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ABSTRACT

The study was carried out in 2011 – 2014 year at Botanical garden of Slovak University of Agriculture in Nitra, Slovak Republic. For the experiment the following woody plants were taken: *Callistemon laevis* Ball.., *Cupressus sempervirens* L., *Lagerstroemia indica* L., *Laurus nobilis* L., *Nerium oleander* L., *Pittosporum tobita* L., *Trachycarpos fortunei* (HOOK) H.WENDL., *Viburnum tinus* L., *Vitex agnus-castus* L., *Zizypus jujuba* L. These woody species were planted in two types of planting, plants planted direct into the soil and stayed outside during winter time and plants planted in pots and protected during winter time, when plants were removed in to polytunel greenhouse from end of November until end of March. Growth phenology of woody plants refers to seasonal biological life cycles driven by environmental factors, and is considered to be a sensitive and significant indicator of climate change. The proposed study attempted to quantify changes in selected species. Phenological studies were carried out during three years, from April 2011 to end of growing season in 2013. Growing phenological characteristics were evaluated and the success of adaptation to the specific environmental conditions which plants was introduced. Within study period the year increment of individual plants was assessed and compared between two forms of plantings. The pigments and carbohydrate content in leaves for ever green species were analysed. The sample of young, one year leaves had been taken in end of January when temperature over night was -7°C. The results showed that there are significant differences between plants planted outside and plants protected during winter time in all of studied characteristics. Plants planted in ground had the higher chlorophyll *a* and, chlorophyll *b* as well as carotene content in the leaves in comparison with plants in pots which were in greenhouse when temperature has recorded from 4 to 8°C. On the other hand there was found lower content of starch and total sugar content in the leaves of plants which were planted in land on open spaces. The differences in studied metabolites content were statistically significant. The study obtained results showed that the lowest winter hardiness was in *Callistemon laevis.* The study found that a better hardiness was shown by the deciduous plants. Growth phenophases presented relatively great differences at the all observed individuals in each year and in both planting types and still greater during all period of observation.

Keywords:

Plant introduction, Mediterranean woody plants, winter hardness, year increments, growth phenology, metabolites content in the leaves

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INTRODUCTION

Plant introduction activities have been carried out throughout the world for the past few centuries. In the past the agencies for plant introduction activities were travellers, pilgrims, invaders, explorers or naturalists. The movement of plants within the old world countries was possible much earlier because of geographic contact compared to the exchange of plants between the new world and the old world. Since the earliest times man has carried, intentionally or unintentionally, plants over great distances and has created new environments in which certain species were able to establish themselves. In this way, he has exercised an influence on the natural distribution areal of plant species and in some cases this has had unfortunate consequences for the original floras. However introduction of an ever-increasing number of ornamental trees and shrubs, exclusively, from European gardens, and may be considered as extending from the middle of the l8th to the middle of the l9th century. Almost all introductions of woody plants were introduced by horticulturalists, botanists, doctors, foresters, agro foresters or gardeners. A discussion of human life on this planet would not be complete without a look at the role of plants, because plants have been an integral part of human society since the beginning of civilization. The main uses of plants include sources of food, edibles, medicine, pesticides and insecticides to protect the crops; timber production, wood for making implements, utensils, tools, musical instruments, boats, oars and other household goods; cordage; ornamental plants, commercial plants; crude drugs, packaging material, wild fruits and vegetables and fuel. Between the years 1810 and 1830 John Reeves sent many valuable trees and shrubs to England, such as *Wisteria sinensis*, *Spiraea cantoniensis* and various *Azalea sp.* The identification of common morphological, life-history and reproductive traits, found among different plant species assemblages living under similar environmental conditions, have often been interpreted as a consequence of adaptive processes.
This monograph recapitulates results of the original long-term research in the field; the chapters are based on own publications mainly. It gives assortment of data, traits, properties and knowledge; those could be used as an assessment introduction of new plant elements to urban landscape in Slovakia.

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1. Current state of the problem

1.1 The importance and the processes of introduction

A great number of studies have been conducted in the field of introduction of woody plants in the world. The pattern of introduction of species has changed since the first colonization of Madagascar, reflecting transport availability as well as the socio-economic factors and three main periods of colonization can be recognized. Human -aided movement of plants and animals species an intrinsic part of our history and social development. Many of the major crops and domestic species that sustain the human population were introduced from different and original regions (MYERS and BAZELY, 2003). During the period dominated by Arab traders, similar categories of species were introduced; however their origin has included many species from east Africa. The opportunity for their introductions would have been greatly enhanced as regular trade routes were maintained. From the 11th to 14th centuries, the port of Mahilaka in the Sambirano valley was the key point of entry, being at the epicentre of land trading circuits and maritime routes (RADIMILAHY, 1997). From the utilitarian point of view the potential of native flora is not sufficient (not only in Slovakia but also in other countries of the Earth) therefore a man sought out and introduced new species in culture, selected or bred them for different reasons and differentiated forms of social-economic forms of exploitation. Many scientists and authors of a wide range of publications paid their attention to the issues of plant introductions. The introduction of North American woody plants into Europe has been treated frequently and especially more recently by K. Wein. The history of the introduction of ligneous plants into North America can be divided into three periods, the first embraces the time from the arrival of the first European settlers up to the middle of the 18th century. This period is characterized by the fact that the introduction of European woody plants is restricted chiefly to fruit trees and other useful plants with the addition of but a few ornamental shrubs. It is not astonishing since pioneers in a foreign land had a hard struggle for existence and were forced to seek the first to assure for themselves for the necessities of life, and only with increasing wealth and security of possession they found leisure to think of their surroundings beautifying. The first fruit tree introduced into the New World was the peach, which as early as the l6th century was brought into Florida by the Spaniards; from there it spread on the west and north and was planted by the white settlers as well as by the Indians. Ironically, one of the first woody ornamentals to be introduced from eastern Asia into Europe in the 18th century was a plant now considered to be extinct in nature. By the middle of the 1730*, Ginkgo biloba*, the maidenhair tree or ginkgo, was established and growing in the botanical garden in Utrecht, the species were brought back to the Netherlands on board a Dutch East India Company ship that had called at their Japanese outpost on the island of Deshima in Nagasaki harbour. While the other plants were followed ultimately from Japan in ginkgo's wake, a handful of species arrived in Europe from China, before the Japanese flora and the many plants of horticultural importance included in that flora, started to be known in the West. As a consequence, two seeds of Chinese species *Koelreuteria paniculata*, the golden rain-tree, and *Sophora japonica*, the pagoda tree or scholar's tree were found their way to Europe and eventually to the Jardin des Plantes in Paris. The seeds of these two species germinated in French soil and they were soon being cultivated on a limited basis in other European botanical gardens. Japanese honeysuckle is native to eastern Asia and it was introduced into New York in 1806 as an ornamental plant and ground cover. Now distributed over most of the southern and eastern United States, it is often planted as a source of food for wildlife. Asian bittersweet is also native to eastern Asia and was introduced into the United States in 1860 for ornamental purposes, for which it is still used in many areas. Having escaped from cultivation, it can be found

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over much of the eastern Midwest and Atlantic coast states. Both species are found throughout Ohio but seem to be more prevalent in the southern part of the state. It is generally accepted that the onset of agriculture came along with clearing of forested areas about 10000 years ago (PÄÄBO, 1999) and the development of some of the major annual food crops like wheat and barley in Mesopotamia; taro, amaranth and rice in South-East Asia; millets in China; and maize, quinoa, cassava, squashes, sweet potato and beans in Central and South America (BRETTING, 1990; HEISER, 1990).

1.2 The most important periods and the introduction content to woody plants in the world

The first recorded importation and assembly of plant material appears to have been done by an Assyrian King, Tilgarth-Pileser, on cedar trees, vines, etc. from various parts of the region around 1130 B.C. However, unrecorded introductions should took place much earlier because of new and interesting plants always attracted the attention of farmers (HARLAN, 1966). Movement of plants within the *Old World* must have occurred with great frequency due to the proximity of the countries in the region and very early contacts, almost on a routine basis. However, the discovery of the *New World* resulted in a space of explorations and plant introductions due to interest in new plants species. These included maize, cassava, beans, squash, pea nut, potato, tomato, pepper, sweet potato, tobacco and many other species during 1500 - 1800. A number of botanists/ plant explorers travelled around the world collecting the plant materials. The origin and introduction period of many species is based on the existence, meaning, and origin of names given by indigenous people (PERRIER de la BÂTHIE, 1931-1932) in relation to biogeographical criteria or human settlements. Low or high morphological variability was also inconsistently used. The status of some species, a few existing even widespread, was debated and current evidence is insufficient to draw clear conclusions. European colonialism took many of these crops to Asia, Africa and other regions of the world. Introduced crops like cotton and sugar brought new prosperity to many of these regions. Based on the area and production levels of all these introduced crops, it can be seen easily that the impact of these crops has been very significant. For example Asian rice (*Oryza sativa*) has been reported to have been grown in China for over 7000 years and 5500 years in Thailand (CHANG, 1988). Asian rice was introduced to the Middle East, North Africa and Europe as early as 1000 B.C. (CHANG, 1989). *Citrus spp.* (*Rutaceae*) and it is relatives arose from South or Southeast Asia, the main centre was apparently in North-eastern India. The natural distribution of citrus species ranges from India and southern China to northern Australia and New Caledonia. Records of earliest cultivation in China are dated back to 2200 B.C. (VERHEIJ and CORNEL, 1991). Cultivation of citrus in southern Asia is considered to be as old as that of China, although there is no recorded evidence for this. *Citrus* species were introduced in Mediterranean following the conquest of Alexander the Great. From the Mediterranean, citrus moved to the New World probably during the 16th century. The introduction of many Asian cultivars to the New World was in the 19th and 20th centuries. Citrus is now grown throughout the tropics and subtropics. The genus *Musa spp.* is native to Asia where some of 45 species abound in the tropical rainforests from India to grassland of a vast region, extending from India to the eastern fringes of Papua New Guinea. STOVER and SIMMONDS (1989) during the 16th century, they probably reached tropical America, where production and export of dessert bananas became the primary agricultural enterprise of many countries. Soybean, *Glycine max*, was first cultivated in China at least 3000 years ago. It has also long been grown in Southeast Asia and in eastern Siberia adjacent to China. Soybean reached North America approximately 200 years ago, but they arrived even earlier to Europe (WANG et al., 1991). Similarly,

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several crops that originated in one part of the world have found a home in another very different area than the original zone of their domestication. Although most plant species were introduced to supply humans with food and raw materials, *Albizia lebbeck* was introduced from Asia via Mauritius in 1814, probably for religious purposes (BINGGELI, 2003). From the above mentioned examples it becomes clear that plant introduction from times before recorded history has played a significant role in the spread and development of agriculture. The movement of plants from one country to another and from one region to another that resulted in the expression of new forms and the adaptation to new environments, has been a critical factor in the development of plants and forms of plants on which humankind is highly dependent by today. The Analamazaotra Forestry Station was established as a seed orchard to supply seeds for reforestation programmes and the use of colonists (FRANÇOIS, 1924). The systematic introduction of forestry species was carried out in the 1950. Almost about 900 tree species were introduced, of total about 440, belonging to 89 genera, grew satisfactorily in trial plots of varying sizes at 35 forestry stations (CHAUVET, 1968). Up to this time America had received eastern Asiatic woody plants entirely by way of Europe, with the possible exception of a few important trees and shrubs such as *Rosa inerrant*, which had previously come direct to America and by the end of the 18th century was already growing wild in the southern states. How it may have come there remains unknown. In the year 1861 Dr. George R. Hall, who spent nearly fifteen years in China and had also visited Japan sent a number of plants from Japan to America. In the following year he brought even more Japanese plants, some of which he sent to Parsons' Nursery, in Flushing, some to Francis Parkman in Boston, and some he planted on his own estate in Bristol, Rhode Island, where many of them are growing until today. Among the plants which he introduced can be mentioned some of them not even known in Europe, as his *Malus halliana*, *Magnolia stellata*, and *Magnolia kobus*, *Hydrangea paniculata, Hypericum patulum* and *Lilium auratum*. Introduction of an ever-increasing number of ornamental trees and shrubs, exclusively from European gardens, may be considered as extending from the middle of the l8th to the middle of the l9th century. In this period two men are outstanding figures, pioneers of the garden-craft. One is John Bartram, who in 1728 established a botanic garden at Kinsessing near Philadelphia, where he planted and cultivated American trees and shrubs, which he had collected during his travels extending from Lake Ontario to Florida. He was in an active communication with England and introduced many American plants there. On the contrary he received plants from European gardens and propagated them in America. Among these may be mentioned the horse chestnut, which probably came to America in the year 1746. His work was continued by his sons, John and William. Bartram's house and garden stand today, preserved in their original form. The distribution and unit yield of the world's current major crops show that domesticated plants frequently reach their optimum yield in a place that is very different from its origin. It is sufficient to consider for the development in Latin America of crops such as coffee, banana, citrus fruit, Soya and various grasses. This phenomenon can be explained by the initial absence of pests and diseases in the place where they have been introduced. The neglect of American native plants became more acute in the nineteenth century and was basically due to socio-economic causes and, to a lesser extent, the failure of varieties originally introduced to adapt. Only if these plants had developed under domestication they were able to expand extensively. Proof of this is the existence of specific American eco-types of many of the plants introduced, which have played a fundamental role in production and in local plant improvement programmes. Records of non-Polynesian introductions also began with the arrival of Cook in 1778. Although Nelson only recorded native and aboriginal plants, Cook in his journal stated that seeds of melons, pumpkins *(Cucurbita pepo*), and onions (*Allium cepa*) were planted on his first visit in 1778. These are the first plants for which they known their introduction dates. To assure an adequate supply

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of provisions on subsequent visits, the early voyagers often planted vegetable and crop seeds and introduced livestock to the Islands. Traveler Meares during his visits in 1788 and 1789 observed potatoes (*Solanum tuberosum*). The identification of Meares' "potato" as *S. tuberosum* is tentative since early observers also used "potato" to mean sweet potato. On his first visit to the Islands in March 1792, Vancouver introduced oranges (*Citrus sinensis*), lemons (*C. limon*), almonds (*Prunus dulcis*), some "vine plants" (grapes), and an assortment of garden seeds. In addition, he mentioned that he received musk melons (*Cucumis melo*). His comments also suggest that oranges and lemons have already existed in Hawaii prior to their arrival. Menzies, the botanist on the voyages, made the second botanical collection in Hawai'i. Most of the specimens were native plants, but he also collected two Polynesian introductions and three exotics of post-Cook origin (KENNETH, 1985).

1.3 Plant introduction process in Europe with emphasize to Slovakia (Czechoslovakia)

From historical documents, excavations, fossils, murals, but also from the first sculptural works of art we learn that this process had taken place already in the first and early human cultures of the world such as Africa, Asia and America, later in the civilizations of ancient Egypt, Mesopotamia and China. Greeks and Romans used to grow and utilize fruits, vegetables and flowers (especially roses), horseradish, onion and radish were quite attractive as well. According to the sources mentioned above (SALAŠ and LUŽNÝ, 2010) a Russian botanist and geneticist Vavilov defined 9 gene centres in terms of the origin and subsequent introduction of the plants in culture. Following are at least some of today's most important crop plants deriving from these regions:

I. Chinese (gene) centre - many fruit and ornamental trees and shrubs
II. Indian centre - eggplant, cucumber, banana, coconut
III. Central Asian centre - bean, carrot, apricot, peach, grape, onion, garlic, spinach and wheat
IV. Front Asian centre - plum, grape, fig, parsley, lettuce, wheat
V. Mediterranean centre - brassica, sugar beet, spice, celery
VI. Abyssinian centre - coffee, ricin and some legumes
VII. South Mexican and Central American centre - peppers, pumpkins, corn, cacao, ornamentals
VIII. South American centre - corn, bean, tomato, potato, groundnut (peanuts), and pineapple, ornamental flowers
IX. North American centre - strawberries, some types of sunflowers

Other authors define phytogeographical zonality of the Earth as so called florozones, where the potential use of plants for ornamental horticulture, gardening (landscape) architecture is further defined (JAKÁBOVÁ and MACHOVEC et al., 2003). In fact, it is the zoning of Walter, described by HENDRYCH (1984), later also by SUPUKA, HREŠKO and KONČEKOVÁ (2005), where the emphasis is placed on the potential use of the first seven vegetation zones from those twelve ones for introduction to Slovak geographical conditions for the open space and interior use in garden and the architectural work design. The authors effectively present a number of families and plant species growing naturally in these zones. Autochthonous flora of Slovakia represents 2500 taxa of vascular plants, 240 species of them represent woody plants (*phanaerophyta*), many of them (70 species) are in various stages of protection and danger (MAGLOCKÝ and FERÁKOVÁ, 1993). From the utilitarian point of view the potential of native flora is not sufficient (not only in Slovakia but also in other countries of the World) therefore a man sought out and introduced new species in the culture, selected or bred them for different reasons and differentiated forms of social-economic forms of utilisation. Many

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scientists and authors of a wide range of publications paid their attention to the issues of plant introductions, but in terms of Slovakia (or Czechoslovakia) were processed in particular by the authors: BENČAŤ (1967, 1982, 2002); BENČAŤ F., BENČAŤ T. and LUKÁČIK (1999); FERIANCOVÁ (2004); HRUBÍK (1995); SUPUKA (1996); SVOBODA (1958, 1976, 1981); TÁBOR and TOMAŠKO (1992); TOMAŠKO (2004); TOMAŠKO and HRUBÍK (2001); TOMAŠKO and SUPUKA (2003);VĚTVIČKA and MATOUŠOVÁ (1992). From foreign works interpretable even into the conditions of Slovakia and the objectives of this dissertation are e.g. BROWICZ (1982, 1984); BUGALA (1991); KRÜSSMANN (1985, 1986); SENETA (1991); SOKOLOV (1957, in BENČAŤ, 1982). The process of introduction of allochthonous plants from different continents or different phytogeographical areas of the Earth to Europe and increasingly also to the conditions of Slovakia (or Czechoslovakia), it was closely associated with the discovery expeditions of important business and economic travels. A cultural-cognitive content of the travellers and their journeys is tightly related to them. From a wide range of travellers will be mentioned only a few famous travellers, those have significantly contributed to the introduction of exotic species to Europe (BENČAŤ, 1982; FERIANCOVÁ, 2004; SENETA, 1991; VĚTVIČKA and MATOUŠOVÁ, 1992):

a) From North America

- J. Robin (1550-1629), French botanist and gardener of King Louis XIII. He brought to Europe
- locust *Robinia pseudoacacia*, in the year 1601 the first plantings in Paris were recorded
- Archibald Menzies (1734-1842) – doctor of the English fleet. He brought and described *Pseudotsuga menziesii, Picea sitchensis*
- David Douglas (1998-1834) – gardener of Royal gardening company in England. He brought seeds of *Abies grandis, A.amabilis, Pinus ponderosa, P. contorta*
- John Jeffrey – Royal BG gardener in Edinburgh. In the years 1850-1853 he brought *Pinus jeffrey, Tsuga heterophylla*

b) From Japan

- Engelbert Kaempfer (1651-1716) – doctor of the Dutch fleet. He described e.g. *Ginkgo billoba, Cryptomeria japonica, Larix Kaempfert*
- Karl Ivanovich Maximovič (1827-1901), Russian botanist. He described e.g. *Picea obovata, P. polita, Abies veitchii*

c) From China

- Jean Marie Delavay (1834-1895) *Abies delavayi* described by French missionary.

- Armand David (1826-1900) *Pinus armandii, Buddleia davidii* and more, it was described by French missionary. In the introductory chapter there were accented the reasons of introduction from the aspect of the provision and distribution of the species composition of food sources for mankind, but also the aspect of the social phenomenon, particularly aesthetic and decorative garden (landscape) architectonic use. The reasons for introduction of woody plants (plants) are much broader and they can be defined as follows (BENČAŤ, 1982; SUPUKA, 1996, 2000 and others): a) Extension of the species composition and diversity of food sources for mankind, but also food for farm animals - are dominant agricultural cultures, and forages, fruit and vegetables, honey plants, fruiting plants; b) Plants for the pharmaceutical and textile industry - medicinal and tonic plants, plants for utility pharmacology and drug stores, industrial plants for textile, design, or construction industry; c) Woody plants for the production of biomass for energy use - especially fast-growing trees, for our conditions, especially species of the genus *Populus, Robinia, Salix, Eucalyptus* (for the Mediterranean zone);

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d) Woody plants for forestry and forest industry, for e.g. *Abies grandis, Pseudotsuga menziesii, Populus sp., Robinia pseudoacacia, Quercus rubra, Juglans nigra, J. cinerea*;
e) Woody plants for changed environmental conditions - shallow and degraded land, emission areas, saline soil, slag heaps and industrial areas, the resort site, nutrient deficiency, local areas affected by global climate change;
f) Range expansion of plants for social benefits - aesthetic and landscape architecture, applied floristry, types of cultural knowledge and education in the field of greenery and its vegetation zones biodiversity;
g) The woody plants for research, selection, breeding and hybridization, transfer of the genome, obtaining hybrids with new properties etc.

