaving of young leaves (needles); color change of leaves (needles), leaf falling. During the generative development: swelling and spreading of generative buds; beginning of flowering, massive flowering, beginning and end of pollen dispensation; knotting of fruit (cone), reaching final size, full ripening; pollen dispensation terms. There has been calculated the size of annual growth for each species. The dynamics of leaves and apical growth is given according to decades. During the intensive growth periods the observations have been conducted according to decades, whereas during the less intensive periods which might be considered as twice a month. The great importance had been given to the fruiting process, as much as the intensive fruiting is the main indicative factor of the adaptation degree of the introduced plants in the new environment. The growth and vegetative development of studying species, flowering and fruiting are given in the tables of dissertation, which show peculiarities and terms of each phenol-phase process in 2015-2020 years.

They consistently go through all the stages of vegetative and generative development, some of them even have a self-renewal ability (*Akebia quinata, Stauntonia hexaphylla, Maclura tricuspidata)*, which is an indicator of successful adaptation.

According to the duration of shoot/sprout growth there can be distinguished 3 groups:

Group I - Species that are abundantly fruitful and give seed or sprout and have two periods of the sprout growth: ***Doryphora sassafras, Maclura tricuspidata , Magnolia figo and Psidium cattleianum*** - **162 days**. The first growth of ***Doryphora sassafras*** shoot starts in spring. The second shoot starts in the second decade of summer.

The first growth of ***Maclura tricuspidata*** shoot starts in spring and covers 89 day growth period. The second shoot starts in the second decade of summer, covers 65 day growth period and finishes in first decade of autumn. The first growth of ***Magnolia figo*** shoot starts in the first decade of April and finishes in the second decade of July covers 90 day growth period, while the secondary growth of the sprout begins in the first decade of July and finish in the second decade of August covers 34 day growth period. The first growth of ***Psidium cattleianum*** shoot starts in spring, covers 70 days growth period and finishes in second decade of july. The second shoot starts in the third decade of August, covers 66 days and finishes in the second decade of autumn.

Group II- includes species with three periods of the sprout growth. The first growth of ***Lindera communis*** shoots starts in the second decade of April and lasts until the second decade of May. The second growth starts, after a short break, in the second decade of July and lasts until the second decade of August. The third period of growth starts, after a short break, from the second decade of September and finishes about after two months. The vegetative period of the ***Lindera communis*** is 128 days.

The species in the ***group III*** normally are the ones with long period of the sprout growth: *Akebia quinata* - duration of shoot growth is 161 days, *Illicium verum*-110days, *Leptospermum scoparium*-170 days, *Leptospermum scoparium var. chapmannii* -170 days, *Leptospermum scoparium var. nichollsiii* -173 days, *Prunus serotina subsp. capuli* - 155 days, *Schinus tereninthifolia* - 255 days, *Stauntonia hexaphylla* - 204 days.

According to the flowering period there can be distinguished **5 groups:** (Table №3)

1. Winter and early spring flowering: *Doryphora sassafras.*

2. Spring flowering*: Akebia quinata, Lindera communis, Magnolia figo, Prunus serotina subsp. capuli.*

3. Late spring, summer and Autumn flowering: *Leptospermum scoparium*, *Leptospermum scoparium var. chapmannii, Leptospermum scoparium var. nichollsiii. Maclura tricuspidata.*

4. Summer flowering: *Psidium cattleianum, Schinus terebinthifolia.*

5. Summer and Autumn flowering: *Illicium verum.*

№	Species	Flower buds		Flowering			Flowering Duration	Flowering Quality
		Swell	Bloom	Start	Massive	finish	Day	
1	*Akebia quinata*	25,03	12, 04	12, 04	21, 04	10, 05	31	Medium
2	*Doryphora sassafras*	18,1	7,01	7,01	26, 02	13,04	96	Medium
3	*Illicium verum*	15,05	15,06	12,06	15,07	18, 12	184	High
4	*Leptospermum scoparium*	15 , 04	2 ,05	5,10	10 ,06	7, 07	131	High
5	*Leptospermum scoparium var. chapmannii*	15 , 04	2,05	9 ,05	13, 06	15,07	131	High
6	*Leptospermum scoparium var. nichollsii*	15, 04	6,05	6,05	11, 06	12,07	131	High
7	*Lindera communis*	5,03	6,04	7, 04	21,04	15,05	39	High
8	*Maclura tricuspidata*	11, 03	10,05	14, 05	3, 06	14,09	l24	High
9	*Magnolia figo*	7,03	20, 04	20, 04	24, 05	7,06	49	High
10	*Prunus serotina subsp. capuli*	8,03	19, 03	16, 04	17, 05	29,05	44	High
11	*Psidium cattleianum*	12, 04	4,06	5,06	25,06	12,07	38	High
12	*Schinus terebinthi folia*	5,04	20,04	21,05	15, 06	5,07	46	High
13	*Stauntonia hexaphylla*	7,03	20,03	29,03	20,04	5,05	43	Medium

Table 3. Flowering of the Observed Species in 2015-2020

The fruiting peculiarities of observed species in new environmental conditions are the integral indicator of this research. There have been singled out 3 groups while evaluating the fruiting process of observed species under the conditions in the Batumi Botanical Garden.

Group I- species with sustained (abundant) fruiting; they are: *Illicium verum, Leptospermum scoparium, Leptospermum scoparium var. chapmannii, Leptospermum*

scoparium var. nichollsii, Maclura tricuspidata, Psidium cattleianum, Schinus terebinthifolia, Stauntonia hexaphylla.

Group II -species with medium fruiting; they are: *Magnolia figo, Doryphora sassafras Prunus serotina subsp. capuli.*

Group III -species with poor fruiting; they are: *Akebia quinata.*

The amplitude reaches the significant value between the limitations of fruiting in some species: *Akebia quinata* (54 days), *Maclura tricuspidata* (64 days), *Doryphora sassafras* (37 days), *Lindera communis* (73 days), *and Psidium cattleianum* (39 days), *Schinu terebinthipholia* (57 days), *Stauntonia hexaphylla* (32 days), *Illicium verum* (33 days).

The amplitude varies slightly between the limitations of fruiting in the following exotics: *Leptospermum scoparium* (21 days), *Leptospermum scoparium var. chapmannii* (9 days), *Leptospermum scoparium var. nichollsii* (7 days), *Magnolia figo (*20 days), *Prunus serotina subsp. capuli* (8 days).

№	Species	Fruiting Quality			Fruiting Degree
		Start	Massive	Finish	
1	*Akebia quinata*	7, 09	5,1	11,1	Low
2	*Doryphora sassafras*	1,07	20,07	8,08	Medium
3	*Illicium verum*	12,07	16,09	20,12	High
4	*Leptospermum scoparium*	23, 05	13,06	3, 10	High
5	*Leptospermum scoparium var. chapmannii*	24, 05	13, 06	4, 10	High
6	*Leptospermum scoparium var. nichollsii*	24, 05	13,06	3, 10	High
7	*Lindera communis*	19,09	5, 10	26, 10	High
8	*Maclura tricuspidata*	22,09	5, 11	2, 12	High
9	*Magnolia figo*	30, 08	19, 09	6, 10	High
10	*Prunus serotina subsp. capuli*	8, 07	26, 07	9, 08	Medium
11	*Psidium cattleianum*	18,08	12,1	2, 11	High
12	*Schinus terebinthifolia*	10, 10	24, 11	11, 12	High
13	*Stauntonia hexaphylla*	22, 09	25 10	9, 11	Medium

Table 4. Fruiting of Research Species

Chapter III Results of Generative Multiplication of the Observed Species

One of the main objectives for diversity of plant propagation is to elaborate effective methods for their reproduction. Studying the reproduction biology during the introduction process has the essential theoretical and practical value.

There had been studied an ability of generative-reproduction of the plants through seeds and on this purpose sowing was conducted in two variants in this study:

1) Sowing of seeds collected in autumn;

2) Sowing of seeds taken in autumn, in early spring,

3.1. Propagation through Seeds

Seed was gathered from the collection of the fruiting exotic species. The studies of the biology of seed propagation, germination and of the species under study were accomplished in the orangery.

While determining seed productivity of the research species, we have singled out three groups:

1. Species with high germination coefficient;

2. Species with medium coefficient of germination.

3. Species with low or none coefficient of germination.

Group I- species with high germination coefficient belongs: *Maclura tricuspidata, Leptospermum scoparium, Leptoapermum scoparium var. chapmannii, Leptoapermum scoparium var. nichollsii, Lindera communis, Magnolia figo, Psidium cattleianum, Stauntonia hexaphylla.*

Group II - species with medium germination coefficient belongs: *Akebia quinata and Illicium verum.*

Group III- species with low germination coefficient or not at all belongs: *Prunus serotina subsp. capuli, Schinus terebinthifolia.*