The principles and criteria for the introduction include the following:
a) Rational choice of vegetation zones as a donator for the potential introduction - climate and hydro-pedological similarity;
b) Ecological analogy e.g. volcanic area - resistance to air pollution, forest steppes and steppes (savannah) areas resistance to drought and salinisation, subalpine zone - resistance to low temperatures;
c) Selection method according to gender complexes, which species occur in comparable vegetation zones e.g. *Acer, Tilia, Fraxinus, Picea, Pinus*, etc.;
d) Controlled acclimation - nutrition, watering, winter protection, hardening;
e) Potential utilization of the wider ecological amplitude, adaptability and phenotypic variability of species.

The process of plants introduction, resp. animals to new sites resp. culture, can be defined in the following categories, which also represent the degree of success (BENČAŤ, 1982; SOKOLOV, 1957):
a) Transfer - taking the plants into the culture of the immediate environment within the same vegetation zone, e.g. species of the genus *Cornus, Corylus, Ribes, Malus, Pyrus, Cerasus, Sambucus;*
b) Introduction – new insertion of a plant into different climatic conditions, resp. in culture, the area outside its natural growth, e.g. *Castanea sativa, Juglans regia, Morus nigra, Persica vulgaris, Tilia argentea, Picea pungens, Cryptomeria japonica;*
c) Acclimatization - adaptation of plants (trees) to new environmental conditions with different amplitude change, e.g. the use of differentiated microclimate environment (sun, shade, exposure) controlled protection from climate extremes, hardening;
d) Adaptation – a plant adapts to new environmental conditions with gradual and differentiated manifestations of growth, development and deployment of phenological stages e.g. it grows, blooms, breeds ;
e) Naturalization – a new plant introduced to new conditions of the culture, it grows, blooms, fruits, has the ability to recover progeny in a generative or vegetative way;
f) Domestication - the plant is fully adapted to new environmental conditions, acquired the ability of auto reproduction without any assistance from humans.
Many of them take the characteristics of invasive species expression, e.g. they grow at the expense of the area of some indigenous species, e.g. *Ailanthus, Reynoutria, Robinia, Syringa, Lycium, Impatiens sp.* A range of successful introduction and acclimatization by SOKOLOV (1957) defined by the following criteria (Tab. 1):

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Table 1 Range of successful introduction and acclimatization by SOKOLOV (1957)

Growth Development		Very weak and dwarf	Slow and stunted	Normal	Stronger than normal
		1	2	3	4
Does not bloom	a	Climate and soil factors at a minimum, sometimes wet	As 1a, but to lesser extent	Different size in photoperiodism, frozen sprouts	Heat moisture, nitrogen excess, frozen sprouts
It blooms but does not fruit	b	Lack of heat in winter and in summer over drought, nutrient deficiency	As 1b, but to lesser extent	Absence of pollinators, fog, rain, drought at the time of flowering	Absence of pollinators, fog, rain, drought, excess of nitrogen
It fruits, but does not give germinant seeds	c	As1b, but to a lesser extent absence of pollinators	As 1c, but to lesser extent	Drought in summer, the rest as 3b	As 4b
It fruits and gives germinant seeds	d	Lack of heat in winter, fluctuations in humidity, soil factors in the minimum	As 1d, but to lesser extent	Ecological optimum but the land is unsuitable for seed growth, competition from domestic species	Some of the factors (heat, moisture, nutrients) in excess with the optimal sites
It reproduces spontaneously	e	As 1d	As 2d	Ecological optimum coming to phytosociological optimum	New Ecological optimum coming to phytosociological optimum

Historical and developmental stages of introduction are focusing on the introduction of plants to culture in the territory of Europe and with emphasis on conditions in Slovakia, BENČAŤ (1982). He distinguishes the following phases:

1st phase - (2nd millennium BC) - mainly agricultural plants were gradually introduced into the European region from Asia, e.g. wheat, oats, peas, as well as medicinal plants (known to be about 700 formulations) and ritual plants, e.g. thyme - *Boswellia carteri*;

2nd phase - (2nd-3rd century BC, especially the period of A. Macedon 356-323 BC) - apricots, peaches, rice, cotton were imported from Asia to the Mediterranean;

3rd phase - (7th-12th century BC) – phase of introduction of agricultural areas from Central Asia to Europe via the Mediterranean, e.g. apricot, peach, mulberry, grape;

4th phase - (12th-17th century BC) – phase of botanical introduction;

- from the Mediterranean to Central Europe, in particular a number of evergreen species
- from North America (1492, resp. in the period 1500 to 1520) to Europe a number of plants and industrial plants, e.g. *Robinia*, *Picea, Thuja sp*. and other; .

5th phase - (18th - 19th century AD) – phase of park introduction and building of the botanical gardens in European area and Slovakia;

6th phase of forestry introduction - (19th-20th century) - the importation of seed plants, particularly from North America to Europe across the English, German and French nurseries and their implementation in forestry practices as a priority for reasons of timber production and diversification of cultivated plants. The most common species of the genus are: *Carya, Celtis, Populus, Quercus, Juglans, Robinia, Abies, Picea, Pinus, Pseudotsuga, Tsuga,* and *Thuja.* The introduction part was the establishment of arboreta in Slovakia, e.g. Feismantlova Garden near B. Štiavnica (1830), Arbo-

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retum Mlyňany (1892), Arboretum Kysihýbel (1900), Arboretum Borová hora near VŠLD (TU) Zvolen (1965);

7th phase of scientifically controlled introduction - a purposeful introduction for comprehensive evaluation and research process of adaptation and acclimation of introduce in new conditions and subsequent multi-use potential. Arboretum Mlyňany became one of these objects in Slovakia - SAV Institute of dendrobiology, especially after 1953, when it started the object of the research institutes of SAV. New areas were established according to phytogeographical regions, e.g. China, Korea, Central Asia, Caucasus, North America, Slovak dendroflora etc. A part of introduction was a growth-production, eco-physiological, reproductive, genetic, phytopathological and garden and architectural research of newly introduced species and their varying forms. The content approach continues even today and not only in the Arboretum area (currently in a substantially reduced form), but also in other botanical gardens and arboretums in Slovakia, the Czech Republic and further abroad.

Currently, according to the available literature sources (BENČAŤ, 1982; BENČAŤ and SUPUKA, 1989; TÁBOR and TOMAŠKO, 1992) exotic species gene pool are balanced according to various forms of exploitation as it follows:

- In the years 1960-1970 in the largest introductory area in Slovakia - Arboretum Mlyňany, ÚD SAV (ID SAS), there was recorded 1658 taxa and taxonoids, 314 of them were sempervirents and hiemivirents, 253 coniferous taxa, 1091 taxa of deciduous trees (BENČAŤ, 1967).
- In 1982 there were recorded 34 species of exotic plants on the forest land of Slovakia on the reduced area of 63 thousand ha and for the application in the development of urban forest parks there was recommended 49 allochthonous tree species.
- For the creation of green spaces in urban settlements in Slovakia (and Czech Republic) it was recommended the possible use of 1400 sorts of plants and 900 cultivars, autochthonous and allochthonous.
- Within the climate regionalization (BENČAŤ, 1982) according to climatic zones A, B, C it was recommended to use 635 kinds of exotic plants.
- In the Arboretum Mlyňany in 1992 (TÁBOR and TOMAŠKO, 1992) there were registered nearly 2200 taxa those have been successfully introduced and potentially applicable in Slovakia.

The process of introduction of exotic species and their growth manifestations in the introductory area of Arboretum Mlyňany later describes TOMAŠKO (1996), dividing them into three phases: acclimatization, domestication and naturalization. He points to the fact that in Arboretum Mlyňany there is recorded more than 150 introduced taxa, which naturally regenerate, as a result of their high adaptability to new environmental conditions. At the same time he introduces a list of 20 species of conifers and 33 species of broadleaved deciduous trees, where naturalization and manifestation of natural regeneration is evaluated according to the following scale:

a) Isolated from the seeds of self-renewal (39 species)

b) Medium self-renewal (12 species)

c) Carpet self-renewal (2 species)

In recent years, the highest degree of the successful introductions of exotic plants (plants) is assessed in terms of a natural gene pool (gene pool of indigenous plant populations and indigenous ecosystems) in Slovakia, where many exotic trees and flowering herbs uncontrollably escaped from the culture into the country via their diaspora (seeds), tubers or polykormons. They have imaginary biological expression, displacing indigenous plants from the original sites and spontaneously occupy such sites. This also resulted in the recent high aversion to native species of plants and herbs, espe-

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cially in terms of nature and landscape protection (ELIÁŠ, 2001; SUPUKA, 1977). The introduction of exotic plants and herbs has its importance and relevance also in the next period particularly in the aspects of defined utilitarian values of a wide range. However, it must be based on the principle of science (scientific research) controlled introduction with the exact evaluation of growth and biological manifestations and precise control of the naturalization process with the potential of invasive expression and escape from the culture into autochthonous populations and ecosystems. The potential for introduction particularly in warmer phytogeographical areas into the Central European Area is closely linked with global climate changes, warming and iridizations. Potential introduce uses occur especially in the preservation of endangered species, culture and education, garden and architectonic development, in alternative forms of prevention, treatment and food sources as well as a wide range of biomass. These are the main reasons for the evaluation of the selected woody species introduction from the Mediterranean zone in the Middle East into Central European conditions of Slovakia (or the Czech Republic).

1.4 Phenology importance for climate change studies

Numerous examples – from the duration of the growing season for gingko trees in Japan to the flowering of lilac in the USA or the flowering of snowdrops in Germany – show that climate change is significantly changing the seasonality of our eco-systems, especially in the middle and higher northern latitudes. The IPCC (Intergovernmental Panel on Climate Change concluded in its Third Assessment Report in 2001 that many physical and biological systems, such as hydrology, glaciers and ice, vegetation, insects, birds and mammals, are already reacting to changing temperatures. By far the majority of these reactions are proceeding in the expected direction, i.e. they reflect the known relationship with temperature. The importance of phenology lies in its effectiveness as a tool to monitor impacts of climate change on plants and animals. Some imminent effects on vegetation include: (1) range shifts towards the Polar Regions and higher altitudes; (2) changes in population density and composition of vegetation; (3) longer growing seasons; and (4) earlier plant flowering, earlier breeding times, earlier egg laying in the year. The last two criteria should be best delineated by phenology. The intervals at which such events occur are very closely related to climate and weather conditions, mainly temperature in spring and summer (MENZEL, 2003; SPARKS et al., 2001). Unlike the change in range shifts or changing composition of eco-systems, which can be confounded by other drivers, such as land use change or habitat fragmentation, however the temperature is a crucial factor of influence here. Thus, phenology is probably the simplest and most cost effective means of observing the properties of changes in temperature, and consequently, phenology has become an important tool in global change research (SPARKS and MENZEL, 2002; WALTHER et al., 2002). The use of phenology as a biological indicator of climate change presupposes which: (1) precise quantitative analysis of changes in phenological time series, (2) is a known relationship with temperature and or precipitation (3) is an analogous change in corresponding temperature and or precipitation series over time (ROOT et al., 2003). In case that phenological study series are correct during the period of instrumental meteorological measurements, such as for the oldest known series which stems from Kyoto in Japan or the observations of the Marsham family in Norfolk, Great Britain, the findings observed in plants can also be taken as proxy or substitute data for temperatures. The records, kept in conjunction with grape picking in France, Switzerland and the German Rhineland since 1480, are a prime example here allowing an assessment of average temperature during the growing season (MENZEL, 2005). The geographical distribution of many plant species included in restoration efforts spans a wide

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range of climatic and edaphically conditions. Habitat heterogeneity, combined with natural selection, often results in multiple, genetically distinct ecotypes within a single species (LINHART and GRANT, 1996). Leaf unfolding, flowering of plants in spring, fruit ripening, colour changing and leaf fall in autumn as well as the appearance and departure of migrating birds and the timing of animal breeding are all examples of phenological events. The task of plant - phenology is to observe and record the periodically recurring growth stages and to study the regularities and dependency of the yearly cycles of development on environmental conditions. Subdivision of the development cycle plants into principal and secondary stages as well as (a) into principal, meso - and secondary stages or (b) the meso- stages, are inserted between the principal and the secondary stages, modified according to a draft by WITZENBERGER et al., (1989) (Fig. 1). Plant traits were associated with geographical extent in several studies with a narrow geographical or taxonomic focus (ROBER et al., 2008).

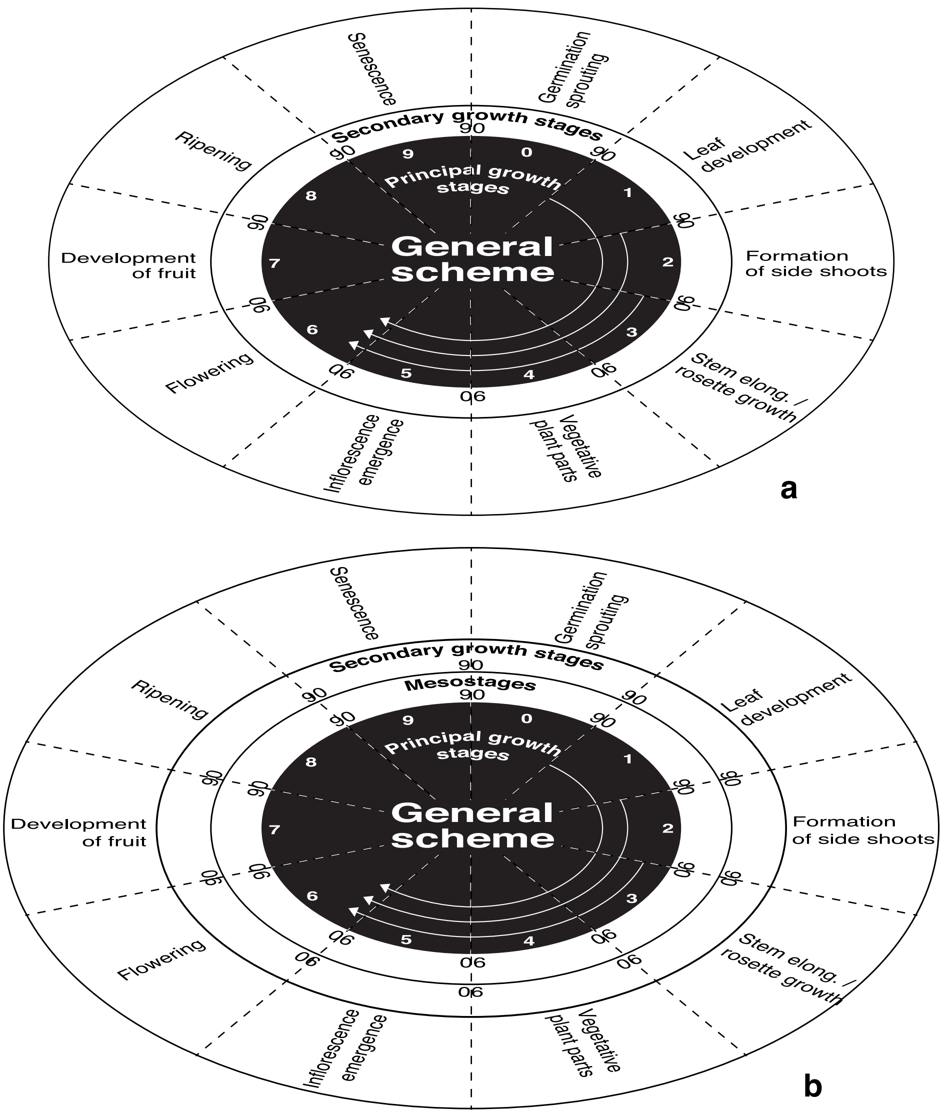

Figure 1 Subdivision of the development cycle plants into principal and secondary stages as well as (a) into principal, meso - and secondary stages or (b) the meso-stages are inserted between the principal and the secondary stages (WITZENBERGER et al., 1989).

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1.5 Hardiness and physical stress in woody plants

Plants are constantly facing the different environmental changes requiring rapid transition and/or seasonal responses. They are able to grow in most natural environments by adapting to a wide range of conditions. This adaptability is an essential natural mechanism, because the anchoring of the plants to the soil does not allow them to escape unfavourable conditions. Among these limiting conditions, low temperatures, i.e. all temperatures below the optimum for the considered species, represent a major environmental constraint affecting the distribution, growth and productivity of crops or wild-plant species (RENAUT et al., 2005). The ability of woody plants to cold harden is promoted in early autumn into leaves where sugars and other protective substances accumulate. The proteins are rearranged, the cells become less turgid and the central vacuole is divided into many small vacuoles. Concomitantly, the growth cessation also occurs. The ability of woody perennials to survive winter is depending on their entry into dormancy state as well as the development of their cold acclimation achieved by a continuous exposure from -5 to -15°C. In late autumn, after leaves have dropped and with the first frosts (up to -3°C), trees become dormant. The wide distribution of this species and its adaptation to a variety of environments, its short generation time and its small stature, it make them ideal for ecophysiological and genetic studies, and it was used for nearly 40 years in a biotic stress and dormancy research (SVENDSEN et al., 2007). Cold acclimation is associated with changes at morphological, metabolic, proteomic and gene expression levels. Among other changes, cold-acclimated plants can cope with the cold-impaired photosynthetic components such as induced changes in pigment complexes, reduced net and maximal photosynthetic rates, induced losses of photochemical efficiency, restricted electron transport and enzyme activity or reduced carbohydrate metabolism. Environmental stresses arise from conditions that are unfavourable for the optimal growth and development of organisms. Environmental stresses can be classified either as a biotic or biotic. A biotic stresses are produced by inappropriate levels of physical components of the environment, including temperature extremes. Biotic stresses are caused by pathogens, parasites, predators, and other competing organisms. Even though biotic and abiotic stresses cause injury through unique mechanisms that result in specific responses, all forms of stress seem to elicit a common set of responses. For instance, both biotic and abiotic stresses can result in oxidative stress through the formation of free radicals, which are highly destructive to lipids, nucleic acids, and proteins. Another example is water stress, which is produced as a secondary stress by chilling, freezing, heat, and salt, as a tertiary stress by radiation, and, of course, as a primary stress during drought (KAPLAN et al., 2004). Cold stress is a major a biotic stress that limits plant distribution and agricultural productivity in hilly areas (MAHFOOZI et al., 2006). In such cold climates, plants are frequently exposed to sub-zero temperatures in the autumn, winter, and spring seasons, since require specialised mechanisms to survive exposure to low temperature (SANDVEA et al., 2011). Most temperate plant species have evolved a degree of cold tolerance, the extent of which is typically dependent on a combination of the minimum temperature experienced and the length of exposure to cold stress. Plants respond and adapt to low temperature stress to survive under cold winter conditions at the molecular and cellular levels as well as at the physiological and biochemical levels. With temperatures decline during the fall and winter, plant cells encounter three main problems: changes in the spatial organization of biological membranes, a retardation of biochemical and chemical reactions, and alterations in the availability and status of water (FERULLO et al., 1997).

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1.6 Climate condition's effect on Mediterranean plants phenology

The typical characteristic of Mediterranean climates is that high-temperature peaks coincide with the lowest rainfall levels along the year: i.e. the distinctive Mediterranean summer drought (DI CASTRI et al., 1981). In relatively cool and cold Mediterranean continental areas winter cold is also a limiting period which, along summer drought, breaks down the growing season into two separate and short periods: spring and the beginning of fall (MITRAKOS, 1980). In spite of these constraints, phenological patterns of Mediterranean phanaerophytes are highly diverse, probably due to a huge variety of structural and floristic backgrounds (CHRISTODOULAKIS, 1992; KUMMEROW, 1983; MOONEY et al., 1977). Such diversity leads to the striking fact that many phenological patterns are seemingly discordant with current climate (MONTSERRAT- MARTI et al., 2004; ORSHAN, 1989). A bulk of previous literature has informed about the phenology of Mediterranean woody plants (CABEZUDO et al., 2009; CASTRO-DIEZ et al., 2005; CORREIA et al., 1992; DE LILLIS and FONTANELLA, 1992; KUMMEROW, 1983; MONTENEGRO, 1987; MILLA et al., 2010; SIMOES et al., 2008). Several general patterns have arisen from this extensive research effort. In mild sites, as compared to harsher ones, the phenophases tend to be long, and also tend to avoid the overlap of one with another (BLUMLER, 2005; KUMMEROW, 1983; MOONEY and DUNN, 1970). Moreover, vegetative phenophases and flowering tend to occur in spring, while other phenophases, such as fruiting, display a more variable chronology (ORSHAN, 1989). Vegetative growth tends to continue in summer in Australian and South African Mediterranean sites (SPECHT et al., 1981), whereas in the Mediterranean basin vegetative growth during the beginning of summer only happens when roots go deep enough (CASTRO-DIEZ et al., 2005; HOFFMANN and KUMMEROW, 1978). Phenological adjustments dealing with the Mediterranean summer drought have been intensively studied (KUMMEROW et al., 1981; KYPARISSIS et al., 1997; MONTENEGRO, 1987; SPANO et al., 2003), but only anecdotal effort has been focused on the adjustments to face winter cold (OLIVEIRA and PENUELAS, 2002; PALACIO et al., 2005), despite the huge extension of winter-cold Mediterranean areas in regions like the Iberian peninsula. In addition, basic phenological issues, such as phenological synchrony within populations or how suitable are different periods of the year for a wide array of phenophases, are poorly addressed.