Species	Seed Quantity	Seed Collection Time	Sowing Time	Emergence			Time Required for Emergence	%
				First	Massive	Final	Day	
Maclura tricuspidata	200	2, 11	24,03	5, 04	30, 04	4,05	20	90±3,2
Leptospermum scoparium	200	12, 06	25,1	24, 03	17, 04	8,05	121	78±2,7
Leptospermum scoparium var. chapmannii	200	12, 06	25,1	24, 03	17, 04	10,1	121	70±3,1
Leptospermum scoparium var. nichollsii	200	12, 06	25,1	24, 03	17, 04	12,1	121	70±2,5
Lindera communis	200	13, 07	25,1	13, 03	19, 04	13,1	62	69±3,4
Magnolia figo	200	6, 10	11,03	5, 04	17, 04	12,1	25	70±3,1
Prunus serotina subsp. capuli	200	26 ,07	25,1	24, 03	8,04	7,05	121	30±1,1
Psidium cattleianum	200	14, 10	25,1	24, 03	9, 04	12,1	121	85±2,4
Schinus terebinthifolia	200	22, 11	24,03	9, 04	24.04.	6,05	16	20±1,3
Stauntonia hexaphylla	200	18, 10	25,1	24, 03	17, 04	30	38	80±2,7

Table 5 Dynamics of Seed Emergence of Research Species

Chapter IV Biochemical Peculiarities of Observed Objects

In General, plant introduction and preservation of diversity have always been a significant priority of botanical gardens. The introduction works in the Batumi Botanical Garden are connected with the foundation of the Garden. Palibin, who was the director of the Garden from 1916, is considered as the founder of the observation activities in the Garden. He had supervised the studies on growth & development peculiarities of the introduced plants and tried to find out how useful our climate conditions might be to spread certain plants or use them in agriculture, decorative gardening and other fields of national economy was observed, though these studies.

The study of Eco-physiological and biochemistry peculiarities and features of introduced plants with various geographical origins still continuous at the Botanical Garden, as well as creating the theoretical basics of plant introduction in order to reveal new plant resources and implement them in different types of farming economy. The scientific studies of plant introduction require a complex integrated approach, which is an understanding of their close relations with the natural environment in the conditions of interrelations between morphological, phylogenetic and bio-ecological factors along with the knowledge of chemical composition. The members of the rose, myrtle, laurel, cypress family are especially rich in aromatic plants [3]. Objects of our study have been the exotics: *Doryphora sassafras* Endl; *Leptospermum scoparium* Forst; *Leptospermum scoparium var. chapmannii*; Dorien Smith Carr; *Leptospermum scoparium var. nichollsii (*Dorr.Sm.); Ewart; *Illicium verum* Hook.; *Lindera communis* Thunb; *Magnolia figo* (Lour.) DC.

Based on the results of growth and development of the introduced plants studies, researchers have been established that they consist all phases of vegetative and generative development, which shows a successful acclimatization rate.

The goal of our study was to reveal the results of the adaptation of the plants, by observing their bio-ecological and biochemical peculiarities and estimate regularities of development under the cultivation.

In order to determine the content of essential oils, there has been conducted experimental research in the regional chromatographic center of western Georgia. The methods of hydro-distillation, high pressure super-fluid extraction (with inert gases) and titration have been applied to isolate of essential oils.

Through the titration method (hydrolysis of essential oils glycosides link in leaves and fruit was conducted with hydrogen chloride action. The free essential oil was titrated with bromine). It was determined that the content of essential oils in ***Leptospermum scoparium var. chapmanii Dorien. Smith***- leaves *is* 0, 1533 ± 0, 005 %; ***Leptospermum scoparium J.R.Forst. & G.Forst*** – leaves is 0,065 ± 0.008 %; ***Leptospermum scoparium v. nichollsii*** **(Dorr. Sm.) Ewart**- leaves is 0,065 ± 0,007 %; ***Doryphora sassafras*** **Endl**- leaves is 0,124% ± 0, 02 %; ***Illicium verum***

Hook. f. - *Fruits* is 0, 0657 ± 0,006*%;* ***Lindera communis*** **Hemsl**- fruits-0, 5474 ± 0, 06 %, ***Magnolia figo*** **(Lour.)DC**- *flowers* is 1,078± 0, 03. **Table 5.**

Species Name	Total Essential Oils %		
	Leaves	Fruits	Flowers
Doryphora sassafras	0,124 ± 0,02		
Illicium Verum		0,0657 ±0,006	
Leptospermum scoparium v. chapmannii	0,1537 ± 0,005		
Leptospermum scoparium	0,065 ± 0,008		
Leptospermum scoparium v. nicholssii	0,065 ± 0,007		
Lindera communis		0, 5474 ± 0,06	
Magnolia figo			1.078 ± 0,03

Table № 5 The Quantity of essential Oils Obtained by the Titration Method

4.1. Obtaining an Aromatic Complex of Leptospermum Scopariums leaves, Illicium Verums and Lindera Communis fruits

The aromatic foliage complex of *Leptospermum scoparium* leaves, *Illicium verum* and *Lindera communis* fruits were obtained by Hydro-distillation. 70 grams of dried leaf (crushed) and fruits together with 200 ml of water were placed in a flask for the distillation process, the distillation process had been carried out using a Clevenger-type apparatus (Pic.1-2) for 1 hours and the condensation in a refrigerator at temperature - 0.0 ° C. The obtained essential oil was extracted with hexane, 0.5 μl of the organic part of which was centrifuged (2 minutes at 1350 revolutions / min) and injected on the chromatograph.

Picture 10. Obtained Essential oils by Clevenger Method

Picture 11. Research Sample Leptospermums

4.1. Essential oils of Fruit of *Leptospermum scoparium* leaves, *Illicium verum* and *Lindera communis* obtained by Gas Chromatography

The temperature mode of the injector was 300 ° C, while the sample in the column was divided into helium flux by a ratio of 1 / 214.3. The chromatography was carried out in four stages at a temperature gradient. In particular, In particular, chromatography was started at 50 ° C, which was continued for 5 minute at that temperature, then increased to 200 ° C (second stage) at a rate of 3.0 (° C / min) and was continued for 5 minute. In the third stage, it increased to 320 ° C, at a speed of 30 (° C / min) and continued at that temperature for 20 minute. The whole chromatographic implementation time was 74.0 minutes. The essential oil components separated by chromatography were detected by an allure-ionization detector. The quantitative content of essential oil was determined with an accuracy of 0.01% in percentage according to the peak area.

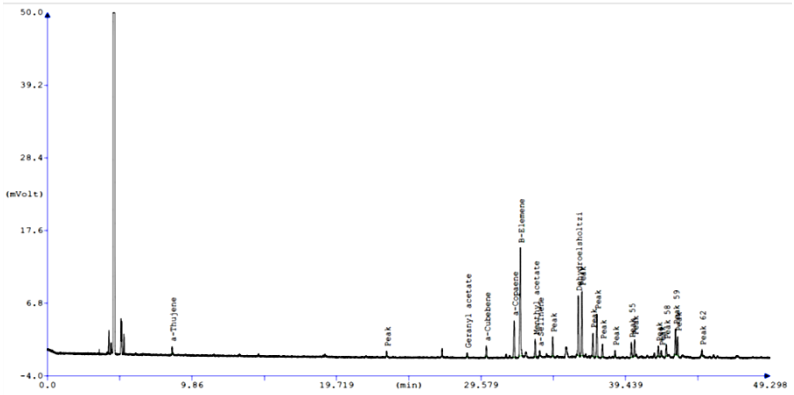

Figure 1. Essential Oils of *Leptospermum scopariums* leaves obtained by Chromatogram

Peak Number №	Peak Time (min)	Component Name	Area, %
1	8,505	a-Thujene	0.955±0.03
2	23,14	Peak	0.643±0.02
3	28,64	Geranyl acetat	0.585±0.02
4	29,95	a-Cubebene	1.710±0.06
5	31,845	a-Copaene	6.717±0.24
6	32,265	B-Elemene	23.238±0.81
7	33,28	Menthyl acetat	3.307±0.12
8	33,59	a-Sellnene	0.855±0.03
9	34,475	Peak	3.296±0.12
10	36,21	Dehydroelsholt	11.556±0.40
11	36,465	Peak	12.321±0.43
12	37,215	Peak	4.214±0.15
13	37,485	Peak	8.568±0.30
14	37,865	Peak	2.273±0.08
15	38,73	Peak	0.816±0.03
16	39,84	Peak 55	3.049±0.11
17	40,06	Peak	3.070±0.11
18	41,675	Peak	1.794±0.06
19	41,88	Peak	0.924±0.03
20	42,22	Peak 58	2.054±0.07
21	42,845	Peak 59	4.749±0.17
22	42,99	Peak	3.307±0.12

Table 6. The Component Composition of the Essential Oil in the Leaves of *Leptospermum scoparium*

As a result of the chromatographic research, 22 components have been found in the essential oils of *Leptospermum scoparium* leaves. Among them, there were identified 8 components, In particular: a-Thujene 0.955 ± 0.03 %, Geranyl Acetat 0.585 ± 0.02 %, a-Cubebene 1.710 ± 0.06 % , a-Copaene 6.717 ± 0.24 %, B-Elemene 23.238 ± 0.81 %, Menthyl Acetat 3.307 ± 0.12 %, a-Sellnene 0.855±0.03 %, Dehydroelsholt 11.556 ± 0.40 %.