1.7 Plant metabolic as potential markers for assessment of adaptability to changed environment conditions

1.7.1 Chlorophyll and carotenoids in plants

Chlorophyll is green molecule in plant cells which plays important role in photosynthesis process. It absorbs sunlight and uses its energy to synthesis carbohydrates from CO_2 and water. There are two types of chlorophyll in plants, chlorophyll a and b, while both of them works as photoreceptor in photosynthesis. It is well known that photosynthesis systems in higher plants are most sensitive to drought stress (FALK et al., 1996). Both biotic and abiotic stress factors affect the content and efficiency of leaf photosynthetic pigments or their reciprocal ratio (BACCI et al., 1998). For example, the assessment of leaf photosynthetic pigments is an important indicator of senescence because breakdown of leaf chlorophyll is associated with environmental stress (BROWN et al., 1991). The chlorophyll content is an important experimental parameter in agronomy and plant biology research (LAMB et al., 2012). Amount of chlorophyll shows alteration depending on many climatic factors such as light (GÜNEŞ and İNAL, 1995; DEMIRCIOĞLU and YILMAZ, 2005), water stress (DEMIREL et al., 2010; KALEFETOĞLU and EKMEKÇI, 2005) and also fertilizing (TUNALI et al., 2012). The quantity of chlorophyll in leaves shows an alteration by being affected with many factors. In addition to this, it

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is known that plant species and position of leave affect the amount of chlorophyll in leave (GOND et al., 2012). (ROSE and HAASE, 2002) reported that chlorophyll fluorescence measurements are useful for determining cold hardiness and resistance to stress, because they provide a rapid assessment of seedling vigour following exposure to freezing. Sun leaves are known to differ from shade leaves in their composition of photosynthetic pigments, chloroplast ultra structure, photosynthetic rates, and resistance to light stress (SARIJEVA et al., 2007). Species of *Acer pseudoplatanus* , *Fagus sylvatica, Tilia cordata* and *Abies alba* have higher total chlorophyll content in leaf dry weight basis on the shade adapted than in sun adapted leaves; however this trend was reversed when sun and shade leaves were compared to the leaf area basis (LICHTENTHALER et al., 2007). Carotenoids have two important functions in plants. First, they can contribute to photosynthesis. They do this by transferring some of the light energy. They absorb to chlorophylls, which then use this energy to drive photosynthesis. Second, they can protect plants which are over-exposed to sunlight. They perform it by harmlessly dissipating excess light energy which they absorb as heat. In the absence of carotenoids, this excess light energy could destroy proteins, membranes, and other molecules. Carotenoids have a very important role in photosynthesis. Biosynthesis of carotenoids in plants is a genetic characteristic, but environmental conditions also have an essential role. Plant carotenoids are red, orange, and yellow lipid-soluble pigments found embedded in the membranes of chloroplasts and chromoplasts. Their colour is masked by chlorophyll in photosynthetic tissues, but in late stages of plant development these pigments contribute to the bright colours of many flowers and fruits and the carrot root. Carotenoids protect photosynthetic organisms against potentially harmful photooxidative processes and they are essential structural components of the photosynthetic antenna and reaction centre complexes. In plants, some of these compounds are precursors of abscise acid (ABA), a phytohormone that modulates developmental and stress processes (KOORNNEEF, 1986).

1.7.2 Content of starch and sugar (carbohydrate) in the plants

The most important thing, if growing for a processing contract, is to grow the right variety. Dry matter content varies considerably between varieties and it is a strongly inherited characteristic. Irrespective of cultural conditions that can affect dry matter, the certain varieties are consistently high in dry matter, while others are consistently low. Starch is the major storage of plants nutrient. Carbohydrate contents of forage vary widely due to the interaction of plants and their environment. These variables include: species and variety of the forage, stage of growth, and environmental conditions during plant growth. Environmental factors include temperature, light intensity and availability of water and nutrients. Temperature was shown to have an effect on mobilizing carbohydrate from leaves (HARTT, 1965; POTVIN and STRAIN, 1985). RODRIGUES and RYAN (1960) reported that the seasonal fluctuation in carbohydrates in various deciduous, subtropical, and tropical fruit trees have shown that similar changes occur in such trees as apple, avocado and citrus, despite important physiological differences between the species. The studies indicated that fluctuations in carbohydrates are influenced by seasonal environmental factors and by the growth activity of the plants. There had the critical evaluations and strong overtones throughout on the role of the principal climate that influence growth by the intermediation of internal bio physicochemical processes such as photosynthesis and carbon balance (KÖRNER, 2003). For example, temperature influences rates of photosynthesis and respiration, as well as growth rate associated with rates of cell division and elongation. Levels of soluble sugars and starch reflect the balance between carbon gain (photosynthesis) and loss (growth and maintenance respiration) within the plant, representing a tree's capital for growth after dormancy and acting as a buffer for insufficient source activity (photosynthesis) due to adverse weather conditions or loss of foliage. In the green-

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house, day/night temperatures are maintained at specific levels for each plant to obtain profitable yield and marketable quality at prevailing solar radiant energy levels. These temperatures determine the rate of apparent photosynthesis for the entire plant over 24- hour's period. Since more plants growth occur during the night than during the day, the night temperatures are stressing in any recommendations of optimum temperature for flowering plants (MASTALERZ, 1977a, 1977b). The temporal type of long-term changes, in non-structural carbohydrates in tree tissues, is an important characteristic that reflects the relative balance between source (net canopy assimilation) and sinks (the use of assimilates for growth and respiration). Carbohydrate dynamics are also related to seasonal fluctuations in cold hardiness (PARKER, 1959). Because of the relationship between carbohydrate concentration and CO_2 exchange, carbohydrate concentration is frequently used as a measure of environmental and physiological constraints on plant yield (STOCKFORS and LINDER, 1998; TJOELKER et al., 1999).

1.7.3 Soil importance for plant growth

Growing media have several important functions in relation to plant growth. The provide a support for plant, serve as a source of supply for water and essential plant nutrients, and permit the diffusion of oxygen to the roots. Mineral soils are composed of inorganic and organic particles, water and air. The solid particles occupy approximately one – half of the total volume of soils surface and they are mainly inorganic.

Many of important physical and chemical properties of soils are related to the size of mineral particles. The contrast in moisture and nutrient retention between the soils of different textures is compensating by adjusting the quantities of organic matter and the coarse aggregate in relation to the texture of soil. Soil structure is another important constituent of soil and soil mixtures (MASTALERZ, 1977b). From the 92 of elements presenting in the earth's crust, only 17 elements are known to be essential to all plants, and 12 elements are proven to be potentially beneficial in trace amounts.

Knowledge of the element content of soil is an essential component, determining soil quality, detecting soil contamination, and monitoring contamination events from accidental spills or atmospheric deposition. Element content, together with other soil properties, is used to assess the soil condition and its suitability for plants. The great attention is paid to the problematic of the chemical elements accumulation and their relationships to each other in plants. At the same time, the biogenic accumulation of chemical elements by plants at the initial stages of primary soil formation in the case of intense year-round plant cultivation under the condition of physical modelling of soil-plant systems under controlled conditions is poorly studied. This problem is very interesting from both theoretical and minerals´ movement (MUKHOMOROV and ANIKINA, 2010). As it is known, the chemical elemental composition of plants differs significantly from the composition of rocks. This causes the plants to observe the ways for self-sufficiency of chemical elements and to adapt to the peculiarities of geochemical environment. This adaptation is reflected in the existence of links in the content of chemical elements into plants, which is leading to synergism or antagonism. These interactions are due to the ability of a chemical element to inhibit or stimulate the absorption of other elements by plants. This problem is interesting both from theoretical and practical point of view. The dynamic relationships identification allows the development the methods of elemental composition regulation for agricultural production in high farming (FALLAHI et al., 2001). Number of fundamental studies dealt with the problem of the close relationship between the plants chemical elements composition and soils on those they grow under natural conditions. At the same time, the biogenic accumulation of chemical elements by plants at initial stages of primary soil formation in the case of intense year-round plant cultivation under the condition of physical modelling of soil-plant systems under controlled conditions has been poorly

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studied. This problem is very interesting from both theoretical and practical points of view (ERMAKOV and MUKHOMOROV, 2001; ERMAKOV and ANIKINA, 2007; NEILSEN et al., 2009). Likewise soil pH directly affects life and growth of plants because it affects the availability of all plant nutrients. Between pH 6.0 and 6.5, majority plant nutrients are in their most available state. A nutrient must be soluble and remain soluble long enough to successfully travel through the soil solution into the roots. Nitrogen, for example, has its greatest solubility between soil pH 4 and soil pH 8. Above or below that range, its solubility is seriously restricted. Yet the nutrient phosphorus is most available for plant uptake at pH 6.0 to 6.8. The aluminium element, which is not a nutrient but it is a component of most soil minerals, becomes increasingly soluble and toxic at soil pH < 5. Certain nutrients also increase in availability for plant uptake as pH decreases, such as iron, manganese, and copper. These same nutrients could become unavailable (chemically "tied up") at pH 7.0 or above.

1.7.4 The role of watering on the plants growth and the irrigation systems

Woody plants are subjected to multiple biotic and abiotic stresses. The important abiotic stresses include extremes in light intensity, drought, flooding, temperature, pollution, wind, low soil fertility and fire. Among the major biotic stresses are plant completions, attacks by insects and pathogens, some activities of humans (KOZLOWSKI and PALLARDY, 1997). Varying soil conditions have a major influence on the suitability of soils for irrigation purposes. Soil with high clay content usually has a lower infiltration rate, intensifying irrigation management not to over-irrigate, while allowing a higher degree of freedom in sandy soils. Soil depth and water-holding capacity contributes to the choice of managing irrigation optimally. The specific use of various irrigation equipment which is more beneficial to water conservation while applying an adequate amount of water is a very controversial question with many advantages and disadvantages to current systems. At present, the systems most widely used are sprinkler irrigation followed by flood and then micro (drip) irrigation. Micro irrigation has the highest efficiency level with a mean of 85% (BACKEBERG and ODENDAAL, 1998). Water is equally important for plants. It performs many important functions in plants, during the process of photosynthesis; plants synthesize carbohydrates from carbon dioxide and water. Therefore, water is one of the essential components for the plant. Water acts as a solvent for fertilizers and other minerals, which are taken up by the plant roots in the form of solution. Thus water serves as medium in which plants absorb soluble nutrients from the soil. Water works as medium for transport of chemicals to and from cells, it also provides pressure in plant cells and the firmness to the plants. Water typically constitutes 80-95% of the mass of growing plant tissues and plays a crucial role for plant growth (ARAYA, 2007). Plants require water, soil nutrients, carbon dioxide, oxygen and solar radiation for growth. From these mentioned, the water is most often the most limiting: influencing productivity. Irrigation water source must be large enough to provide sufficient water when it is needed. Because irrigation is not totally efficient, the water supply rate must exceed the rate of crop use. The water requirements depend on climate, plant, and amount of available soil moisture. Water use changes during the growing season and is difficult to predict. Therefore, the water supply systems are generally evaluated using two criteria-seasonal water demands and daily water demands. The water supply must be sufficient to satisfy the requirements of the irrigation system and supply enough water to meet crop needs. For choosing the irrigation system must consider many factors. These may include issues relating to: field considerations such as soil type, drainage, erosion potential, location of power sources, topography (including pumping lifts), and distance from water supplies, water considerations such as availability, quantity, quality, costs to develop a water supply, and annual plants water requirements, plants considerations such as yield potential, frost protection requirements, and cultural practices relating to planting, pest

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management, and harvesting system considerations such as the type of power supply, labour requirements and availability, and initial capital and annual operating costs. Growers use basically six types of irrigation systems: hand-moved sprinklers, solid-set sprinklers, hand-moved big guns, travelling big gun, centre pivots, and trickle/drip. Each irrigation system type has its own advantages and disadvantages for a given application. Irrigation with a drip system uses less water than sprinkler irrigation (PROEBSTING, 1994). The advantages of drip irrigation are water saving and a huge benefit of plants because water accesses to the root zone directly leading to decrease weed problem, instead of losing in between the plant rows. Its disadvantage is a clogging of emitters which may require the high maintenance and good water filtration (KELLER, 1990).

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2. Scientific research aims

In consideration to the graduate country of origin, which is the Middle East, the State of Iraq, the objectives of the thesis are defined as it follows:
a) Evaluation of the woody species introductions over the world and of the Mediterranean zone, with the emphasis on the Middle East, to Central European conditions of Slovak Republic, resp. Czechoslovakia.
b) Comparison of the climate and geographical conditions of original Mediterranean zone - Middle East (Iraq and surrounding areas) to the conditions of studied objects in Slovakia, resp. Czech Republic.
c) The evaluation of the current genetic resources state of Mediterranean dendroflora in selected arboretums and botanical gardens in Slovakia, resp. the Czech Republic. Principal arboretums and botanical gardens for the purpose of this evaluation are: Arboretum Mlyňany of the Slovak Academy of Science (AM – SAS), Botanical garden of the Slovak University of Agriculture in Nitra (SUA), Botanical Garden in Brno (Mendel University), and Lednice Park in Moravia.
d) Setting up an experiment by pots and land experiments with 10 lesser-known woody plants (shrubs) of Mediterranean autochthonous and or most often used dendroflora. Each species is represented by a number of 3-5 individuals, and research was conducted during 2-3 growing seasons (2011-2013). The experiment was established at the premises of the Botanical Garden SUA Nitra.
e) The phenology observation and growth characteristics continuous assessment as well as the statistical significance final evaluation.
f) Assessment of nutrient content in the land and pot's soils at the experimental plots of woody plants.
g) Evaluation of chosen metabolic in the leaves of studied woody plants as potential markers of the hardiness (chlorophyll *a, b*, *a+b, a/b,* chlorophyll *a+b/* car., carotenoids, total sugars and starch).

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3. Materials and methods

3.1 The introduction processes database and list of Mediterranean woody plant collection in chosen dendrological objects in Slovak Republic and Czech Republic

In this study we selected the Lednice park, Arboretum Mlyňany, Brno and Botanical garden in Nitra to evaluate the introduced Mediterranean woody plants in this dendrogical objects according to (ZELENÝ, 2012; HOŤKA and BARTA, 2012; HOŤKA et al., 2010; BRINDZA, 2003).

3.2 Mediterranean woody plants, short description which are used in experiment and the study plots scheme in Botanical Garden of the SUA Nitra

The study was realised (2011 – 2014) in Botanical garden of Slovak University of Agriculture in Nitra, Slovak Republic. Ten species of Mediterranean woody shrubs were planted into the kind of plantings, plants planted directly into the soil and the distance between plants and other was 1000 mm in the same species and 700 mm between species and plant planted in pots which is removed during the winter time from middle of November until end of March in side the greenhouse average temperature was 8°C during winter time (Fig. 2). The plants which were planted into the ground were protected over winter by covering the part of plants which is near the ground by foliage. The species, selected from Florence nursery in Italy, were all the plants in the same size and in the same age. The plants were irrigated by drip irrigation system and during the experiment period the plants were controlled against the pest. The occurrences of diseases and pests on study woody plants are processed according to method of JUHÁSOVÁ and HRUBÍK (1984). At the same time the plants were supplied with NPK nutrients twice in a year.
The identification of common morphological, life-history and reproductive traits were found among different plant species assemblages living under similar environmental conditions, those have often been interpreted as a consequence of adaptive processes. However, with the inclusion of biogeography and paleontological thought into our understanding of the ways that different plant assemblages have been formed, ecologists are now aware that ecological patterns can also be the result of historical process derived from the dynamics of regional taxonomic assemblage and or from differential representation in regional species assemblages caused by differences in diversification rates of lineages (HERRERA, 1992; SUC, 1984). For research study it was used 10 woody species. Their general biological characteristics are described as it follows:

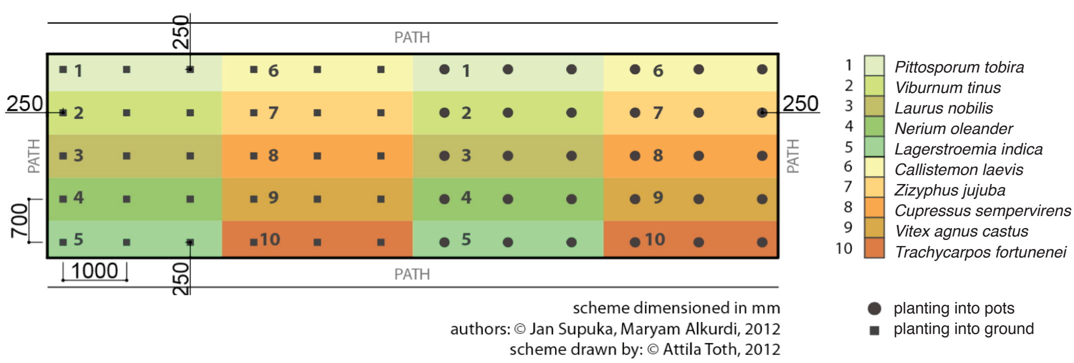

Figure 2 Planting scheme for studied woody plant species (1-10)

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3.2.1 *Vitex agnus –castus* L.

Vitex agnus –castus (Chaste tree) is a member of the *Verbenaceae* (*Lamiaceae*) family, native to the Mediterranean and central Asia. The fruit has aroma and taste like a spicy pepper. The dried ripe fruits are used in medicine (YUNUS and GUNGOR, 2008). Chaste tree can be grown as a large, deciduous, multi stemmed shrub or small, 10 to 15 feet tall tree perhaps 20 feet (with lots of training), and it is noteworthy for its splendid during the summer displaying (late springtime in the deep South) of fragrant, upwardly pointing, terminal panicles of white or blue blooms which are quite attractive to butterflies and bees. (The tree is often planted there, where honey is marketed to promote excellent honey production). The trunk is gray and blocky and somewhat ornamental. The sage scented leaves of Chaste tree are shaped liked a hand, or palmate, and they were once believed to have sedative effects and no fall colour change *Vitex* has the common name “Chaste tree” since Athenian women used the leaves in their beds to keep themselves chaste during the feasts of Ceres. *Vitex* seeds itself into landscaped beds and they can become somewhat weedy, tree grows in shade part of sun; tree grows in full of sunny part. Soil tolerances are: clay; loam; sand; acidic; alkaline and well-drained (EDWARD and DENNIS, 1994a; YUNUS and HASAN, 1998).

3.2.2 *Nerium oleander* L.

Nerium oleander is an evergreen shrub originating from Mediterranean and is widely cultivated in tropical and subtropical regions as an ornamental plant. The plant grows rapidly and often is used for highway barriers, road sides, and other areas that require screening from noise and pollution (ARASH and ALIREZA, 2011). Four meters high, having dark or grey leaves, 10-22 cm long, narrow, and toothed with short – stalk leaves with prominent midrib, leathery texture in groups of three leaves. The plant produces pink or white terminal flower, flowering appears from June to October (HILLIER and COOMBES, 2007). The fruit consists of a long narrow capsule 10-13 cm in diameter which opens to disperse fluffy seeds, fruiting is uncommon in cultivated plants. The plant exudes a thick white sap when a twig or branch is broken or cut (BELL and BRYAN, 2008). It is widely cultivated as ornamental plant worldwide particularly in warm, temperate, and sub – tropical environment in parks, gardens and along roadsides. This plant is highly toxic to living organisms. The main poisonous components of the toxicity are cardiac glycoside e.g. oleandrine (HERITEAU, 2005).

3.2.3 *Viburnum tinus* L.

Viburnum tinus (Laurustinus, Laurestine) is distributed in the whole southern Europe and North Africa in areas of Mediterranean climate. It is a constituent of the larger and more vigorous macchia type of associations. It is a shrub (rarely a small tree) reaching up to 2-7 m tall, with a dense, rounded crown, the Family is *Adoxaceae*. The leaves are evergreen, persisting 2-3 years, ovate to elliptic, borne in opposite pairs, 4-10 cm long and 2-4 cm broad, with an entire edge. The flowers are small, white or light pink, produced from reddish-pink buds in dense cymes 5-10 cm diameter during the winter. The fragrant flowers are bisexual and pentamerous. The flowering period is from October to June. Pollination is by insects. The fruit is a dark blue-black drupe 5-7 mm long. The upright, dense, evergreen form makes it a good shrub for background, barrier or screen plantings, especially if there is not much room for a wide spreading plant. Stems are strong, keeping the plant upright, even when flowering, they are working well as clipped or unclipped hedges. Laurestine can also be used as a specimen planted alone as accenting in the garden Laurustinus grows in full sun or partial shade on moderately fertile, nematode-free, well-drained soils, but it tolerates fairly poor soils. They are easy to maintain it in the container. Plants on 3 to 4 foot-centres, they form a massive planting in the landscape. Because

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plants grow slowly, they require little pruning to maintain the upright form (EDWARD and DENNIS, 1999).

3.2.4 *Laurus nobilis* L.

Laurus is a genus of evergreen trees belonging to the Laurel Family, *Lauraceae*. The genus includes three species, whose diagnostic key characters often overlap (MABBERLEY, 1997). Sweet bay or bay laurel is an evergreen tree which may grow to 40 feet in its native Mediterranean regions, though in Zones 8-10 in the U.S., it can grow from 6 to 25 feet if protected from winter winds. It is adaptable to grow into pot in colder climates, rising outside during the summer and as an ordinary houseplant during the winter. Pot grown plants can be clipped into topiary forms. Clusters of small yellow flowers are followed by cluster of 1.2-2.5 cm black berries. The flowers occur towards the end of the terminal branches interspersed between the last dozen leaves. The leaves are dark green, evergreen, alternate and simple, elliptical-lanceolated, tapering to a short petiole, entire and with slightly wavy edges. The flowers are dioeciously, in groups of 4-6 in little axillaries umbels and the fruit is an elliptical blackish drupe, the size of a small olive, and contains a single seed. In the past, bay laurel was form into wreaths to crown poets, scholars and athletes. Culinary, the leaf is added at the beginning of cooking soups and stews and it slowly imparts a deep, rich flavour. The leaf is left whole so it can be retrieved before serving the dish. Medicinally, bay laurel has been used as an antisepticum and a digestive stimulant. Ancient use is to put leaves in containers of rice or flour to deter weevils. The leaves dry easily on the stem. Fresh leaves are stronger than dried ones (RUTH, 1992).

3.2.5 *Pittosporum tobira (*Thunb.) W.T. Aiton

Pittosporum tobira is a species of flowering plant in the *Pittosporaceae* Family known by several common names, including Japanese Pittosporum, Japanese mock-orange and Japanese cheesewood. It is native to Japan but it is used all around the world as an ornamental plant in the landscape and as cut foliage. It is a shrub which can reach several meters in tall and become like tree. It can also be trimmed into a hedge. The leaves are oval in shape with edges that curl from below and measure up to 10 cm in length. They are leathery, hairless, darker and shinier on the upper surfaces. *Pittosporum tobira,* Japanese Pittosporum is a popular evergreen shrub that is used as a landscape plant, as a cut foliage crop, and occasionally as a potted plant for interior design. *P. tobira* is a shrub that withstands trimming well and it is used for hedge establishement and mass plantings, as a screen, and in planter boxes. *P. tobira* is a subtropical plant that can be damaged by cool in cold regions during winters, when temperatures decreases bellow the 0°C or lower, especially if cool weather has not preceded the freezing event and the plants have not become cold acclimated (STAMPS et al., 1994). It is a medium sized frost hardy perennial evergreen tree/shrub with white and cream flowers during the late Spring and early Summer. The flowers are circular shaped. This plant requires 220 frost free days minimally to grow successfully. It has high drought tolerance. The best looks during the spring and autumn.

3.2.6 *Lagerstroemia indica* L.

The Crape myrtle (*Lagerstroemia* species) is native to Japan, China, Korea and other parts of Southeast Asia, but it has been so popular by Southerners, that has become a dominant landscape plant throughout the South. It is deciduous shrub or tree, in a medium to large shrub or a small multistemmed tree that can grow up to 10 m height. Many of the *Lagerstroemia indica* cultivars leaves are rounded, alternated or whorled, simple, elliptical with entire margin edges, from 3 to 9 cm long, dark green above and paler below. Most hybrid cultivars have lance-shaped leaves up to 10 cm long

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and 6 cm wide, while other species have even larger leaves. Leaves are often coloured in red during the spring and turn dark green from the summer. Several cultivars are known for new growth that is bronze, red or burgundy and some cultivars are claimed to have burgundy-coloured foliage during all summer. When the leaves fall during the winter, crape myrtle becomes a living sculpture. The trunks and branches of tree-form plants have an attractively gnarled, sinuous character with smooth bark. Flowering begins as early as May in some cultivars and continues into the fall. Each 18- to 45 cm cluster of flowers (or panicle) is developing on the tips of new growth and is composed of hundreds of 2 to 5 cm flowers. Colour ranges include shades of purple, lavender, white, pink and red, including "true" red, in a relatively recent development. Some cultivars have bicolour flowers (two colours on each petal), some cultivars have flower colours that fade with age or certain environmental conditions, and other cultivars have panicles composed of a mix of flower colours. Strips of bark peel off in early summer to reveal mottled new bark ranging in colour from pale cream to dark cinnamon to rich brown to bright orange. The bark colour gradually fades over the winter until it peels again the next summer. It grows the best in full sun with rich, moist soil, but it tolerates less hospitable locations in the landscape as well, once it becomes established. It grows well in limited soil spaces in urban areas such as along boulevards, in parking lots, and in small pavement cut outs if provided with some irrigation until is well established (MIZELL and GARY, 1993). Pruning should be done in late winter or early in the spring before growth begins because it is easier to see which branches to prune. New growth can be pinched during the growing season to increase branches and flower number (EDWARD and DENNIS, 1993a). It is used for buffer strips around parking lots, for median strip plantings along highways, near decks, patios, as shade trees in small parking lots and around homes.

3.2.7 *Callistemon laevis* Ball.

Callistemon laevis are shrubs in the Family *Myrtaceae* and native to Australia, Callistemon species are commonly referred to as bottlebrushes because of their cylindrical, brush like flowers resembling a traditional bottle brush. They are found in the more temperate regions of Australia, mostly along the east coast and south-west, and in the typically favour moist conditions. The species are shrubs and trees growing (depending on species) to 2–30 m (6.6–98 ft) tall, often with flaky, exfoliating bark. The leaves are evergreen, alternately arranged, ovate to lanceolate, 1–25 cm (0.39–9.8 in) long and 0.5–7 cm (0.20–2.8 in) broad, with an entire margin, dark green to grey-green in colour. The flowers are produced in dense clusters along the stems, each flower with fine small petals and a tight bundle of stamens. Flower colour varies from white to pink, red, pale yellow or greenish. The fruit is a small capsule containing numerous tiny seeds. They have been grown in Europe since a specimen of *C. citrinus* was introduced to Kew Gardens in London by Joseph Banks in 1789. *Callistemon laevis* (Bottle Brush) is a medium sized frost hardy perennial evergreen shrub with red flowers in midsummer and late summer. It grows well in direct sun, and prefers medium levels of water. The flowers are arranged in a spike inflorescence, the best look during the summer. In Europe, the most widely is used *Callistemon* sp. *C. citrinus* and *C. laevis*, the latter is characterized by a good tolerance to environmental stresses, such as drought and salinity (VERNIERI et al., 2006; LIPPI et al., 2003).

3.2.8 *Ziziphus jujuba* Mill.

Chinese jujube (also known as Chinese date) is the fruit of *Ziziphus jujuba* Mill. Chinese Jujube is an interesting deciduous tree with spines. It has gnarled branches and an open, irregular form. It is growing in the moderate places. Chinese Jujube reaches anywhere from 4.5 to 11 m in height with a spread of 3 to 9 m and it can be trained to a single trunk. Most of pruned plants grow with several trunks (EDWARD and DENNIS, 1994a, b). It is a small deciduous tree or shrub reaching a height of

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5–10 metres (16–33 ft), usually with thorny branches. The leaves are shiny-green, ovate-acute, 2–7 centimetres (0.79–2.8 in) wide and 1–3 centimetres (0.39–1.2 in) broad, with three conspicuous veins at the base, and a finely toothed edge. The flowers are small, 5 millimetres (0.20 in) wide, with five inconspicuous yellowish-green petals. The fruit is an edible oval drupe 1.5–3 centimetres (0.59–1.2 in) deep. When immature it is smooth-green, with the consistency and taste of an apple, maturing brown to purplish-black and eventually wrinkled, looking like a small date. There is a single hard stone similar to an olive stone (RUSHFORTH, 1999). The tree tolerates a wide range of temperatures and rainfall, though it requires hot summers and sufficient water for acceptable fruiting. Unlike most of the other species in the genus, it tolerates fairly cold winters, surviving temperatures below to –15 °C (5 °F). This enables the jujube to grow in mountain or desert habitats, where is enable access to ground water during the summer (SHAUKAT, 2001).

3.2.9 *Cupressus sempervirens* L.

Cupressus sempervirens, Family *Cupressaceae*, the Mediterranean *Cupressus* is a species of *Cupressus* native to the Mediterranean region. It has been widely cultivated as an ornamental timber tree for its source of wood, shade and forage in different soil types, it is very long-lived more then 1000 years old (FATMA et al., 2007). It is a tall tree (usually 15-20 m high but it can reach 30-40 m) with a well-developed trunk (may be 3 m in circumference). It grows quickly until the age of 20 and it can live to over 800 years. Its leaves are evergreen, dark green, rather circular (in young stages) or very small, scale-like and overlapping in four ranks. The female cones are globular (2-4 cm), shiny, with 6-12 woody, peltate, unequal scales, opposed crosswise on a short axis. The ovuliferous scales bear many ovules. The seeds are jagged, shining brown and narrowly winged. Flowering takes place during the spring; the cones mature the following spring (GAMMAR, 1995). Italian Cypress is often used for framing, as a strong accent around large buildings, or in the original landscape, it but does not match itself well to many home landscapes. It grows quickly rather high for most of the residential landscapes, looking similar to a green telephone pole. It is growing in full sun on various well-drained soils. Italian Cypress should be planted in a well-prepared site and watered periodically until it is well-established. Italian Cypress should not be pruned. It is very susceptible to mites and the trees are often infested (EDWARD and DENNIS, 1993b), the young plants are susceptible to the damage in cold areas (KELLY, 2004).

3.2.10 *Trachycarpus fortunei* (Hook.) H.Wendl

Trachycarpus fortunei is commonly known as the Chinese windmill palm; it is an evergreen palm that is primarily cultivated for ornamental purposes. It is recognisable according to its large, fan-shaped leaves. It can grow in varied climates - from warm-temperate to sub-tropical. This wide range of climactic suitability has allowed *T. fortunei* to be used as a bio-indicator for tracking climate change, as the recent range increases correlating with climate warming. *T. fortunei* seeds are spreading by birds, and plants are frequently documented as they escaped from cultivation. Invaded environments include scattered and natural forests, disturbed areas, riparian zones, shrub and scrublands, urban areas and wetlands. While *T. fortunei* is native to sub-tropical China (along with Myanmar and the Himalayas) it belongs to one of the most cold-resistant palms. *T. fortunei* is thus cultivated as an ornamental tree in many countries and its cold-tolerance is well documented (KOIKE, 2006; WALTHER and BERGER, 2003). Outside of its native range, *T. fortunei* was maintained in Australia, Japan, New Zealand, Spain, the United States, and more recently in Switzerland. Windmill Palm should be grown in the shade or partial shade on fertile soils, where the best look like. However it is also tolerant to full

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sun sites on well-drained soils, considering to sufficient moisture in the northern part of its occurrence range. Plants should be watered adequately. Protection from harsh winds can minimize leaf tearing, nevertheless these plants can be used successfully to close the shore, because they are quite tolerant of salt and wind (EDWARD and DENNIS, 1994c).

3.3 Woody plants phenology observation and growth processes assessment in the experimental plots of the SUA Botanical Garden

The phenological observation and assessment is recorded according to methods proposed by the Slovak Institute of Hydrometeorology in Bratislava (SHMU) (ANONYMUS, 1984), it is applied also for other woody plant phenological evaluation (ŠKVARENINOVA et al., 2008). The following phenophases and their stages are assessed by:

- Vegetative phases: leaf bud swelling (LBS 10%, 50%, 100%), bud-burst (BB 10%, 50%, 100%), leafing (L 10%, 50%, 100%), leaf discolouration (LD 10%, 50%, 100%), leaf fall (LF 10%, 50%, 100%).
- Generative phases: flower buds (FB 10%, 50%, 100%), flowering (F 10%, 50%, 100%), blossom fall (BF 10%, 50%, 100%), running to seeds (RS 10%, 50%, 100%), leaf colouration (LC 10%, 50%, 100%) and defoliation (D 10%, 50%, 100%).

Phenological observations were analyzed in 2012-2013 during all year round. During spring and summer time they were performed every other day, and during autumn and winter it was twice a week in the time when changes were registered only. During the whole period the expansion of observation we state just in global view. This expansion is obvious with shortening in month (J_{1-31}- January-31, F- February, M- March, A- April, My- May, Jn- June, Jl- July, Ag- August, S- September, O- October, N- November, D- December) and by number of date (e.g. M_{11} is 11^{th} March). The plants height was measured every year at the end of growing period by using the Biltmore stick. Measurement of tree height was carried out from land level to mean of the branches top. Terminal shoots growth (year increment) of 15-20 from selected branches was measured for each individual species.

3.4 Adaptation processes assessment and the investigation of woody plants hardiness

Winter hardiness and bio-growth manifestation was evaluated on the 7-point hardiness scale and 5-point scale for Bio-phenological and reproductive characteristics according to (BENČAT, 1967):

<u>I) Frost resistance</u>

I, plants do not freeze;
II, 50% of the annual shoots' length freezes;
III, 50–100% of the annual shoots' length freezes;
IV, older shoots freeze;
V, the aboveground part of the plant freezes to the snow cover height;
VI, the entire aboveground part of the plant freezes;
VII, plants are winter-killed.

<u>II) Bio-phenological and reproductive characteristics</u>

VIII, Wood species vegetate, but do not bloom;
IX, They bloom, but do not fruit;
X, They fruit, but give ungerminant seed;

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XI, They fruit and give germinant seed;
XII, Plants permanently regenerate in a natural way.

3.5 The experimental plots soil properties assessment from the point of nutrient regime

Nutrients are essential environmental factors affecting growth and development of the plants. The predominant part of the plant nutrients is derived from the soil and therefore it puts such emphasis on the soil nutrient regime. The achievement of the suitable nutrition can produce biomass plants in required quality and quantity; therefore it can withstand the adverse environmental factors.
Samples were taken from the experimental soil surface of each planting types in two dept (0 -50 mm, 0-300 mm) to determine the nutrient content, heavy metals and soil acidity in the soil. We analysed and assessed subsequently the content of essential nutrients (Ca, Mg, K, P, and N), and cation content of heavy metals (Fe, Zn, Cu, Cd, Mn and S) in samples taken at the Department of Soil Science FAaFR - SAU Nitra. Data are evaluated according to criteria evaluation of the results for chemical analyzes of agricultural soils on the basis of no. 338/2005 Coll. Ministry of Agriculture of the Slovak Republic on 6th July, 2005. Assessment of the soils nutrient regime in comparison with the evaluation criteria for analyzes soils, were evaluated for arable land and for permanent grassland and they were compared subsequently. The limit values of the risk elements in relation with the agricultural soil and plant (critical value) was evaluated in accordance with Act no. 220/2004 Coll, of 10 March 2004 on the conservation and use of agricultural land and amending Act 245/2003 Coll. concerning integrated pollution prevention and control environment and on amendments to certain laws. The classification of the soil samples into categories according to the granularity of soils (light, moderate and heavy) we defined in accordance with the structure of soil in Slovak Republic according to grain size listed in the law 220/2004 Coll.
Soil pH is a term used to indicate acid-base reactions in soils. The soil reaction exchange is one of the most important factors affecting the soil fertility. The soil reaction influences primarily on mooring and solubility of the nutrients to improve the structural conditions of the soil humus formation (KOTVAS et al., 2007). Many chemical and biochemical reactions take place only under specific pH conditions. These reactions effect the decomposition of mineral and organic substances, the formation of clay minerals, the movement (mobilization) elements and thus their availability to plants. Proton ions (H+) in excess have a toxic effect on the plant. When we think the acid soils it means that they prevails in the concentration of H+ ions; if we think the alkaline soils, it means that they have the predominant OH-ions.
Soil pH can be measured in different ways: in an aqueous extract or in aqueous suspension; the suspension was given - KCl solution, soil - $CaCl_2$ solution. The pH of the aqueous suspension is referred to as an active pH, suspended in a solution of KCl soil, pH-exchange (LINTNEROVÁ, 2006). The active soil reaction, for the practical purpose of the soil conditions, is evaluating according to the categories. The results of analysis of soil samples were compared according to the criteria evaluation of soil reaction set Decree no. 338/2005 Coll.

3.6 Evaluation of the study area climate conditions in relation to methodology of the phenological observations

The geographical factors are the most important for the temperature distribution and the amount of rainfall. Nitra belongs to the areas with very warm and warm climate comparing to the higher parts of mountains. The average annual air temperature for Nitra ranging between 10.51°C -11.16°C, the

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coldest month is January and the warmest is June and July. The average annual rainfall in the city of Nitra ranges from 550 to 600 mm (FAŠKO and ŠŤASTNÝ, 2002). Most of the precipitation falls during the months from May to August. In Nitra the snow cover is on average from 30 to 40 days per year. Its average height is about 8.8 cm in Nitra and in mountains about 30-40 cm (up to more than 1 m) (FAŠKO et al., 2002). Average monthly air temperature and rainfall for the last three years (2011, 2012, and 2013) are displayed in Table 2.

Table 2 Average temperature in °C and sum of rainfalls in mm (Nitra: 2011 - 2014)

Average temperature in °C					**Sum of rainfalls in mm**				
Month	**2011**	2012	2013	2014	Month	**2011**	2012	2013	2014
January	-0.90	1.36	-0.8	2.7	January	25	61.1	71.2	38.2
February	-0.60	-2.49	1.5	4.3	February	6	23.5	75.6	37.5
March	5.90	7.41	3.1	9.3	March	27	2.8	113.9	15.4
April	12.70	11.23	12.1	12.4	April	13	36.1	20.4	48.9
May	15.80	17.29	15.6	15.2	May	48	19.6	77.8	57.6
June	19.80	20.86	19.3	19.3	June	91	70.1	46.7	52.5
July	19.70	22.77	22.8	21.8	July	122	61.4	2.1	64.1
August	20.90	21.47	21.9	18.9	August	152	7.3	73.9	55.9
September	17.70	17.02	14.7	16.8	September	92	32.7	60.0	122.0
October	9.90	10.46	12.1	12.1	October	37	76.1	30.5	34.6
November	3.00	7.45	6.8	7.5	November	1	34.6	71.3	21.5
December	2.20	-0.91	2.3	3.1	December	42	44.4	11.0	42.0
Average Temperature per Year	10.51	11.16	11.0	11.9	Sum of Rain-falls per Year	656	469.7	654.4	590.2

3.7 Carbohydrates and pigments content in the leaves of investigated woody plants as potential metabolic markers for adaptability assessment to changed environment conditions

The samples of evergreen woody plants leaves were taken in January 2014 when the temperature

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was (-3°C) at 9 am and during the night was (-7°C) outside. The young leaves were taken from the plants and the pigments, total sugar and starch were analysed and assessed.

3.7.1 *Pigments analyse*

Assimilation pigments contents were measured in control leaves as it follows: The segments of the youngest mature leaves of evergreen woody plants were homogenized with using sea sand, MgCO3 and 100% acetone and then extracted with 80% acetone. Extracts were centrifuged 2 minutes at 2500 rpm. Absorbance (A) of the solution was measured by UV-VIS spectrophotometer (Jenway, UK), at 470 nm, 647 nm, and 663 nm, with correction for scattering at 750 nm; the measurements were done in three repetitions (OLŠOVSKÁ et al., 2013). The concentrations of chlorophyll *a* (Chl *a*), chlorophyll b (Chl b) and carotenoids (Car) in mg*l^{-1} was determined by using the equations of LICHTENTHALER (1987):

$$\text{Chl } a = 12.25*(A_{663} - A_{750})-2.79*(A_{647} - A_{750})*D \quad \text{(Eq. 1)}$$
$$\text{Chl } b = 21.50*(A_{647} - A_{750})-5.10*(A_{663} - A_{750})*D \quad \text{(Eq. 2)}$$
$$\text{Chl } a{+}b = 7.15*(A_{663} - A_{750}) +18.71*(A_{647} - A_{750})*D \quad \text{(Eq. 3)}$$
$$\text{Car} = [(1{,}000*(A_{470} - A_{750}) -1.82*(\text{Chl } a) - 85.02*(\text{Chl } b))/198]*D \quad \text{(Eq. 4)}$$

The concentrations of the pigments were calculated in mg.dm^{-3}; A_n was the absorbance at given wavelengths (n) after correction for scattering at 750 nm; D was the optical thickness of cuvette; results were also recalculated in mg.m^{-2} using the volume of solution and the area of leaf segments: [mg.m^{-2}] = V/1000*1/A, when V is volume of 80% acetone and A is area of leaf segments.

3.7.2 *Total carbohydrates analysis*

Analyzing of starch content

Starch is the major storage carbohydrate in higher plants. It is composed of glucose (glucans) polymers that adopt an insoluble, semi-crystalline structure, resulting in massive, osmotic inert granules that can reach up to 200 mm in diameter in the storage tissues of some species. The starch content was determined according to the polarimetric method of Ewers (MICHALIK et al., 1978). A portion of 5 g of a homogenised sample was weighed in 100 ml Kohlrausch volumetric flask and its content is mixed with 25 ml of 1.124% HCl solution. After addition of another 25 ml of 1.124% HCl solution, the suspension was heated on the boiling water bath for 15 min. (after 3 min. the content of a volumetric flask is mixed to avoid coagulation). Once the hydrolysis is finished, 20 ml of 1.124% HCl solution was added. After fast cooling (using a stream of flowing water), clarification using 5 ml of Carrez I (30% $ZnSO_4$ solution) and 5 ml of Carrez II (15% $K_4[Fe(CN)6]$ solution) solutions was evaluated. Finally, the volumetric flask was filled up by distilled water, its content was properly mixed, and filtrated using a filtration funnel. The obtained filtrate is then transferred to a polarisation tube (2 dm) and measured using a polarimeter.