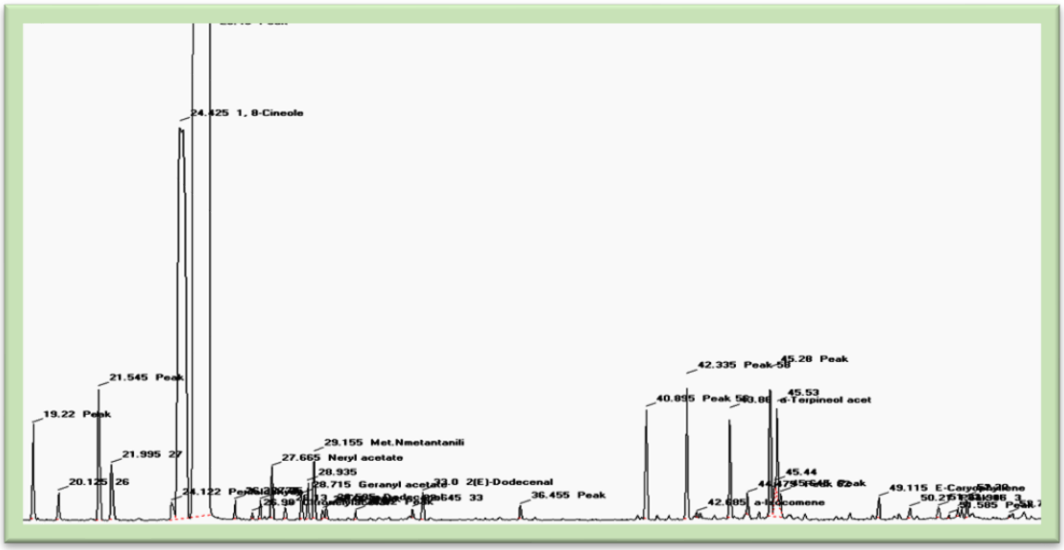

Figure 2. Chromatogram of *Lindera communis* fruits Essential oils

Peak №	Peak Time (min)	Component Name	Area %
1	19.220	Peak	0.230 ± 0,0069
2	20.125	26	0.070± 0,0021
3	21.545	Peak	0.369 ± 0,01107
4	21.995	27	0.173 ± 0,0051
5	24.122	Perilaldehyde	0.075 ± 0,00225
6	24.425	1, 8-Cineole	4.420 ± 0, 1326
7	25.460	Peak	92.017 ± 2,7605
8	26.360	30	0.036± 0,0010
9	26.980	Citronelylacet	0.012 ± 0,00036
10	27.250	Peak	0.040 ± 0,0012
11	27.665	Neryl acetate	0.112 ± 0,0034
12	28.130	a-Copaene	0.025 ± 0, 0008
13	28.715	Geranyl acetat	0.054 ± 0,0016
14	28.935	Peak	0.084 ± 0,0025
15	29.155	Peak	0.149 ± 0,0046
16	29.470	Peak	0.019 ± 0,0005
17	29.595	Dodecanal	0.023± 0,0007
18	30.620	Peak	0.017± 0,0005
19	32.645	33	0.020 ± 0,0006
20	33.000	2(E)-Dodecenal	0.064 ± 0,0019
21	36.455	Peak	0.032 ± 0,0010
22	40.895	Peak 56	0.262± 0,0079
23	42.335	Peak 58	0.362 ± 0,0109
24	42.685	a-Isocomene	0.009 ± 0,0003
25	43.860	a-Terpineol ac	0.270 ± 0,0081
26	44.475	Peak 62	0.051 ± 0,0015
27	45.280	Peak	0.547 ± 0,0164
28	45.440	Peak	0.026 ± 0,0008
29	45.530	Peak	0.203 ± 0,0061
30	45.645	Peak	0.037 ± 0,0011
31	49.115	E-Caryophyllen	0.050 ± 0,0015
32	50.210	Peak 46	0.029 ± 0,0009
33	51.220	Peak	0.028 ± 0,0008
35	51.905	3	0.021 ± 0,0006
36	52.220	Peak	0.050 ± 0,0015
37	53.715	4	0.005 ± 0,0002

Table 7. The Component Composition of *Lindera communis* Fruits Essential Oil

As a result of our chromatographic research, 37 components have been found in the essential oils of *Lindera communis* fruits. Among them there were identified 11 , In particular:

Perilaldehyde 0.075 ± 0,00225 %, 1,8-Cineole 4.420 ± 0, 1326 %, Citronelylacetat 0.012 ± 0,00036 %, Nerylacetate 0.112 ± 0,0034 %, a-Copaene 0.025 ± 0, 0008 %, Geranyl acetate 0.054 ± 0,0016 %, Dodecanal 0.023 ± 0,0007 %, 2(E)-Dodecenal 0.064 ± 0,0019, alpha-Isocomene 0.009 ± 0,0003 %, alpha -Terpineol acetate 0.270 ± 0,0081%, (e)-beta-Caryophyllene 0.050 ± 0,0015%.

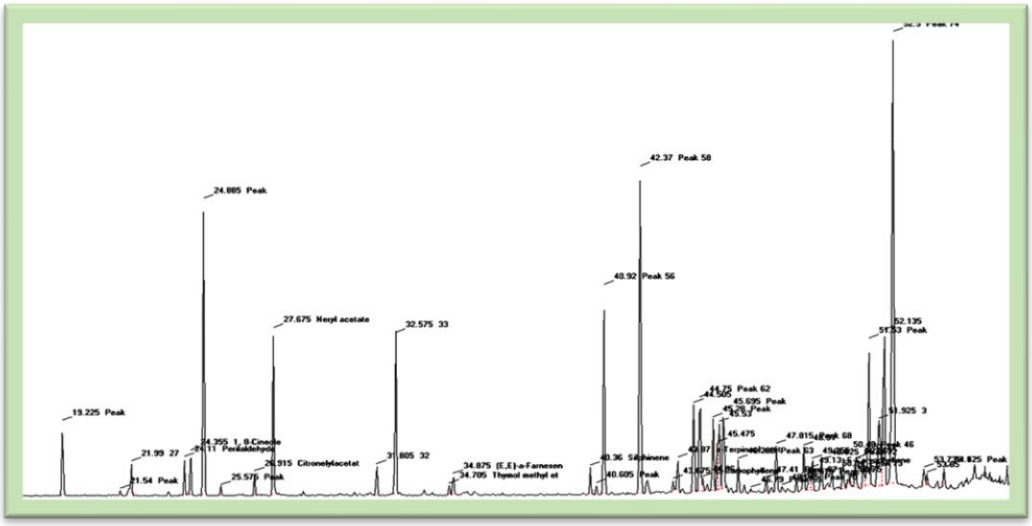

Figure 3. Chromatogram of *Illicium verum* fruits Essential oils

Peak №	Peak Time (min)	Component Name	Area %
1	19.225	Peak	1.838 ± 0,0551
2	21.540	Peak	0.108 ± 0,0032
3	21.990	27	0.645 ± 0, 0194
4	24.110	Perilaldehyde	0.941 ± 0,0282
5	24.355	1, 8-Cineole	1.188 ± 0,0356
6	24.885	Peak	7.728 ± 0,2318
7	25.575	Peak	0.216 ± 0,0065
8	26.915	Citronelylacet	0.563 ± 0,0169
9	27.675	Neryl acetate	4.585 ± 0,1375
10	31.805	32	0.821 ± 0,0246
11	32.575	33	4.802 ± 0,1441
12	34.705	Thymol methyl	0.263 ± 0,0079
13	34.875	(E,E)-a-Farnes	0.509 ± 0,0153
14	40.360	Silphinene	0.702 ± 0,0211
15	40.605	Peak	0.247 ± 0,0074
16	40.920	Peak 56	5.861 ± 0,1758
17	42.370	Peak 58	10.076 ± 0,3023
18	43.675	Z-Caryophyllen	0.282 ± 0,0085
19	43.870	a-Terpineol ac	0.852 ± 0,0256
20	44.505	Peak	2.553 ± 0,0766
21	44.750	Peak 62	2.885 ± 0,0865
22	44.860	Peak	0.219 ± 0,0066
23	45.280	Peak	2.169 ± 0,0651
24	45.475	Peak	1.121 ± 0,0336
25	45.530	Peak	1.980 ± 0,0594
26	45.695	Peak	2.221± 0,0666
27	46.285	Peak 63	0.938 ± 0,0282
28	46.790	Peak 65	0.059 ± 0,0018
29	47.410	Peak 67	0.370 ± 0,0111
30	47.815	Peak 68	1.253 ± 0,0376
31	48.045	Peak 70	0.134 ± 0,0040
32	48.615	Peak 71	0.312 ± 0,0094
33	48.910	Peak	1.326 ± 0,0398
34	49.130	E-Caryophyllen	0.780 ± 0,0234
35	49.255	Peak	0.939 ± 0,0282
36	49.625	Peak 72	1.192 ± 0,0358
37	50.040	Peak 73	0.520 ± 0,0156
38	50.480	Peak 46	1.053 ± 0,0316
39	50.670	Peak	0.114 ± 0,0034
40	50.750	Peak	0.063 ± 0,0019
41	50.965	Peak	0.996 ± 0,0299
42	51.310	Peak	0.960 ± 0,0288
43	51.530	Peak	4.860 ± 0,1458
44	51.925	3	3.731 ± 0,1119
45	52.135	Peak	5.564 ± 0,1669
46	52.500	Peak 74	18.073 ± 0,5421
47	53.735	4	0.546 ± 0,0164
48	53.850	Peak	0.237 ± 0,0071
49	54.525	Peak 48	0.604 ± 0,0181