The extent of polarisation is related to the concentration of the optically active molecules in solution by:

$$\alpha = [\alpha]_{\lambda}^{t}.\ell.c \qquad \text{(Eq. 5)}$$

Where α is measured rotation angle, [α] is the optical activity (which is a constant for each type of molecule), ℓ is the path length and c is a concentration. The overall rotation angle depends on the

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temperature, the used light wavelength and at the same time these parameters are usually standardised (e.g. 20°C and 589.3 nm (the D-line for sodium).
The obtained value is firstly corrected for a laboratory temperature (t) drift using:

$$\alpha_{\text{Corrected}} = \alpha_{\text{measured}} [S] - 0.0144(t-20) [S] \qquad \text{(Eq. 6)}$$

Followed by multiplying by a factor of (0.3462)

The amount of starch (*X*) in the sample is calculated using:

$$X = \frac{10^4 . \alpha}{[\alpha]^t_\lambda . \ell . m} \qquad \text{(Eq. 7)}$$

Where α is calculated value of optical rotation, $[\alpha]^t_\lambda$ is the optical activity (specific rotation) depending on the discharge lamp, the used light wavelength, the starch variety, ℓ is the path length (2 dm), and m is the sample weight (5 g). For mercury discharge lamp and a wavelength (λ) of 546.1 nm, the $[\alpha]^t_\lambda$ values are 214.7, 216.3, 213.3, 213.1, 218.5, 217.0 and 215.5 for wheat, rye, barley, oaten, rice, and maize and unknown cereal starch, respectively (Note: the correction for moisture was not taken in account in the equation).

Total sugar content

Total sugar content was evaluated according to methodology NELSON (1944) and SOMOGYI (1952). The samples of 1ml were combined either with 10 mg substrate and 1 ml citrate buffer (0.1 M, pH 5.0) or with 1 ml substrate solubilised in 0.1 M citrate buffer (pH 5.0) at 1% (w/v) in 50-ml Folin tubes. A control for each sample was prepared with substrate and buffer. Tubes were incubated at 40°C for 24 h. After incubation, 2 ml of copper reagent, consisting of 4 parts KNa tartarate: Na_2C0_3:Na_2SO_4:$NaHCO_3$ (1:2:12:1.3) and 1 part Cu- $SO_4 \cdot 5H_2O$:Na_2SO_4 (1:9), it was added to each tube. Both copper reagents were boiled to completely dissolve the components; then they could be stored at room temperature. They were mixed together just prior to use. After that 1 ml of sample was added to the appropriate control tubes, all tubes were boiled for 10 min in a water bath. The tubes were then cooled completely, 2ml of arsenomolybdate reagent (25 g ammonium molybdate in 450 ml H_2O + 21 ml H_2SO_4 + 3 g Na_2HASO_4 * $7H_2O$ dissolved in 25 ml H_2O) was added to each tube, and the tubes were shaken thoroughly before adjusting to the final volume of 25 ml water. Individual samples were filtered through filter paper, and colorimetric measurements were determined by transmitted light at 500 nm in the spectrophotometer.

3.8 Statistical data processing

An experiment was led out as factorial Randomized Complete Design (RCD) in three replications, the data were analyzed with the general linear model procedures in SAS, and Duncan test at level 0.05 was used for the means separation, year increment was also measured every year and the data was analyzed with factorial sampling (RCD) in three replication, Duncan test at 0.05 was used for the means separation.

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4. Results and discussion

4.1 Geographic and climate assessment of the natural and introduction study areas

4.1.1 Mediterranean geography and climate conditions

The Mediterranean is a region with strongly seasonal climate due to variable dominant high and low pressure systems. This seasonality is inclusive of both for temperature as well as for precipitation. In addition in the region much of the climate is affected by mountainous terrain**.** Many of the regions with Mediterranean climates have relatively mild winters and very warm summers. However winter and summer temperatures can vary greatly between different regions within a Mediterranean climate. In case of winters for instance Lisbon experiences very mild temperatures during the winter, with frost and snow practically unknown, whereas Thessaloniki has colder winters with annual frosts and snowfall. In the case of summers for instance, Athens experiences rather high temperatures during the summer (48 °C). Because most regions with a Mediterranean climate are near large water bodies, the temperatures are moderate in generally with a comparatively small temperatures range between the winter low and summer high (although the temperature daily range during the summer is large due to dry and clear conditions, except along the immediate coasts). Temperatures during the winter only occasionally fall below the freezing point and snow is seldom seen in generally. In the summer, the temperatures range from mild to very hot, depending on distance from a large water body, elevation above sea level, and latitude. However even in the warmest locations with a Mediterranean climate type, the temperatures usually do not reach the highest readings found in adjacent desert regions because of cooling from water bodies. Although strong winds from inland desert regions can sometimes boost summer temperatures, it is quickly increasing the risk of wildfires (ZELENÝ, 2005). Mediterranean regions occur between approximately 30° to 40° north and south latitude on the west sides of continents. Temperatures in these areas are from warm to hot in the high sun season with high evaporation rates and they are mild in the low sunny season with reduced evaporation rates. These regions have thus been called “winter-rain and summer-dry” climates. The Mediterranean vegetation is dominated by evergreen shrubs and sclerophyllous trees adapted to the distinctive climatic regime of summer drought and cool moist winters with only sporadic frost. The most favoured time for vegetative growth is during the spring, when the soil is moist and the temperatures are rising, or during the autumn, after the first rain. The winter temperatures of 10°C and lower are already too cool for growth. The regions within Mediterranean climate are under the dominant influence of subtropical anticyclones in the summer and experience strong cyclonic activity in winter. In the most of Mediterranean the mean monthly temperature range is 20°–25°C in summer and 5°–12°C in winter. The annual precipitation is usually 400–600 mm (more than 1,000 mm in the mountains places), with its minimal occurrence during the summer, in a drought time. A permanent snow cover never forms. The Southwest Asian Highlands have cold winters. The natural vegetation in the regions with Mediterranean climate consists of many drought-resistant species, including evergreen trees and shrubs. Mediterranean climate type is defined: (1) Geographically, as climate similar to those found around the Mediterranean Sea; (2) Vegetationally, as climate, where broad-leaved evergreen sclerophyllous shrub lands (maquis, chaparral, matorral, macchia, fynbos, kwongam) are common or dominant; and (3) Climatically, as regions of summer droughts and winter rainfalls (BLUMLER, 2005). Mediterranean soils have:

- a *xeric* moisture regime, whereby most of the rainfall occurs immediately after the winter solstice; and it is followed by a relatively important dry period after the summer solstice.
- a temperature regime which is *thermic* (mean annual soil temperature range is between 15° and

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22°C or occasionally *mesic* (8°-15°C), e.g. it is intermediate between the temperate regions and the tropics. Soil formation and weathering in Mediterranean soils is the most active during the rainy winter period when also evapo transpiration is minimal. The conditions are then optimal for an effective dissolution and leaching of calcium carbonate and other easily soluble elements, as well as for clay migration. During the hot, dry summer the soil desiccates, causing the development of red dehydrated oxidized iron compounds (hematite, magnetite, etc.) within the profile (TORRENT, 2004).

4.1.2 Iraq Republic geography and climate

The Iraq Republic lies in south-west Asia between latitudes 29° 5' and 37° 22' N and longitudes 38° 45' and 48° 45' E. Iraq, with a total area of 438 320 km², is bordered by Turkey to the north, by the Islamic Republic of Iran to the east, by the Persian Gulf to the south-east, by Saudi Arabia and Kuwait to the south, and by Jordan and the Syrian Arab Republic to the west. Topographically, Iraq is shaped like a basin, consisting of the Great Mesopotamian alluvial plain of the Tigris and the Euphrates rivers (Mesopotamia means, literally, the land between two rivers). This plain is surrounded by mountains in the north and in the east, which reaches altitudes of 3 550 m above sea level, and by desert areas in the south and west, which account for over 40 percent of the land area. The total cultivated area is about 6 million he, of which almost 50 percent in the northern Iraq under rainfall conditions. The climate in Iraq is mainly continental, subtropical semi-arid, with north and north-eastern mountainous regions having a Mediterranean climate. The rainfalls are a very seasonal and they occur during the winter from December to February, except north and north-east of the country, where the rainy season is from November to April. The average annual rainfall is estimated at 216 mm, but it ranges from 1 200 mm in the north-east to less than 100 mm in the south, which cover about 60 percent of the country. Winters are from cool to cold, with a day air temperature of about 16°C decreasing during the night to 2°C with a freeze possibility. Summers are from dry and hot to extremely hot, with a shade temperature over 43°C during July and August, however decreasing during the night to 26°C. Iraq can be divided into four agro- ecological zones (FAO, 2001). The climate of Iraq is semi-arid, called as "continental, sub-tropical" mainly characterized by wide diurnal and annual temperature ranges (Tab. 3).

Table 3 Monthly mean temperatures and rainfall in upper and down Iraq the Baghdad (B) and Mosul (M) cities (EVAN, 1966)

Month	Temperature °C						Rainfall mm			
	Mean maximum		Mean		Mean minimum		Highest maximum		Lowest minimum	
	B	M	B	M	B	M	B	M	B	M
January	15	12	9	6	4	2	77	69	18	12
February	17	14	11	8	5	3	86	78	22	15
March	21	18	15	11	9	6	99	87	26	25
April	29	25	21	17	14	9	110	104	37	31
May	36	33	28	23	20	14	113	106	47	40
June	40	39	32	30	22	18	119	115	58	50
July	43	42	34	33	24	22	123	124	62	56
August	43	43	34	32	24	21	121	119	64	55
September	40	38	30	27	21	16	117	117	51	45
October	33	31	25	20	16	11	108	105	39	32
November	25	22	17	13	11	7	98	95	28	26
December	17	15	11	8	6	3	81	76	19	19
Mean	30	28	21	19	15	11				

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4.1.3 Slovak Republic geography and climate conditions

Slovak Republic is a landlocked Central European country with mountainous regions in the north and flat terrain in the south. Slovakia lies between 49°36’48” and 47°44’21” northern latitude and 16°50’56” and 22°33’53” eastern longitude. The country’s area is 49 034 km$^{2.}$ From the total area 50% is agriculture land, 41% forests, 4.7% built up area and 3% water and other areas. Slovak Republic climate is moderate, because Slovakia lies in northern moderate climatic zone. Its geographical position is continental Europe, wind circulation dominantly from west; its direction is a key factor that influence Slovakia climate. The climate in Slovakia, due to landscape variations in lowlands is warmer than climate in mountains and elevation above sea level similarly effect the climate seasons. The warmest part of Slovakia includes Danubian Lowland and Eastern Slovak Lowland. Yearly air temperature average in lowlands is about 10°C and total annual precipitation is about 530 mm. With higher elevation above sea level the air temperature decreases and amount of precipitation increase. The lowest air temperature is on the mountains with average annual temperature range about 3-6 °C and total average precipitation amount is more than 1600 mm (Tab. 4). There are significant temperature and precipitation differences all year round as well as in day and night course. In generally in Slovakia the climate seasons vary irregularly. This is caused mostly by the influence of the dry continental air and humid oceanic air (MIKLOS and HRNČIAROVÁ, et al., 2002). There are a number of soil types due to the topography and climate differences. The most fertile soils are in the southwest, where are black chernozems. The core of the alluvial deposits is in the Slovakia Danube basin, and it is known as Žitný ostrov (Island). In the upper part the alluvial deposits are in the southern draining river valleys, those are covered with typical brown forest soils; while brown acid soils dominate the central and northern areas of middle elevations above sea level. The highest situated regions have shallow, stony mountain soils. Table 5 and 6 shows the average air temperature in °C and sum of rainfalls in mm (Nitra, 2011, 2012 and 2013).

Table 4 Climate regions of Slovakia and their main characteristics (MIKLOS and HRNČIAROVÁ et al., 2002).

Climate region main characteristics	T(A) Warm region	MT(B) Moderately warm region	CH(C) Cold region
Number of summer days	50-70	20-50	0-3
Number of days with average 10°C and more	160-180	120-160	0-140
Number of days with frost	90-130	110-180	140-180
Number of ice days	30-40	30-50	50-80
Mean January temperature °C	-1- -5	-2- -6	-5- -8
Mean April temperature °C	7-10	5-8	0-6
Mean July temperature °C	17-20	15-18	10-16
Mean October temperature °C	7-10	6-8	2-7
Sum precipitation in growing season, mm	300-400	350-600	500-1000
Sum precipitation in winter season, mm	200-300	200-350	350-700
Number of days with snow cover	50-80	60-120	100-200

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Table 5 Average air temperature in °C and characteristics of the month (Nitra, 2011 -2014)

Month	**2011**	Characteristics of the month *	2012	Characteristics of the month *	2013	Character-istics of the month *	2014	Characteristics of the month *
January	-0.90	normal	1.36	warm	-0.8	normal	2.7	very warm
February	-0.60	normal	-2.49	cold	1.5	warm	4.3	very warm
March	5.90	normal	7.41	warm	3.1	normal	9.3	very warm
April	12.70	warm	11.23	normal	12.1	warm	12.4	warm
May	15.80	normal	17.29	warm	15.6	normal	15.2	normal
June	19.80	normal	20.86	warm	19.3	normal	19.3	normal
July	19.70	normal	22.77	warm	22.8	warm	21.8	warm
August	20.90	normal	21.47	warm	21.9	warm	18.9	normal
September	17.70	warm	17.02	warm	14.7	normal	16.8	warm
October	9.90	normal	10.46	normal	12.1	warm	12.1	warm
November	3.00	warm	7.45	warm	6.8	warm	7.5	warm
December	2.20	warm	-0.91	cold	2.3	warm	3.1	warm
Year Average Temperature	10.51		11.16		11.0		11.9	

*Characteristics of the month according to DOORENBOS and PRUITT (1977), 1951-2000

Table 6 Sum of rainfalls in mm and characteristics of the month (Nitra, 2011- 2014)

Month	**2011**	Characteristics of the month *	2012	Characteristics of the month *	2013	Characteristics of the month *	2014	Characteristics of the month *
January	25	normal	61.1	normal	71.2	normal	38.2	externally dry
February	6	extremely dry	23.5	extremely dry	75.6	normal	37.5	externally dry
March	27	very dry	2.8	very dry	113.9	very wet	15.4	dry
April	13	very dry	36.1	very dry	20.4	very dry	48.9	normal
May	48	very dry	19.6	extremely dry	77.8	wet	57.6	normal
June	91	normal	70.1	dry	46.7	very dry	52.5	dry
July	122	normal	61.4	dry	2.1	extremely dry	64.1	dry
August	152	very wet	7.3	extremely dry	73.9	wet	55.9	dry
September	92	normal	32.7	extremely dry	60.0	dry	122.0	wet
October	37	extremely dry	76.1	normal	30.5	externally dry	34.6	externally dry
November	1	extremely dry	34.6	extremely dry	71.3	dry	21.5	very dry
December	42	very dry	44.4	very dry	11.0	externally dry	42.0	very dry
Year sum of Rainfalls	656		469.7		654.4		590.2	

*Characteristics of the month according to DOORENBOS and PRUITT (1977), 1951-2000.

4.2 Some results of introduction processes and list of Mediterranean woody plants collection in chosen dendrological objects in Slovakia and Czech Republic

4.2.1 Castle Park in Lednice

Castle Park in (Lednice na Moravě) is a part of Lednice-Valtice Cultural Landscape, being formed as a cultural landscape by the Liechtenstein family since the 14th century. According to Government Regulation No. 262/1995 Coll., on the declaration and nullification of declaration of certain cultural monuments as national cultural monuments, the area of castle in Lednice, including the park, was declared as a national culture monument (PEJCHAL and KUŤKOVÁ, 2003). In 1996 Lednice-Valtice Cultural Landscape was inscribed in the World Heritage List of UNESCO for its unique value. Many of

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the plants located in the park have origin from the entire world. In this study we observed plants, those are native for Mediterranean Region, they are planted inside of the greenhouses; and the plants those are planted outside have hardiness for winter conditions (Tab. 7).

Table 7 Mediterranean woody plants collection in Lednice Park

Acer cappadocicum	*Jasminum officinale*	*Salix babylonica*
Acer tataricum	*Lonicera caerulea*	*Spiraea bella*
Ailanthus altissima	*Lonicera caucasica*	*Spiraea crenata*
Caragana spinosa	*Lonicera korolkowii*	*Spiraea hypericifolia*
Carpinus orientalis	*Lonicera standischii*	*Spiraea salicifolia*
Clematis integrifolia	*Lonicera tatarica*	*Staphylea colchica*
Clematis orientalis	*Malus baccata*	*Tamarix ramosissima*
Colutea gracilis	*Malus prunifolia*	*Salix arbuscula*
Cornus alba	*Melia azederach*	*Ruscus hypophyllum*
Cotoneaster conspicuus	*Morus alba*	*Prunus cerasifera*
Cotoneaster multiflorus	*Osmanthus decorus*	*Prunus domestica*
Cotoneaster procumbens	*Picea meyeri*	*Prunus dulcis*
Cotoneaster racemiflorus	*Picea orientalis*	*Forsythia viridissima*
Elaeagnus angustifolia	*Platanus orientalis*	*Genista tinctoria*
Euonymus latifolia	*Hibiscus syriacus*	*Hippophaë rhamnoides*

4.2.2 Mediterranean woody plant collection in Brno

Botanical Gardens and Arboretum belongs to Mendel University in Brno. The Garden was established by Prof. A. Bayer in 1938 as 2 hectare area. This garden is situated 220-250 m above sea level in the region with average annual rainfall 547 mm and average annual air temperature 8. 4°C. Soils are mostly clay with high CaO_2 content. There are about 1 500 natural species and 3 000 hybrids, 500 alpine plants, 2 000 perennials and 4 000 woody plants in the outdoor area.
There are also many of the Mediterranean plants, those are planted outside or inside in the protected areas (MENDELU, Arboretum and Botanical Garden Plant Database, 2009).
We observed plants, those are native for Mediterranean Region, they are planted inside of the greenhouses; and the plants those are planted outside and have hardiness for winter condition (Tab. 8).

Table 8 Mediterranean woody plants collection in Brno - beginning

Albizia julibrissin	*Fuchsia magellanica*	*Phillyrea angustifolia*
Aristotelia chilensis	*Fokienia hodginsii*	*Phillyrea latifolia*
Artemisia tridentata	*Garrya elliptica*	*Pinus pinaster*
Azara microphylla	*Garrya fremontii*	*Piptanthus laburnifolius*
Aphananthe aspera	*Griselinia littoralis*	*Pittosporum tobira*
Arbutus andrachne	*Grewia biloba*	*Podocarpus acutifolius*
Arbutus unedo	*Hedera hibernica*	*Podocarpus andinus*
Asimina triloba	*Hibiscus paramutabilis*	*Podocarpus elatus*
Austrocedrus chilensis	*Hymenanthera angustifolia*	*Podocarpus neriifolius*
Acca sellowiana	*Hymenanthera crassifolia*	*Podocarpus nivalis*
Berberis darwinii	*Hymenanthera latifolia*	*Prunus lusitanica*
Berberis verruculosa	*Hedera canariensis*	*Pyracantha crenulata*
Bumelia lycioides	*Hovenia dulcis*	*Pachistima canbyi*
Buxus sempervirens	*Idesia polycarpa*	*Photinia glabra*
Buxus balearica	*Itea virginica*	*Pileostegia viburnoides*
Berchemia racemosa	*Jasminum humile*	*Pinus greggii*
Buxus colchicus	*Jasminum parkeri*	*Pinus pinea*

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Table 8 Mediterranean woody plants collection in Brno - finishing

Carmichaelia flagelliformis	*Juniperus ashei*	*Pittosporum heterophyllum*
Ceanothus × delilianus	*Juniperus drupacea*	*Plagianthus divaricatus*
Cordyline indivisa	*Juniperus excelsa*	*Podocarpus nivalis*
Corokia × virgata	*Juniperus phoenicia*	*Podocarpus totara*
Cistus sp	*Sapindus mukorossi*	*Prumnopitys taxifolia*
Cupressus macrocarpa	*Laurus nobilis*	*Phillyrea latifolia*
Cupressus sempervirens	*Ligustrum japonicum*	*Platycrater arguta*
Cytisus battandieri	*Ligustrum lucidum*	*Pistacia chinensis*
Cotoneaster crispii	*Lindera obtusiloba*	*Pistacia vera*
Euphorbia characias	*Lithocarpus glaber*	*Pistacia terebinthus*
Erica arborea	*Myrtus communis*	*Pueraria lobata*
Erica multiflora	*Magnolia grandiflora*	*Punica granatum*
Elaeagnus pungens	*Muehlenbeckia axillaris*	*Quercus coccifera*
Ehretia dicksonii	*Myrtus luma*	*Quercus ilex*
Elaeagnus × ebbingei	*Notospartium carmichaeliae*	*Quercus macrolepis*
Ficus carica	*Nemopanthus mucronatus*	*Rhamnus alaternus*
Fagara ailanthoides	*Osmarea burkwoodii*	*Rhaphiolepis umbellata*
Fatsia japonica	*Osmanthus fragrans*	*Ribes laurifolium*
Firmiana simplex	*Osteomeles schweriniae*	*Rosmarinus officinalis*
Stauntonia hexaphylla	*Olea europaea*	*Ruscus aculeatus*
Sophora frutescens	*Viburnum davidii*	*Sassafras albidum*
Trachelospermum jasminoides	*Sophora davidii*	*Sequoia sempervirens*
Trachycarpus fortunei	*Viburnum tinus*	*Schisandra sphaerandra*
Sarcococca humilis	*Umbellularia californica*	*Stranvaesia davidiana*

4.2.3 Mediterranean woody plant collection in Arboretum Mlyňany

Arboretum Mlyňany was established in the year 1892 by the Ugrian lord Dr. Štefan Ambrózy-Migazzi. The park area has 67 ha; it is divided on the geographic principle base. It is composed from the oldest core - Ambrózy park (40 ha), Eastern-Asian area (14 ha), Northern-American area (7. 5 ha) and Korean area (5. 5 ha). There can be recognized flora from Far East, Japan, China, Himalayas, Caucasus, Middle and Far Asia as well as from many other regions. Table 9 shows the Mediterranean Region plants, those were planted inside greenhouses and/or outside and they have hardiness for winter condition (HOŤKA and BARTA, 2012; HOŤKA et al., 2010).