Table 8. The component composition of the essential oil in the fruits of *Illicium verum*

As a result of our chromatographic research, 49 components have been found in the essential oils of *Illicium verum* fruits. Among them there were identified 10, In particular:

Perilaldehyde 0.941 ± 0,0282 %, 1, 8-Cineole 1.188 ± 0,0356 %, Citronelylacetat 0.563 ± 0,0169 %, Nerylacetate 4.585 ± 0,1375 %, Thymol methyl ether 0.263 ± 0,0079 %, (e)-alpha-farnesene 0.509 ± 0,0153 %, Silphinene 0.702 ± 0,0211%, Z-Caryophyllene 0.282 ± 0,0085 %, Alpha-Terpinyl Acetat 0.852 ± 0,0256 %, (e)-beta-Caryophyllene 0.780 ± 0,0234 %.

Chapter V Conclusions and Recommendations

On the basis of the conducted introductive research, while studying morphological peculiarities of separate species, vegetation period the peculiarities of seasonal growth and development, reproduction issues, terms of separate phenol-phases, period of dormancy, winter resistance, heir aromatic, ornamental, medicinal nutritious and other economic-biological characteristics were evaluated.

1. According to the growth and developmental characteristics of the observed species, it has been concluded that they go through all the stages of vegetative and generative development in sequence, which indicates their successful adaptation. For the purpose of research, there has been carried out phonological observations on the experimental plants. Interrelation between the flowering and fruit bearing was estimated in related to the internal and external factors. Furthermore, plant development phases, air temperature, drought- resistance, seed quality (germination capacity) and other indices were evaluated. The studies of seed productivity have established that the coefficient of seed emergence is quite high. they consistently go through all the stages of vegetative and generative development, some of them even have a self-renewal ability (*Akebia quinata, Stauntonia hexaphylla, Maclura tricuspidata*), which is an indicator of successful adaptation.

2. According to the duration of sprout growth 3 groups have been singled out;

Group I- species with two period of shoot growth: shoot growth period of *Doryphora sassafras* - 180 days, *Maclura tricuspidata* 114 days *Magnolia Figo* 122 days and *Psidium cattleianum* - 136 days.

Group II - species with three period of sprout growth: *Lindera communis* growth period is 180 days.

Group III -species with a long period of shoot growth: *Akebia quinata* - duration of shoot growth is 161 days, , *Illicium verum* - 110 days, *Leptospermum scoparium* - 170 days, *Leptospermum scoparium var. chapmannii* – 170 days, *Leptospermum scoparium var. nichollsiii* -173 days, *Prunus serotina subsp. capuli*- 152 days, *Schinus tereninthifolia* - 213 days, *Stauntonia hexaphylla* - 233 day.

3. **According to the flowering period five groups have been singled out on the basis of observation:**
   - ***Winter and early spring flowering***: *Doryphora sassafras.*
   - ***Spring flowering****: Akebia quinata, Lindera communis, Magnolia figo, and Prunus serotina subsp. capuli.*
   - ***Late spring and summer flowering***: *Leptospermum scoparium*, *Leptospermum scoparium var. chapmannii, Leptospermum scoparium var. nichollsiii.*
   - ***Summer flowering***: *Psidium cattleianum, Schinus terebinthifolia.*
   - ***Summer and autumn flowering:*** *Illicium verum.*

4. In assessing the fruiting in new environmental conditions, it is established that the fruiting of introduced species in the conditions of the Batumi Botanical Garden is stable and the quality is quite high. ***According to the degree of fruiting there can be distinguished 3 groups of species:***

Group I -species with sustained (abundant) fruiting: *Maclura tricuspidata, Illicium verum, Leptospermum scoparium, Leptospermum scoparium var. chapmannii, Leptospermum scoparium var. nichollsii, Psidium cattleianum, Schinus terebinthifolia, and Stauntonia hexaphylla.*

Group II- species with medium fruiting: *Magnolia figo, Doryphora sassafras, Prunus serotina subsp. capuli.*

Group III -species with poor fruiting: *Akebia quinata.*

The amplitude reaches a significant value in assessing the limitations of fruiting in some species: *Akebia quinata* (54 days), *Maclura tricuspidata* (64 days), *Doryphora sassafras* (37 days), *Lindera communis* (73 days), *Psidium cattleianum* (39 days), *Schinus terebinthipholia* (57 days), *Stauntonia hexaphylla* (32 days), *and Illicium verum* (33 days). The amplitude varies slightly in assessing the limitations of fruiting in the following exotics: *Leptospermum scoparium* (21 days), *Leptospermum scoparium var. chapmannii* (9 days), *Leptospermum scoparium var. nichollsii* (7 days), *Magnolia figo (*20 days), *Prunus serotina subsp. capuli* (8 days).