Table 9 Mediterranean woody plants collection in Arboretum Mlyňany - beginning

Acantholimon acerosum	*Ballota frutescns*	*Laburnum anagyroides*
Acantholimon androsaceum	*Berberis aetnensis*	*Laburnum caramanicum*
Abies borisii-regis	*Berberis cretica*	*Laurus azorica*
Abies bornmulleriana	*Berberis hispanica*	*Laurus nobilis*
Abies cephalonica	*Buxus balearica*	*Malus florentina*
Abies marocana	*Buxus sempervirens*	*Malus silvestris*
Abies nebrodensis	*Carpinus betulus*	*Morus nigra*
Abies numidica	*Carpinus orientalis*	*Myrica faya*
Abies pardei	*Castanea sativa*	*Myrtus communis*
Abies pinsapo	*Celtis australis*	*Nerium oleander*
Acer x bornmuelleri	*Corema album*	*Nerium odorum*
Acer campestre	*Coriria myetifolia*	*Osyris alba*
Acer heldreichii	*Corylus colurna*	*Phoenix canariensis*
Acer hyrcanum	*Corylus maxima*	*Phoenix dactylifera*
Acer lobelii	*Cotoneaster multiflorus*	*Pistacia lentiscus*
Acer x martinii	*Crataegus azarolus*	*Pitacia terebinthus*

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Table 9 Mediterranean woody plants collection in Arboretum Mlyňany - finishing

Acer monspessulanum	*Crataegus heldreichii*	*Platanus orientalis*
Acer opalus	*Crataegus laevigata*	*Prunus cerasus*
Acer reginae-amaliae	*Crataegus monogyna*	*Prunus coconilia*
Acer sempervirens	*Crataegus orientalis*	*Prunus incana*
Acer tataricum	*Cytisus albus*	*Punica granatum*
Adenocarpus complicatus	*Cytisus ardoini*	*Punica protopunicea*
Adenocarpus decorticans	*Cytisus austriacus*	*Pyracantha coccinea*
Adenocarpus foliolosus	*Cytisus canariensis*	*Pyrus amygdaliformis*
Adenocarpus hispanicus	*Cytisus hirsutus*	*Pyrus bourgaeana*
Adenocarpus telonensis	*Dafne collina*	*Pyrus communis*
Adenocarpus viscosus	*Dafne oleoides*	*Pyrus cordata*
Aesculus hippocastanum	*Elaegnus angustifolia*	*Pyrus pyraster*
Alnus cordata	*Erica arborea*	*Quercus alnifolia*
Alnus elliptica	*Erica australis*	*Quercus canariensis*
Alnus glutinosa	*Erica scaoparia*	*Quercus cerris*
Alnus orientalis	*Fagus moesiaca*	*Quercus ilex*
Amelanchier ovalis	*Forsythia eurolaea*	*Quercus infectoria*
Anagyris foetida	*Fraxinus elonza*	*Quercus lusitanica*
Anagyris latifolia	*Fraxinus holotrich*	*Mespilus germanica*
Apollonias canariensis	*Fraxinus ornus*	*Rhamnus alaternus*
Arbutus andrachne	*Fraxinus palisae*	*Rhamnus fallax*
Arbutus x andrachnoides	*Genisa acanthoclada*	*Rhamnus infectorius*
Arbutus canariensis	*Genisa aetnensis*	*Rhus coriaria*
Arbutus unedo	*Genisa cinerea*	*Rosa agrestis*
Atriplex halimus	*Genisa ovata*	*Rosa collina*
Cedrus brevifolia	*Genisa radiata*	*Rosa coriifolia*
Cedrus libani	*Gesnouina arborea*	*Rosa horrida*
Cupressus sempervirens	*Hedera canariensis*	*Rosa micrantha*
Ephedra distachya	*Hedera colchica*	*Rosa orientalis*
Ephedra major	*Hedera helix*	*Ruscus aculeatus*
Juniperus brevifilia	*Ikex aquifolium*	*Salix aegyptica*
Juniperus cedrus	*Ilex canariensis*	*Salix atrocinerea*
Picea omorika	*Ilex perado*	*Sorbus domestica*
Pinus brutia	*Jasminum azoricum*	*Sorbus umbellata*
Pinus canariensis	*Jasminum fruticans*	*Spartium junceum*
Pinus halepensis	*Juglans regia*	*Syringa rhodopea*
Pinus heldreichii	*Laburnum alpinum*	*Syringa vulgaris*
Pinus leucodermis	*Tilia dasystyla*	*Tamarix africana*
Pinus nigra	*Tilia tomentosa*	*Tamarix gallica*
Pinus peuce	*Ulex galli*	*Tamarixparviflora*
Pinus pinaster	*Ulex europaeus*	*Tamarix tetrandra*
Pinus pityusa	*Ulmus canescens*	*Ulmus laevis*
Pinus pinea	*Viburnum tinus*	*Ulmus procera*
Zelkova abelicea	*Verbascum dumulosum*	*Vitex agnus-castus*
		Viburnum rigidum

4.2.4 Mediterranean woody plants collection in Botanical Garden in Nitra

The botanical garden is a part of the Slovak University of Agriculture in Nitra as Experimental Education and Training Areas with collection of fruits and ornamental plants, in which the native and introduced woody plants are collected also. The botanical garden was founded in 1982. There are 4 000 species and cultivars of the tropical and subtropical plants, 600 species and cultivars of woody plants, 1 800 species of annuals and perennials (BRINDZA, 2003) (Tab.10).

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Table 10 Mediterranean woody plants collection in Botanical Garden in Nitra

Acer tataricum	*Myrthus communis*	*Genista tinctoria*
Anthyllis montana	*Nerium oleander*	*Junipirus sabina*
Artemisia arborescens	*Picea omorica*	*Hedra helix*
Astragalus angustifolius	*Pinus halepensis*	*Fraxinus ornus*
Buxus balearica	*Pinus nigra*	*Helianthemum apenninum*
Buxus sempervirens	*Pittosporum tobira*	*Helianthemum nummularium*
Chamaerops humilis	*Phlomis fruticosa*	*Helianthemum oelandicum*
Carpinus betulus	*Phlomis purpurea*	*Hippophae rhamnoides*
Coltulea arborescens	*Phoenix canariensis*	*Hypericum calycinum*
Corylus colurna	*Potentilla fruticosa*	*Laburnum anagyoides*
Corylus maxima	*Prunus insititia*	*Laurus nobilis*
Cotinus coggyria	*Punica granatum*	*Tamarix pentandra*
Daboecia cantabrica	*Pyracantha coccinea*	*Ulex parviflorus*
Daphne alpine	*Pyrus communis*	*Lavandula lanata*
Daphne cneorum	*Quercus cerris*	*Lavandula stoechas*
Elaeagnus angustifolia	*Quercus petraea*	*Ligustrum vulgare*
Euonymus europaenus	*Quercus robur*	*Lonicera periclymenum*
Erica vagans	*Rosmarinus officinalis*	*Lonicera xylosteum*
Euphorbia characias	*Salix purpurea*	*Sorbus domestica*
Santolina pinnata	*Genista sagittalis*	*Sorbus torminalis*
Sorbus aria	*Syringa vulgaris*	

4.3 Adaptation processes, hardiness and the year increments evaluation of investigated woody plants

Slightly poorer winter hardiness was found for species ranging to Australia *Callistemon laevis* which died after the severe winter of the years 2011-2012, other species are in good health conditions and some of them flowered and fruited annually, some plants produced germinable seeds. The biochemical, physiological and morphological changes associated with low temperature tolerance clearly affect active growth and development. In addition, as a result, plants were set up to recognize and respond the temperatures that are favourable for growth and environmental cues signalling seasonal changes (FOWLER and LIMIN, 2004). The wide distribution of this species, its adaptation to a variety of environments, its short generation time and its small stature make it ideal for eco-physiological and genetic studies. It has been used for nearly 40 years in a biotic stress and dormancy research (SVENDSEN et al., 2007). The final phase is plant recovery after winter (LI et al., 2008). The deciduous species, which are planted in the open air, starts vegetation later than the plants those are planted in protected area during the winter time. In most of the species the vegetation season (leaf shedding) ends in October while (*Vitex agnus -castus*) ends it later than the other plants, where it was in the last week of November. About 80% of species showed superb winter hardiness (see Tab. 11). The study found that better hardiness was proved by the deciduous plants. Several studies have shown that environmental factors, especially low temperatures at higher elevations above sea level restrict the physiological processes responsible for tissue formation, such as photosynthesis, respiration, allocation of food and shoot growth (DAY et al., 1989; DELUCIA, 1986; KOCH et al., 2004). The plants response to low temperature stress can be divided into three district phases; the first is cold acclimation (pre-hardiness) occurring at low temperature, but above zero. The second stage (hardening) during which the leaf fall tolerance degree is achieved requires exposure to period of above zero temperature. ASSMANN (1970) stated that the growth rates fluctuate throughout the year according to weather conditions. However, he stressed that the growth rate depends not only on climate conditions during the evalu-

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ated year, but also on the conditions of previous years, especially in months when apical buds were form. The ability of woody perennials to survive winter depends on their entry into dormancy state as well as on the development of their cold acclimation achieved by a continuous exposure from -5 to -15°C. In late autumn time when leaves have dropped and occurred the first frosts (up to -3°C), the trees become dormant (WEISER, 1970; GARCÍA BAÑUELOS et al., 2008). Data obtained among the species *Vitex agnus –castus* and *Lagerstroemia indica* had the flowers, fruits and produced germinable seeds in each planting type (see Tab. 11)*. Ziziphus jujube* into ground and into pots had the flowers and fruits but the seeds were non-germinable. *Nerium oleander* and *Pittosporum tobira* into pots blossomed and fruited with non-germinable seeds, while plants into ground were no flowered. *Viburnum tinus* into pots flowered and fruited, but the seeds were non-germinable, while plants into ground flowered only about 10% in first and second year, however in third year were fully flowered. Genetic variations in growth and development of woody plants differ among species, populations within species and the individual plants as well (KOZLOWSKI and PALLARDY, 1997). *Laurus nobilis*, *Trachycarpos fortunei* and *Cupressus sempervirens* there were flowerless in both planting types. In *Pittosporum tobira* and *Nerium oleander* all the fresh shoots were damaged by the frost and during spring time they produced new shoots; the results are in accordance with PALACIO et al., (2005). The plants height increased significantly in 2012-2013 for all studied species, comparing the first planting year 2011, except (*Nerium oleander* and *Pittosporum tobira*), those were planted into ground and were situated in the open air during winter time. *Callistemon laevis* was totally killed by frost in open air and planted into grounds. Adaptation development over time and generations is a response to the ever changing environment (KING, 1990). It allows to the organism reduce competition for space and nutrients, diminish predation and increase reproduction. However there are, several factors that can limit these adaptations: water availability, light, predation and temperature.

Concerning to year increments among the species there were highly significant differences (Tab. 12). Maximum rates varied from around 60.7 cm per year from the year 2011 to 2012 and 47.7 cm from 2012 to 2013 in *Vitex agnus -castus* those were planted into ground and situated in the open air and 67.6 cm per year from 2011 to 2012 and 13.4 cm from 2012 to 2013 for plants those were planted into pots and protected during winter time. Probably due to the limited space in which plants were situated; height and diameter growth increments decreased with increasing age in generally. The environmental conditions both in the previous and current year could affect the annual height increment of trees. Minimum growth rates indicated in *Trachycarpos fortunei*, which was recorded 2.3 cm per year from 2011 to 2012 and 15 cm per year from 2012 to 2013 for plants planted into ground, while plants planted into pots and protected during winter time had height increment about 9 cm per year from 2011 to 2012 and 18 cm from 2012 to 2013. Year interval between the measurements was adequate to ensure a representative range of the environmental conditions and hence growth rates. The rapid growth in some year may tend to be balanced by slow growth in other year. These results agree with CLOSE et al., (1996), who found that the terminal shoot growth showed the significant differences in line of trees (39.4 cm) and close canopy trees (27.3 cm), nevertheless we could argued that genotypic differences can be a reason. Each species has a genetically determined maximum rate at which it can be collected and make use of light, water and nutrients. This determines the sites on those they will grow on and their potential growth rate. Planting type also affected the height of plants significantly. Maximum and mean tree height growth at different elevations above sea level is representing by a temperature gradient. It can provide a major insight into the biophysical determinants of the maximum amount of tree growth where resources are abundant, stresses are minor and competition for light places is a premium for height growth. The study showed a strong inverse correlation

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between height increments and planting type in all species. This result suggests that the increment is not particularly sensitive to climate variations, but slightly influenced by energy reserves and metabolic activities intrinsic to the trees, or in adaptation to the specific location as in *Vitex agnus- castus.* This study observed that the highest year increment was for *Vitex agnus- castus* in plants those were planted into ground, where it was 95.36 cm in 2011, 84.53 cm in 2012 and 75.04 cm in 2013; while the annual increment showed differences with plants those were planted into pots, where it was as it follows: 39 cm in 2011, 58.56 cm in 2012 and 58.69 cm in 2013, (see Tab. 12).

Table 11 The winter hardiness rating, bio-phenological and reproductive characteristics according to BENČAT (1967)

Species	Origin	Type of growth	Winter hardiness rating	Phenological and reproductive characteristics	
				Plants into ground	Plants into pots
Lagerstroemia indica	Japan and Southeast Asia	Deciduous	I	XI	XI
Nerium oleander	Mediterranean	Ever green	III -VI	VIII, XII	X
Laurus nobilis	Mediterranean	Ever green	I- II	VIII	VIII
Viburnum tinus	Mediterranean	Ever green	I	IX	X
Pittosporum tobira	Japan	Ever green	III	VIII	X
Trachycarpos fortunei	China	Ever green	I	VIII	VIII
Vitex agnus -castus	Mediterranean and Central Asia	Deciduous	I	XI	XI
Cupressus sempervirens	Mediterranean	Ever green	I	VIII	VIII
Ziziphus jujuba	China	Deciduous	I	X	X
Callistemon laevis	Australia	Ever green	VII	VIII	X

Table 12 Mean and standard deviation of annual increment for species during studying period (cm) - beginning

Species	Planting type	2011		2012		2013	
		Mean	SD	Mean	SD	Mean	SD
Lagerstroemia indica	**Into ground**	20.83^{a}	5.73	43.57^{b}	14.40	31.32^{a}	7.00
Nerium oleander		34.57 ^{a}	9.19	60.77^{b}	15.61	36.48^{a}	6.38
Laurus nobilis		24.76^{b}	11.69	57.29^{b}	25.00	36.56^{a}	13.84
Viburnum tinus		13.17^{a}	18.72	21.33^{b}	6.96	27.50^{b}	5.72
Pittosporum tobira		14.98^{a}	4.39	21.02^{a}	4.80	9.04^{a}	3.89
Trachycarpos fortunei		19.15^{a}	3.18	20.48^{a}	2.73	29.68^{a}	4.07
Vitex agnus -castus		95.36^{b}	32.92	84.53^{b}	20.63	75.04^{b}	17.20
Cupressus sempervirens		21.00^{b}	5.05	35.50^{b}	7.50	19.98^{b}	2.30
Ziziphus jujuba		22.33^{b}	3.34	17.03^{a}	3.20	15.63^{a}	2.12
Callistemon laevis		29.32^{b}	10.35	0.00	0.00	0.00^{a}	0.00

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Table 12 Mean and standard deviation of annual increment for species during studying period (cm) - finishing

Species	Planting type	2011		2012		2013	
		Mean	SD	Mean	SD	Mean	SD
Lagerstroemia indica	Into pots	20.90[a]	6.31	21.12[a]	5.64	39.27[b]	14.95
Nerium oleander		34.57[a]	8.66	38.57[a]	11.85	35.86[a]	6.02
Laurus nobilis		19.39[a]	8.41	20.50[a]	7.34	33.42[a]	8.57
Viburnum tinus		11.08[a]	2.29	15.33[a]	3.34	17.68[a]	4.69
Pittosporum tobira		31.85[b]	7.70	19.82[a]	5.52	8.10[a]	2.07
Trachycarpos fortunei		17.42[a]	4.21	27.46[b]	6.48	32.69[b]	6.08
Vitex agnus -castus		39.00[a]	9.70	58.56[a]	14.69	58.69[a]	11.20
Cupressus sempervirens		16.67[a]	2.71	28.73[a]	4.65	9.59[a]	1.70
Ziziphus jujuba		18.15[a]	2.92	21.62[b]	4.13	24.95[b]	2.52
Callistemon laevis		24.22[a]	7.49	36.00[b]	9.74	32.55[b]	5.80

* It means that the same letters in the same rows have no significant differences

4.4 Phenology observation and growth processes assessment of woody plants in the experimental plots in the Botanical Garden SUA

4.4.1 Leaf development phenophase process

Data in table (Tab. 13) shows that the growth phenophases presented relatively big differences for all observed individuals of each year and for both planting types and even greater differences during all compared observation periods. Winter was obviously the less active season in all years and for all plants. The first marks of spring activity was the beginning of leaf buds swelling; in generally for all species it was earlier for plants those were planted into pots and protected during the winter time, which might be related to the environmental conditions in those they were grown. The temperature increase influence the beginning of phenophases and the growing season length (BARTA and HOŤKA, 2013). The first marks of spring activity that is beginning of leaf bud swelling generally in all species was earlier in plants which were planted in pots and protected during the winter time. For *Lagerstroemia indica,* which was planted into pots, the leaf buds swelling was in February while for plants those were planted into ground it was second half of April in 2012 and it was last days of March in 2013. *Nerium oleander* planted into pots, it had earlier leaf buds swelling, which was in February comparing to *Nerium oleander* planted into ground, and it started in May. During the year 2012 *Laurus nobilis* had no the difference between both planting types, where it was almost the same, while in 2013 into pots leaf buds swelling started in February and plants planted into ground it started later in second half of April. *Viburnum tinus* began the leaf buds swelling in second half of March in 2012, while in 2013 it was seven days earlier. For the plants, those were planted into ground, the buds swelling was in April too. (AHL et al., 2006) found that the period encompassing onset of greenness and onset of leaf maturity occurred during 10–12 days period. On May of 27th, budburst was already occurring for many of the trees. *Pittosporum tobira* stared leaf buds swelling on February of 20[th] in 2012 and it was 12[th] in 2013 of the same month, while for plants those were planted into ground in 2012 it was in last days in April and in 2013 it was second half of May. In *Trachycarpos fortunei* those were planted into pots it was earlier in 2012 comparing to 2013 when it was five days later, whereas for plants those were planted into ground in 2013 it was earlier than in 2012 (17 days). In 2012 *Vitex agnus –castus* plants into pots showed the earliest leaf buds swelling on January of 20[th] while in 2013 it was later, however

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for plants into ground the leaf bud swelling was displayed at the same date. *Cupressus sempervirens* into pots during 2012 started leaf buds swelling in second half of January though plants into ground during the last days of April, whereas in 2013 plants those were planted into ground it started earlier than in 2012. Leaf buds swelling in *Ziziphus jujuba* was in February for plants planted into pots and it was later for plants planted into ground in both years. *Callistemon laevis* those were planted into pots started leaf buds swelling in February and in 2012 it was earlier than in 2013; although plants planted into ground did not tolerate the winter coldness as it is shown in table (Tab. 11). The beginning of the leaf buds breaking was almost equal in *Lagerstroemia indica, Nerium oleander* and *Trachycarpos fortunei* those were planted into pots and it was earlier in 2012 comparing to 2013. *Lagerstroemia indica* and *Trachycarpos fortunei* planted into ground started leaf buds breaking in April but for *Nerium oleander* it was later what means in second half of May in 2012 and it was later in June during 2013. *Laurus nobilis* and *Pittosporum tobira,* those were planted into pots, showed about equally early in leaf buds breaking while for *Pittosporum tobira* into ground during 2012 it started earlier than in 2013. Leaf buds breaking in *Vitex agnus –castus* started in 31th of January in 2012 and in 2013 was later in 10th of March, however for *Vitex agnus –castus* into ground it was in April in both years. *Cupressus sempervirens* and *Callistemon laevis* those were planted into pots showed the same date for the leaf buds breaking. *Ziziphus jujuba* into pots during 2012 it started earlier what was in 20th of February and in 2013 it was in 10th of March, while for plants into ground during 2013 it was earlier than in 2012. The leafing was first for *Lagerstroemia indica* into pots and it started in 3rd of February during 2012, whereas in 2013 it was later for the same plants. However *Lagerstroemia indica* into ground started leafing in April and during 2013 it was earlier (12 days). *Nerium oleander* started leafing in March for plants those were into pots in 2013 and during 2012 it was earlier, though for *Nerium oleander* into ground during 2012 it was in 23rd of March and in 2013 was later i.e. in 26th June. *Laurus nobilis* into pots started leafing during 2013 earlier in 25th of March comparing to 2012; but plants into ground it had at the same date in both evaluated years. *Viburnum tinus* started leafing into pots and into ground in May during the year 2012, despite the fact that during 2013 into pots it started in 17th of March and into ground it started in 29th of April. *Pittosporum tobira* into pots during 2012 and 2013 showed almost equal date in leafing, even though the plants those were into ground during 2012 it started in 23rd of May and in 15th July in 2013. *Trachycarpos fortunei* and *Ziziphus jujuba,* planted into pots, were almost the same in both years and into ground it was the same only in 2013. *Vitex agnus –castus* into ground had the same leafing time in both years. *Cupressus sempervirens* into pots started leafing in March and in July during 2012 and it was almost equal with plants into ground in 2013.

4.4.2 Flowering phenophase process

Dates on flowering phenological process are given in Table 13 and 14. The earliest flowering had species *Viburnum tinus* into pots what was in 12th of February 2013 following of flowering in 2012 and 2nd of January in 2014 following of flowering in 2013. Into ground the flowering started in 22nd of October in 2013 and 18th of October in 2014. *Pittosporum tobira* into pots had the beginning of flowering at the first week of March during 2012 and plants planted into ground flowered in 30th of March during the same year. But into pots it started flowering in last days of April during 2013. Plants into ground during 2013 were no flowered.

Callistemon laevis into pots started flowering in 15th of March and 17th of April during 2012, whereas in 2013 the same plants started flowering in 28th of March and 13th April in 2012. *Nerium oleander* and *Vitex agnus –castus* started flowering almost at the same time, what was in July. *Lagerstroemia indica* was the latest species which started flowering into pots 1st of August during 2012 and 5th of September

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in 2013. *Lagerstroemia indica* planted into ground during 2012 flowered in 18th July and in 2013 in 2nd of August. The flowering beginning had the difference between planting types and species and it started from January to October. As it is known within plants spieces there is a wide range of diversity for low temperature tolerance. First flowering was advanced by high temperatures between January and June, but it was delayed by warm conditions during cold accumulation phase (from late October to early January). Data in table (Tab. 11) shows that *Trachycarpos fortunei, Cupressus sempervirens* and *Laurus nobilis* in both planting types were no flowered. The earliest senescent of flowers was in *Viburnum tinus* and *Pittosporum tobira* those were planted into pots. *Callistemon laevis* into pots had senescent of flowers in May and in September during 2012 and it was in 29th of May and 1st October of during 2013. In *Nerium oleander* the blossom fall started in 10th of August during 2012 and it was in 26th of July during 2013. *Ziziphus jujuba* into pots had it in 12th of July during the years 2012 and 2013, although plants planted into ground had it during August in both compared years. *Vitex agnus –castus* planted into pots during 2013 started the senescent of flowers earlier than during 2012 and plants planted into ground were the same in both years. *Lagerstroemia indica* into ground started the blossom fall in September and plants into pots it started in October 2013.

4.4.3 Fruit bearing phenophase process

The earliest fruit bearing started *Viburnum tinus* in 2013 (7th of March) and in 2012 (28th of March). *Callistemon laevis* had the fruit bearing low during 2012 (from 28th to April and 25th of May), while in 2013 it started from 5th of March to 30th of May). *Lagerstroemia indica* into pots during 2012 was similar comparing to *Nerium oleander* during 2013. *Pittosporum tobira* planted into pots during 2012 started the fruit bearing earlier in 10th of April and during 2013 it was in 19th of May. The plants situated into ground only during 2012 fruited and started the fruit bearing in 30th of June. *Vitex agnus –castus* started the fruit bearing in August during 2012 in both planting types, whereas plants into ground it started earlier in 24th of July during 2013. Data in Table 13 and 15 has shown that *Ziziphus jujuba* planted into pots started fruit bearing in July during 2012 and it was 8 days earlier than 2013. The plants placed into ground during 2012 had no fruiting, which started only in in 7th of August 2013.

4.4.4 Leaf colouration phenophase process

According to the data in Table 13 and 16, the leaf colouration in deciduous species was different. The earliest leaf colouration started *Ziziphus jujuba,* which started in September 2012, while *Lagerstroemia indica* planted in pots started the leaf colouration in 8th October during 2012 and in 20th of September during 2013. The plants into ground started the leaf colouration in 10th of September in 2012 and in 9th of October in 2013. *Vitex agnus –castus* planted into pots and into ground were similar during the year 2012, but during 2013 plants into pots started the leaf colouration 10 days earlier than plants into ground. *Ziziphus jujuba* planted in pots had defoliation during 2012 earlier than during the year 2013. The plants into ground started it almost at the same times in both evaluated years. The latest defoliation had *Vitex agnus –castus* during 2012 for plants into ground, though *Vitex agnus –castus* into pots were similar in both compared years. *Lagerstroemia indica* situated into pots was almost similar in both years. *Lagerstroemia indica* started defoliation similarly into pots and into ground during 2013; whereas the plants into ground it had later during 2012. Leaf colouring was advanced by warm conditions during the most of the growing season, but delayed by high temperatures in autumn. Variation in the growing season length was strongly correlated to variation in spring phenology (GUO et al., 2013). SUPUKA (1988) found that *Forsythia x intermedia* showed the significant difference in the onset of phenophases. The beginning of burst was almost equal in all studied oak trees each year at

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the end April and at the beginning of May (POŽGAJ and MERCEL, 1999).

Table 13 Observation of growth phenophases for the studied woody plants - beginning

Pheno-phases	Species	Planting into pots			Planting into ground		
		2012	2013	2014	2012	2013	2014
10% of leaf bud swelling	*Lagerstroemia indica*	F_{10}	F_{26}	------	A_{15}	M_{24}	------
	Nerium oleander	F_{12}	F_{26}	------	My_{5}	My_{17}	------
	Laurus nobilis	M_{24}	F_{16}	------	A_{15}	A_{12}	------
	Viburnum tinus	M_{15}	M_{7}	------	A_{17}	A_{3}	------
	Pittosporum tobira	F_{20}	F_{12}	------	A_{24}	My_{17}	------
	Trachycarpos fortunei	F_{7}	F_{12}	----	A_{20}	A_{3}	------
	Vitex agnus -castus	J_{20}	F_{26}	------	A_{8}	A_{6}	------
	Cupressus sempervirens	J_{16}	F_{12}	------	A_{22}	M_{28}	------
	Ziziphus jujuba	F_{8}	F_{26}	------	A_{18}	A_{10}	------
	Callistemon laevis	F_{15}	F_{21}	------	------	------	------
50% of leaf bud swelling	*Lagerstroemia indica*	F_{18}	M_{5}	------	A_{18}	A_{28}	------
	Nerium oleander	F_{18}	M_{5}	------	My_{10}	My_{25}	------
	Laurus nobilis	M_{1}	M_{3}	------	A_{18}	A_{16}	------
	Viburnum tinus	M_{18}	M_{12}	------	A_{22}	A_{5}	------
	Pittosporum tobira	M_{3}	F_{26}	------	A_{26}	My_{5}	------
	Trachycarpos fortunei	F_{17}	F_{16}	----	A_{25}	A_{12}	------
	Vitex agnus -castus	J_{25}		------	A_{11}	A_{10}	------
	Cupressus sempervirens	J_{25}	F_{26}	------	A_{27}	A_{5}	------
	Ziziphus jujuba	F_{10}	M_{1}	------	A_{22}	A_{15}	------
	Callistemon laevis	F_{20}	F_{26}	------	------	-------	------
100% of leaf bud swelling	*Lagerstroemia indica*	F_{20}	M_{10}	------	A_{20}	A_{3}	------
	Nerium oleander	F_{23}	M_{10}	------	My_{16}	My_{29}	------
	Laurus nobilis	M_{7}	M_{10}	------	A_{20}	A_{17}	------
	Viburnum tinus	M_{25}	M_{18}	------	A_{28}	A_{12}	------
	Pittosporum tobira	M_{8}	M_{5}	------	A_{30}	My_{29}	------
	Trachycarpos fortunei	F_{23}	M_{5}	------	A_{30}	A_{18}	------
	Vitex agnus -castus	J_{31}	M_{5}	------	A_{13}	A_{14}	------
	Cupressus sempervirens	J_{28}	M_{5}	------	A_{3}	A_{12}	------
	Ziziphus jujuba	F_{15}	M_{6}	------	A_{25}	A_{24}	------
	Callistemon laevis	M_{3}	M_{5}	------	------	-------	------

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Table 13 Observation of growth phenophases for the studied woody plants - continuing

Pheno-phases	Species	Planting into pots			Planting into ground		
		2012	2013	2014	2012	2013	2014
10% of bud breaking	*Lagerstroemia indica*	F_{23}	M_{10}	------	A_{22}	A_{8}	------
	Nerium oleander	F_{23}	M_{10}	------	My_{16}	Jn_{2}	------
	Laurus nobilis	M_{15}	M_{10}	------	A_{25}	A_{18}	------
	Viburnum tinus	A_{1}	M_{20}	------	A_{30}	A_{14}	------
	Pittosporum tobira	M_{15}	M_{10}	------	M_{5}	A_{29}	------
	Trachycarpos fortunei	F_{27}	M_{10}	------	A_{30}	A_{18}	------
	Vitex agnus -castus	J_{31}	M_{10}	------	A_{31}	A_{14}	------
	Cupressus sempervirens	M_{5}	M_{10}	------	A_{10}	A_{18}	------
	Ziziphus jujuba	F_{20}	M_{10}	------	A_{25}	A_{19}	------
	Callistemon laevis	M_{7}	M_{10}	------	------	-------	------
50% of bud breaking	*Lagerstroemia indica*	F_{26}	M_{17}	------	A_{25}	A_{10}	------
	Nerium oleander	F_{27}	M_{13}	------	My_{19}	Jn_{6}	------
	Laurus nobilis	M_{20}	M_{15}	------	A_{30}	A_{22}	------
	Viburnum tinus	A_{10}	M_{25}	------	My_{5}	A_{18}	------
	Pittosporum tobira	M_{18}	M_{15}	------	My_{11}	Jn_{6}	------
	Trachycarpos fortunei	M_{5}	M_{14}	------	My_{5}	A_{22}	------
	Vitex agnus -castus	F_{10}	M_{15}	------	A_{20}	A_{18}	------
	Cupressus sempervirens	M_{10}	M_{15}	------	A_{21}	A_{29}	------
	Ziziphus jujuba	F_{28}	M_{15}	------	A_{28}	A_{22}	------
	Callistemon laevis	M_{10}	M_{15}	------	------	--------	------
100% of bud breaking	*Lagerstroemia indica*	M_{1}	M_{20}	------	A_{28}	A_{12}	------
	Nerium oleander	M_{3}	M_{15}	------	M_{23}	Jn_{18}	------
	Laurus nobilis	M_{27}	M_{20}	------	My_{5}	A_{29}	------
	Viburnum tinus	A_{18}	A_{15}	------	My_{10}	A_{22}	------
	Pittosporum tobira	M_{21}	M_{20}	------	My_{21}	Jn_{10}	------
	Trachycarpos fortunei	M_{15}	M_{17}	------	My_{10}	A_{29}	------
	Vitex agnus -castus	F_{22}	M_{24}	------	A_{27}	A_{28}	------
	Cupressus sempervirens	M_{17}	M_{20}	------	A_{28}	My_{7}	------
	Ziziphus jujuba	M_{10}	M_{20}	------	A_{30}	A_{29}	------
	Callistemon laevis	M_{15}	M_{20}	------	-------	-------	------
10% of leafing	*Lagerstroemia indica*	F_{3}	M_{27}	------	A_{30}	A_{18}	------
	Nerium oleander	M_{5}	M_{18}	------	M_{23}	Jn_{26}	------
	Laurus nobilis	A_{5}	M_{25}	------	My_{8}	My_{7}	------
	Viburnum tinus	My_{2}	M_{17}	------	My_{12}	A_{29}	------
	Pittosporum tobira	M_{25}	M_{28}	------	My_{23}	Jl_{15}	------
	Trachycarpos fortunei	M_{17}	M_{20}	----	My_{15}	My_{7}	------
	Vitex agnus -castus	F_{28}	M_{28}	------	A_{30}	A_{29}	------
	Cupressus sempervirens	M_{25-} Jl_{30}	A_{12-} Ag_{26}	------	M_{30-} Jl_{30}	My_{25-} Ag_{13}	------
	Ziziphus jujuba	M_{15}	M_{28}	------	A_{30}	My_{7}	------
	Callistemon laevis	A_{3}	A_{3}	------	------	------	------

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Table 13 Observation of growth phenophases for the studied woody plants - continuing

Pheno-phases	Species	Planting into pots			Planting into ground		
		2012	2013	2014	2012	2013	2014
50% of leafing	*Lagerstroemia indica*	F_{15}	M_{29}	------	My_{5}	A_{29}	------
	Nerium oleander	M_{15}	M_{22}	------	Jl_{2}	Jl_{11}	------
	Laurus nobilis	A_{30}	A_{29}	------	My_{12}	M_{17}	------
	Viburnum tinus	My_{12}	Jn_{6}	------	My_{23}	My_{11}	------
	Pittosporum tobira	A_{15}	A_{3}	------	M_{30}	Ag_{6}	------
	Trachycarpos fortunei	M_{25}	M_{22}	------	My_{23}	My_{18}	------
	Vitex agnus -castus	M_{15}	A_{11}	------	My_{5}	My_{6}	------
	Cupressus sempervirens	Jn_{25},S_{10}	Jl_{5},S_{5}	------	Jn_{10},Ag_{20}	Jn_{24},S_{5}	------
	Ziziphus jujuba	M_{30}	A_{18}	------	My_{8}	My_{13}	------
	Callistemon laevis	A_{12}	My_{10}	------	----	--------	-----
100% of leafing	*Lagerstroemia indica*	F_{24}	M_{31}	------	My_{8}	My_{7}	------
	Nerium oleander	A_{12}	A_{18}	------	Jl_{13}	Ag_{2}	------
	Laurus nobilis	My_{5}	My_{7},Ag_{26},$O_{10,}$$N_{20}$	---	My_{25},N_{27}	My_{29},Ag_{26},$O_{10,}$$N_{20}$	------
	Viburnum tinus	My_{30}, N_{7}	Jn_{10}	------	Jn_{12},N_{7}	My_{29}	------
	Pittosporum tobira	My_{5}	My_{10}	------	Jn_{18}	S_{5}	------
	Trachycarpos fortunei	A_{5},N_{11}	A_{5},$Ag1_{7}$,S_{10},O_{10}	------	Jn_{18},N_{16}	Jn_{4},Ag_{20},O_{1}	------
	Vitex agnus -castus	A_{5}	A_{25}	------	My_{25}	My_{29}	------
	Cupressus sempervirens	My_{15-} O_{8}	My_{29-} O_{1}	------	Jl_{10-} S_{29}	Jl_{16-} S_{20}	------
	Ziziphus jujuba	A_{5}	A_{25}	------	My_{24}	My_{22}	------
	Callistemon laevis	A_{20}	My_{29}	------	------	----------	------
10% of flower budding	*Lagerstroemia indica*	Jl_{2}	Jl_{24}	------	Jl_{3}	Jl_{11}	------
	Nerium oleander	A_{12}	A_{8}	------	-------	--------	-------
	Laurus nobilis	-----	-------	------	-------	-------	-------
	Viburnum tinus	N_{16}	Jl_{17}	------	Jl_{15}	Jl_{1}	------
	Pittosporum tobira	F_{15}	M_{20}	------	My_{20}	-------	------
	Trachycarpos fortunei	-------	-------	----	-------	-------	-------
	Vitex agnus -castus	Jn_{8}	Jn_{18}	------	Jn_{12}	Jn_{18}	------
	Cupressus sempervirens	-------	----------	------	-------	----------	-------
	Ziziphus jujuba	My_{8}	My_{11}	------	Jn_{3}	My_{29}	------
	Callistemon laevis	$F_{20,}$$Jl_{18}$	J_{10},Jl_{16}	------	-------	-------	---------
50% of flower budding	*Lagerstroemia indica*	Jl_{12}	Ag_{2}	------	Jl_{7}	Jl_{17}	------
	Nerium oleander	A_{30}	A_{12}		------	------	
	Laurus nobilis	------	------	------	------	------	------
	Viburnum tinus	N_{23}	Jl_{28}	------	Jl_{25}	Jl_{7}	------
	Pittosporum tobira	F_{25}	M_{28}	------	My_{25}	------	------
	Trachycarpos fortunei	------	------	----	------	------	------
	Vitex agnus -castus	Jn_{15}	Jl_{24}	------	Jn_{18}	Jn_{22}	------
	Cupressus sempervirens	------	------	------	------	------	------
	Ziziphus jujuba	My_{20}	My_{18}	------	Jn_{11}	Jn_{5}	------
	Callistemon laevis	F_{28},Ag_{1}	$J_{12,}$$Jl_{24}$	------	------	------	------

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Table 13 Observation of growth phenophases for the studied woody plants - continuing

Pheno-phases	Species	Planting into pots			Planting into ground		
		2012	2013	2014	2012	2013	2014
100% of flower budding	*Lagerstroemia indica*	Jl_{26}	Ag_{19}	------	Jl_{12}	Jl_{24}	------
	Nerium oleander	My_{8}	A_{29}	------	------	--------	------
	Laurus nobilis	------	------	------	------	------	------
	Viburnum tinus	D_{15}	Ag_{3},S_{13},	------	O_{18}	O_{18}	------
	Pittosporum tobira	M_{8}	A_{12}	------	M_{30}	---------	------
	Trachycarpos fortunei	------	------	------	------	------	------
	Vitex agnus -castus	Jn_{29}	Jl_{3}	------	Jn_{23}	Jn_{24}	------
	Cupressus sempervirens	-------	----------	------	-------	----------	------
	Ziziphus jujuba	Jn_{10}	My_{26}	------	Jn_{18}	Jn_{19}	------
	Callistemon laevis	F_{28},Ag_{17}	J_{10},Jl_{24}	------	-------	---------	-------
10% of flowering	*Lagerstroemia indica*	Ag_{1}	S_{5}	------	Jl_{18}	Ag_{2}	------
	Nerium oleander	Jl_{11}	Jl_{7}	------	------	-------	------
	Laurus nobilis	------	------	------	------	------	------
	Viburnum tinus	-----	F_{12}	J2	O_{22}	O_{18}	------
	Pittosporum tobira	M_{8}	A_{29}	------	M_{30}	-------	------
	Trachycarpos fortunei	------	------	---	------	------	------
	Vitex agnus -castus	Jl_{18}	Jl_{5}	------	Jn_{24}	Jl_{7}	------
	Cupressus sempervirens	------	-------	------	------	-------	------
	Ziziphus jujuba	Jn_{20}	Jn_{2}	------	Jn_{20}	Jn_{24}	------
	Callistemon laevis	M_{15},Ag_{17}	M_{28},Ag_{13}	------	------	------	------
50% of flowering	*Lagerstroemia indica*	Ag_{15}	S_{15}	------	Jl_{28}	Ag_{7}	------
	Nerium oleander	Jl_{18}	Jl_{14}	------	------	-------	-------
	Laurus nobilis	------	------	------	------	------	------
	Viburnum tinus	-------	F_{12}	J_{12}	N_{7}	N_{8}	------
	Pittosporum tobira	M_{15}	My_{9}	------	Jn_{7}	-------	------
	Trachycarpos fortunei	------	------	---	------	------	------
	Vitex agnus -castus	Jl_{28}	Jl_{8}	------	Jn_{6}	Jl_{9}	------
	Cupressus sempervirens	------	------	------	------	------	------
	Ziziphus jujuba	Jn_{28}	Jn_{18}	------	Jl_{2}	Jl_{1}	------
	Callistemon laevis	M_{15},Ag_{17}	A_{12},Ag_{13}	------	------	------	----------
100% of flowering	*Lagerstroemia indica*	S_{10}	S_{20}	------	Ag_{1}	Ag_{19}	------
	Nerium oleander	Ag_{1}	Jl_{24}	------	------	-------	------
	Laurus nobilis	------	------	------	------	------	------
	Viburnum tinus		M_{4}	J_{18}	-----	------	-------
	Pittosporum tobira	M_{25}	My_{17}	------	Jn_{14}	-------	------
	Trachycarpos fortunei	------	------	---	------	------	------
	Vitex agnus -castus	Ag_{17}	Jl_{15}	------	Jl_{2}	Jl_{17}	------
	Cupressus sempervirens	-------	-------	------	------	-------	------
	Ziziphus jujuba	Jl_{12}	Jn_{24}	------	Jl_{13}	Jl_{10}	------
	Callistemon laevis	My_{23},S_{28}	My_{17},S_{13}	---	------	------	------

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Table 13 Observation of growth phenophases for the studied woody plants - continuing