5. In According to determine the seed productivity of the observed species *there can be distinguished 3 groups of species:*

1. Species with high germination coefficient;

2. Species with medium coefficient of germination.

3. Species with low or none coefficient of germination.

The first group of species with high germination coefficient belongs: *Maclura tricuspidata, Leptospermum scoparium, Leptospemum scoparium var. chapmannii, Leptoapermum scoparium var. nichollsii, Lindera communis, Magnolia figo, Psidium cattleianum, and Stauntonia hexaphylla.*

The second group of species with medium germination coefficient belongs: *Akebia quinata, Illicium verum.*

The third group of species with low germination coefficient or none at all belongs: *Prunus serotina subsp. capuli, Schinus terebinthifolia.*

6. *For the purpose of determining the content of essential oils* there has conducted experimental research in the regional chromatographic center of western Georgia. For the isolation of essential oils the methods of hydro-distillation, high pressure super-fluid extraction (with inert gases) and titration have been applied. Through the titration method (hydrolysis of essential oils glycosides link in leaves and fruit was conducted with hydrogen chloride action. The free essential oil was titrated with bromine). It was determined that the content of essential oils in the *Leptospermum scoparium var. chapmanii leaves* 0, 1533 ± 0, 005 %, *Leptospermum scoparium*. leaves 0,065 ± 0.008 %, *Leptospermum scoparium v. niichollsii*

leaves 0,065 ± 0,007 %, *Doryphora sassafras* leafs 0,124% ± 0,02 %, *Illicium verum* fruits - 0,0657 ± 0,006%, *Lindera communis* fruits -0,5474 ± 0, 06 %, *Magnolia figo* flowers 1,078± 0,03.

7. As a result of our chromatographic research, 22 components have been found in the essential oils of *Leptospermum scoparium* leaves. Among them there were identified 8 components. As a result of our chromatographic research, 37 components have been found in the essential oils of *Lindera communis* fruits. Among them there were identified 11 components. As a result of our chromatographic research, 49 components have been found in the essential oils of *Illicium verum* fruits. Among them there were identified 10 components. are Perilaldehyde 0.941 ± 0,0282 %, 1, 8-Cineole 1.188 ± 0,0356 %, Citronelylacetat 0.563 ± 0,0169 %, Nerylacetate 4.585 ± 0,1375 %, Thymol methyl ether 0.263 ± 0,0079 %, (e)-alpha-farnesene 0.509 ± 0,0153 %, Silphinene 0.702 ± 0,0211%, Z-Caryophyllene 0.282 ± 0,0085 %, Alpha-Terpinyl Acetat 0.852 ± 0,0256 %, (e)-beta-Caryophyllene 0.780 ± 0,0234 %.

8 . The some aromatic and medicinal plant species introduced at Batumi Botanical Garden take a significant place in terms of their application in medicine and can widely be implemented in modern pharmacology. According to the adaptation degree, the studied plants can be recommended for the reasonable application in the Adjara coastline.

Chapter VI Recommendations

Some exotic plants introduced in the soil-climatic conditions of Batumi Botanical Garden have high adaptation ability, so we recommend interested legal entities and individuals to distribute for various purposes in the Adjara coast.

Winter flowering decorative exotic plant *Doryphora sassafras* can be used in ornamental gardening, in medicine, modern pharmacology, as a unit copy or in group plantings, due to the content of essential oils in the leaves. Summer and autumn flowering *Illicium verum* can be

widely used in decorative gardening, as far as the fruit contains an essential oil, it also be it can be used in medicine, cooking and cosmetology.

A decorative exotic, Leptospermum (*Leptospermum scoparium*) creates an excellent ensemble, especially with its red and pink varieties. Also they contain essential oils and can be used in decorative gardening, medicine, and cosmetology. It is possible to cultivate agricultural plantations as very valuable exotic.

Spring flowering, aromatic *Lindera communis* and *Magnolia figo* can be used in decorative gardening, medicine, cosmetology as the promising essential oil.

Summer flowering *Schinus terebinthifolia* can be used in the food industry, perfumery.

Lardizabalaceae family members: spring flowering *Akebia quinata* and *Stauntonia hexapylla are precious* fruit-decorative exotic plants and can be used in food industry, medicine and decorative gardening.

Maclura tricuspidata is decorative with beautiful, red fruits.; its fruit contains sugar and natural acids, also, large amounts of B, C, PP vitamins, carotene and rutting. It is also rich in glycosides, pectin, resin substances and iron; therefore it can be widely used in medicine.

Summer-flowering, fruit-decorative exotics: *Prunus serotina subsp. capuli and Psidium cattleianum* can be cultivated in agricultural plantations.

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