Pheno-phases	Species	Planting into pots			Planting into ground		
		2012	2013	2014	2012	2013	2014
10% of blossom fall	*Lagerstroemia indica*	S_{20}	O_{1}	------	S_{10}	S_{13}	------
	Nerium oleander	Ag_{10}	Jl_{26}	------	------	-------	------
	Laurus nobilis	-------	-------	------	------	-------	------
	Viburnum tinus	-------	M_{15}	J_{21}	------	-------	------
	Pittosporum tobira	M_{15}	My_{17}	------	Jn_{14}	-------	------
	Trachycarpos fortunei	-------	-------	---	------	-------	------
	Vitex agnus -castus	S_{3}	Jl_{24}	------	Jl_{30}	Jl_{27}	------
	Cupressus sempervirens	-------	-------	------	------	-------	------
	Ziziphus jujuba	Jl_{12}	Jl_{10}	------	Ag_{17}	Ag_{7}	------
	Callistemon laevis	My_{25},S_{18}	My_{29},O_{1}	------	------	------	--------
50% of blossom fall	*Lagerstroemia indica*	S_{27}	O_{4}	------	S_{28}	S_{20}	------
	Nerium oleander	Ag_{20}	Ag_{6}	------	------	----------	----
	Laurus nobilis	------	------	------	------	------	------
	Viburnum tinus		M_{28}	J_{30}	------	-------	------
	Pittosporum tobira	A_{3}	My_{22}	------	Jn_{18}	------	------
	Trachycarpos fortunei	------	-------	---	------	------	------
	Vitex agnus -castus	S_{10}	Ag_{3}	------	Ag_{8}	Ag_{7}	------
	Cupressus sempervirens	------	------	------	------	------	------
	Ziziphus jujuba	Jl_{18}	Jl_{22}	------	Ag_{20}	Ag_{13}	------
	Callistemon laevis	Jn_{1},Ag_{30}	Jn_{6},Ag_{28}	------	------	------	------
100 % of blossom fall	*Lagerstroemia indica*	O_{30}	O_{7}	------	O_{8}	O_{11}	------
	Nerium oleander	S_{28}	S_{10}	------	------	-------	------
	Laurus nobilis	-------	-------	------	------	-------	------
	Viburnum tinus		A_{7}	F_{5}	------	---------	-----
	Pittosporum tobira	A_{30}	Jn_{1}	------	Jn_{24}	-------	------
	Trachycarpos fortunei	-------	-------	---	------	-------	------
	Vitex agnus -castus	S_{25}	Ag_{7}	------	S_{29}	Ag_{20}	------
	Cupressus sempervirens	------	-------	------	------	-------	------
	Ziziphus jujuba	Ag_{5}	Ag_{15}	------	Ag_{24}	Ag_{19}	------
	Callistemon laevis	Jn_{22},S_{30}	Jn_{18},S_{28}	---	------	------	---------
10% of frui bearing	*Lagerstroemia indica*	S_{3}	S_{20}	---	S_{28}	S_{13}	------
	Nerium oleander	S_{10}	S_{3}	------	------	-------	------
	Laurus nobilis	-------	-------	------	------	-------	------
	Viburnum tinus		M_{28}	M_{7}	-----	-----	-----
	Pittosporum tobira	A_{10}	My_{19}	------	Jn_{30}	-------	------
	Trachycarpos fortunei	-------	-------	---	------	-------	------
	Vitex agnus -castus	Ag_{17}	Ag_{7}	------	Ag_{8}	Jl_{24}	------
	Cupressus sempervirens	------	-------	------	------	-------	------
	Ziziphus jujuba	Jl_{16}	Jl_{24}	------	----	Ag_{7}	------
	Callistemon laevis	A_{28},My_{25}	M_{5},My_{30}	------	------	------	------

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Table 13 Observation of growth phenophases for the studied woody plants - continuing

Pheno-phases	Species	Planting into pots			Planting into ground		
		2012	2013	2014	2012	2013	2014
50% of fruit bearing	*Lagerstroemia indica*	S_{10}	O_{1}	------	S_{28}	O_{1}	------
	Nerium oleander	S_{21}	S_{17}	------	------	------	------
	Laurus nobilis	------	-----	----	-----	-------	----
	Viburnum tinus		A_{10}	M_{20}	-----	-------	------
	Pittosporum tobira	My_{30}	Jn_{12}	------	J_{l2}	-------	-----
	Trachycarpos fortunei	------	-----	---	-----	-------	----
	Vitex agnus -castus	Ag_{25}	Ag_{16}	------	S_{3}	Ag_{7}	------
	Cupressus sempervirens	------	-----	----	-----	-------	----
	Ziziphus jujuba	Ag_{3}	Ag_{7}	------	------	Ag_{18}	------
	Callistemon laevis	Jn_{15},Ag_{30}	Jn_{18},S_{13}	-----	-----	------	---------
100% of fruit bearing	*Lagerstroemia indica*	S_{28}	O_{7}	------	O_{8}	O_{9}	------
	Nerium oleander	O_{18},N_{7}	S_{29},N_{20}	------	------	-------	------
	Laurus nobilis	-------	-------	------	------	-------	------
	Viburnum tinus		A_{29}	M_{25}	----	-------	-----
	Pittosporum tobira	Jl_{18}	Jl_{5}	------	Jl_{13}	-------	------
	Trachycarpos fortunei	-------	-------	---	------	-------	------
	Vitex agnus -castus	S_{28}	S_{2}	------	S_{28}	Ag_{19}	------
	Cupressus sempervirens	------	-------	------	------	-------	------
	Ziziphus jujuba	Ag_{15}	Ag_{18}	------	------	S_{5}	------
	Callistemon laevis	Jn_{15},O_{8}	Jn_{24},S_{28}	----	-----	-----	----
10% of leaf colouration	*Lagerstroemia indica*	O_{8}	S_{20}	------	S_{10}	O_{9}	------
	Nerium oleander	-------	-------	------	------	-------	------
	Laurus nobilis	-------	-------	------	------	-------	------
	Viburnum tinus	-------	-------	------	------	-------	------
	Pittosporum tobira	-------	-------	------	------	-------	------
	Trachycarpos fortunei	-------	----------	---	------	-------	------
	Vitex agnus -castus	O_{14}	O_{11}	------	O_{15}	O_{22}	------
	Cupressus sempervirens	-------	-------	------	------	-------	------
	Ziziphus jujuba	S_{17}	S_{20}		S_{20}	S_{29}	
	Callistemon laevis	-------	-------	------	------	-------	---------
50% of leaf clouration	*Lagerstroemia indica*	O_{15}	O_{1}	------	O_{14}	O_{12}	------
	Nerium oleander	-------	-------	------	------	-------	------
	Laurus nobilis	-------	-------	------	------	-------	------
	Viburnum tinus	-------	-------	------	------	-------	------
	Pittosporum tobira	-------	-------	------	------	-------	------
	Trachycarpos fortunei	-------	-------	---	------	-------	------
	Vitex agnus -castus	O_{19}	O_{18}	------	O_{22}	O_{26}	------
	Cupressus sempervirens	-------	-------	------	------	-------	------
	Ziziphus jujuba	S_{24}	O_{1}	------	S_{28}	O_{1}	------
	Callistemon laevis	-------	-------	------	------	-------	------

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Table 13 Observation of growth phenophases for the studied woody plants - finishing

Pheno-phases	Species	Planting into pots			Planting into ground		
		2012	2013	2014	2012	2013	2014
100% of leaf colouration	*Lagerstroemia indica*	O_{22}	O_{10}	------	O_{22}	O_{18}	------
	Nerium oleander	-------	-------	------	------	-------	------
	Laurus nobilis	-------	-------	------	------	-------	------
	Viburnum tinus	-------	-------	------	------	-------	------
	Pittosporum tobira	-------	-------	------	------	-------	------
	Trachycarpos fortunei	-------	-------	---	------	-------	------
	Vitex agnus -castus	O_{25}	O_{27}	------	O_{30}	O_{30}	------
	Cupressus sempervirens	-------	-------	------	------	-------	------
	Ziziphus jujuba	S_{28}	S_{8}	------	O_{8}	O_{10}	------
	Callistemon laevis	-------	-------	------	------	-------	-------
10% of defoliation	*Lagerstroemia indica*	O_{15}	O_{12}	------	O_{26}	O_{12}	------
	Nerium oleander	-------	-------	------	-------	-------	------
	Laurus nobilis	-------	-------	------	------	-------	------
	Viburnum tinus	------	------	------	------	------	------
	Pittosporum tobira	-------	-------	------	-------	-------	------
	Trachycarpos fortunei	-------	-------	---	------	-------	------
	Vitex agnus -castus	O_{25}	O_{27}	-------	N_{1}	O_{30}	------
	Cupressus sempervirens	-------	---------	------	-------	--------	------
	Ziziphus jujuba	S_{28}	O_{1}	------	O_{8}	O_{10}	------
	Callistemon laevis	------	------	------	------	------	------
50% of defoliation	*Lagerstroemia indica*	O_{22}	O_{18}	------	N_{3}	O_{18}	------
	Nerium oleander	------	------	------	------	------	------
	Laurus nobilis	------	------	------	------	------	------
	Viburnum tinus	------	------	------	------	------	------
	Pittosporum tobira	------	------	------	------	------	------
	Trachycarpos fortunei	------	------	----	------	------	------
	Vitex agnus -castus	N_{2}	N_{3}	------	N_{16}	N_{12}	------
	Cupressus sempervirens	------	------	------	------	------	------
	Ziziphus jujuba	O_{15}	O_{11}	------	O_{16}	O_{18}	------
	Callistemon laevis	------	------	------	------	------	-------
100% of defoliation	*Lagerstroemia indica*	N_{14}	O_{22}	------	N_{16}	O_{22}	------
	Nerium oleander	------	------	------	------	------	------
	Laurus nobilis	-------	-------	------	------	-------	------
	Viburnum tinus	------	------	------	------	------	------
	Pittosporum tobira	------	-------	------	-------	-------	------
	Trachycarpos fortunei	-------	-------	----	------	-------	------
	Vitex agnus -castus	N_{7}	N_{12}	------	N_{27}	N_{20}	------
	Cupressus sempervirens	-------	-------	------	-------	-------	------
	Ziziphus jujuba	O_{22}	O_{18}	------	O_{23}	O_{22}	------
	Callistemon laevis	------	------	------	------	------	------

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4.4.5 Flowering periods and duration

Data in table (Tab. 14) showed that the shortest flowering period was in *Pittosporum tobira* planted into ground during 2012 (10 days) and the longest was in *Callistemon laevis* into pots (143 days). *Lagerstroemia indica* planted into pots had the flowering duration 90 days during 2012 and it decreased in 2013 to 33 days. Whereas the flowering duration in *Lagerstroemia indica* planted into ground during 2012 was 83 days, this duration decreased in 2013 to 71 days. There are differences between *Lagerstroemia indica* into pots and into ground. The difference during 2012 was 17 days and this period increased in 2013 to 38 days. According to datas (Tab. 14), *Lagerstroemia indica* into pots started 10% of flowering in 214th Julian Day (JD) and 100% of blossom fall in 304 JD in 2012. Into ground it started 10% of blossoming in 200 JD, blossom fall in 282 JD during 2012. *Lagerstroemia indica* started 10% of blossoming in 214 JD and 100% of blossom fall in 284 JD into ground and 10% of blossoming started in 248 JD and 100% blossom fall in 280 JD in pots during 2013. *Nerium oleander* into pots had duration of flowering longer in 2012 comparing to 2013 (14 days). Presented datas showes that 10% of flowering started in 193 JD, 100% of blossom fall in 272 JD during 2012 and during 2013 10% of flowering started in 188 JD, 100% of blossom fall in 153 JD at plants planted into pots. *Viburnum tinus* into pots had the flowering duration longer in 2013 comparing to 2014 (21 days); although *Viburnum tinus* into ground started flowering in the last October`s days without continuing the flowering. Table values showes that 10% of flowering started in 43 JD, 100% of blossom fall in 97 JD during 2013 and during 2014 about 10% of flowering started in 2nd Julian day, 100% of blossom fall in 36 JD. *Pittosporum tobira* into pots during 2012 had the flowering duration longer than in 2013 (31 days), while there was only the difference between plants into pots and into ground in 2012. The plants into pots had the longest duration comparing to 2013 (37 days). Results showes that 10% of flowering started in 75 JD, 100% of blossom fall in 121 JD during 2012 and during 2013 about 10% of flowering started in 137 JD, 100% of blossom fall in 152 JD in plants planted into pots; but the plants planted into ground blossomed only in the year 2012. Phenological observation showes that 10% of flowering started in 166 JD, 100% of blossom fall in 176 JD (see Tab. 14).

Vitex agnus –castus into ground had during 2012 the longest duration of flowering (97 days) comparing to the same planting type in 2013 (44 days); at the same time there was a difference with plants into pots during 2012 (64 days) and during 2013 (33 days). As is given in table datas (Tab.14), *Vitex agnus –castus* into pots started 10% of flowering in 200 JD and 100% of blossom fall in 269 JD in the year 2012; however 10% of blossoming started in 186 JD and 100% of blossom fall in 219 JD in 2013. Into ground it started 10% of blossoming in 176 JD, the blossom fall was in 273 JD during the year 2012. *Vitex agnus –castus* during 2013 it started 10% of blossoming in 188 JD and 100% of blossom fall in 232 JD into ground (see Tab. 14). *Ziziphus jujuba* in 2013 had the longest period of blossoming for plants those were into pots (74 days), while in 2012 the plants into ground had the longest duration (65 days) comparing to 2013 (56 days). *Ziziphus jujuba* into pots started 10% of flowering in 172 JD and 100% of blossom fall in 218 JD in 2012 and 10% of blossoming it started in 153 JD and 100% of blossom fall in 227 JD in 2013 (Tab. 14). Into ground it started 10% of blossoming in 172 JD, blossom fall was in 238 JD during the year 2012. *Ziziphus jujuba* during 2013 it started 10% of blossoming in 175 JD and 100% of blossom fall in 231 JD into ground. Finally during the year 2012 *Callistemon laevis* had the longest blossoming duration comparing to to year 2013 and this difference was 15 days. According to registered datas *Callistemon laevis* in 2012 started 10% of flowering in 75 and 230 JD and 100% of blossom fall in 174 and 274 JD, while in 2013 it started 10% of flowering in 87 and 225 JD and 100% of blossom fall in 169 and 271 JD, because this specimen flowered two times during growing season (see Tab. 14).

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Table 14 Observation of the flowering period of the blossomed species in Julian days (JD)

Species	Planting type	Year	10% of blossoming (JD)	100% of blossom fall (JD)	blossoming duration (days)
***Lagerstroemia indica* L.**	**Planting into pots**	2012	$Ag_{1\ (214)}$	$O_{30\ (304)}$	90
		2013	$S_{5\ (248)}$	$O_{7\ (280)}$	33
	Planting into ground	2012	$JL_{18\ (200)}$	$O_{8\ (282)}$	83
		2013	$Ag_{2\ (214)}$	$O_{11\ (284)}$	71
***Nerium oleander* L.**	**Planting into pots**	2012	$Jl_{11\ (193)}$	$S_{28\ (272)}$	80
		2013	$Jl_{7\ (188)}$	$S_{10\ (253)}$	66
	Planting into ground	2012	---------------	------------	--------
		2013	-------------	------------	---------
***Viburnum tinus* L.**	**Planting into pots**	2013	$F_{12\ (043)}$	$A_{7\ (097)}$	56
		2014	$J_{2\ (002)}$	$F_{5\ (036)}$	35
	Planting into ground	2012	$O_{22\ (296)}$	-----------	--------
		2013	$O_{18\ (291)}$	------------	----------
***Pittosporum tobira* L.**	**Planting into pots**	2012	$M_{15\ (075)}$	$A_{30\ (121)}$	47
		2013	$My_{17\ (137)}$	$Jn_{1\ (152)}$	16
	Planting into ground	2012	$Jn_{14\ (166)}$	$Jn_{24\ (176)}$	10
		2013	---------------	-----------	-------------
***Vitex agnus-castus* L.**	**Planting into pots**	2012	$Jl_{18\ (200)}$	$S_{25\ (269)}$	69
		2013	$Jl_{5\ (186)}$	$Ag_{7\ (219)}$	33
	Planting into ground	2012	$Jn_{24\ (176)}$	$S_{29\ (273)}$	97
		2013	$Jl_{7\ (188)}$	$Ag_{20\ (232)}$	44
***Ziziphus jujuba* L.**	**Planting into pots**	2012	$Jn_{20\ (172)}$	$Ag_{5\ (218)}$	46
		2013	$Jn_{2\ (153)}$	$Ag_{15\ (227)}$	74
	Planting into ground	2012	$Jn_{20\ (172)}$	$Ag_{24\ (238)}$	65
		2013	$Jn_{24\ (175)}$	$Ag_{19\ (231)}$	56
***Callistemon laevis* Ball**	**Planting into pots**	2012	$M_{15\ (075)}$, $Ag_{17\ (230)}$	$Jn_{22\ (174)}$ $S_{30\ (274)}$	99, 44=143
		2013	$M_{28\ (087)}$ $Ag_{13\ (225)}$	$Jn_{18\ (169)}$ $S_{28\ (271)}$	82, 46=128
	Planting into ground	2012	--------------	------------	----------

4.4.6 Fruiting periods and duration

Table 15 shows, that the fruit bearing had the differences between the individual species, the planting types and the years. *Lagerstroemia indica* planted into pots started in S_3 and ended in S_{28}, while during 2013 the fruit bearing started in S_{28} and ended in $O_{7.}$ The period of fruit bearing was 25 days in 2012 and its duration decreased to 9 days in 2013. *Lagerstroemia indica* which was planted into ground during 2012 started the fruit bearing in S_{28} and ended in O_8; its duration was 10 days while in 2013 this duration increased to 26 days. *Nerium oleander* into pots started the fruit bearing only in S_{10} and ended in O_{18} during the year 2013; its duration was 38 days during the year 2012, while this duration decreased to only 6 days in 2013. *Viburnum tinus* started the fruit bearing in M_{28} and ended

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in A_{29} during 2012; whereas in 2013 the fruit bearing started in M_7 and ended in M_{25}, the duration decreased to 18 days in 2013 (Tab.15). *Pittosporum tobira* started the fruit bearing for plants planted into pots in A_{10} and it ended in Jl_{18} during 2012, when this period was 99 days; while in 2013 the fruit bearing started in My_{19} and ended in Jl_5, it means that the period decreased to 47 days. It was found that within-species variations of the phenological response to temperature as well as to regional variations, there were less plant populations with lower genetic diversity (DOI et al., 2010). Thus the genetic diversity influences on the variation in phenological responses of the plant populations. The increased temperatures, low variation in phenological responses can caused the drastic changes in the phenology of the plant populations with synchronized phenological timings. *Pittosporum tobira* planted into ground had only the flower and the fruit period and the fruit bearing period was 13 days in 2012. In 2012 *Vitex agnus –castus* planted into pots started the fruit bearing in Ag_{17} and it ended in S_{28}, this period was 42 days; while in 2013 it started earlier in Ag_7 and ended earlier in $S_{2,}$ this period was 26 days. *Vitex agnus –castus* into ground started in Ag_8 and ended in $S_{28,}$ this period was 51 days during the year 2012; although during the year 2013 it decreased to 26 days (Tab.15). In 2012 *Ziziphus jujuba* planted into pots started the fruit bearing in Jl_{16} and ended in Ag_{15}, this period was 30 days; however in 2013 this period decreased to 5 days. During 2012 *Ziziphus jujuba* into ground had no fruiting; wheras during 2013 it started in Ag_7 and ended in S_5, when this period was 29 days. Finally *Callistemon laevis* into pots had even two times fruiting, the first started in A_{28} and ended in Jn $_{15}$, the second started in My_{25} and ended in O_8 during 2012. During 2013 into ground the fruiting started in $M_{5,}$ My_{30} and ended in $Jn_{24,}$ S_{28} because this specimen flowered two times during growing season (see Tab. 15).

Table 15 Observation of the fruiting period for blossomed species in Julian days (JD) - beginning

Species	Planting type	Year	10% fruit of bearing (JD)	100% of fruit bearing (JD)	Fruiting duration (days)
***Lagerstroemia indica* L.**	**Planting into pots**	2012	$S_{3(247)}$	$S_{28(272)}$	25
		2013	$S_{28\ (271)}$	$O_{7\ (280)}$	9
	Planting into ground	2012	$S_{28\ (272)}$	$O_{8\ (282)}$	10
		2013	$S_{13\ (256)}$	$O_{9\ (282)}$	26
***Nerium oleander* L.**	**Planting into pots**	2012	$S_{10\ (254)}$	$O_{18\ (292)}$	38
		2013	$S_{3\ (246)}$	$S_{9\ (252)}$	6
	Planting into ground	2012	---------------	-------------	--------
		2013	-------------	-------------	---------
***Viburnum tinus* L.**	**Planting into pots**	2013	$M_{28\ (087)}$	$A_{29\ (119)}$	32
		2014	$M_{7\ (066)}$	$M_{25\ (084)}$	18
	Planting into ground	2012	------------	-----------	--------
		2013	-------	------------	----------
***Pittosporum tobira* L.**	**Planting into pots**	2012	$A_{10\ (101)}$	$Jl_{18\ (200)}$	99
		2013	$My_{19\ (139)}$	$Jl_{5(186)}$	47
	Planting into ground	2012	$Jn_{30\ (182)}$	$Jl_{13\ (195)}$	13
		2013	---------------	-----------	-----------

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Table 15 Observation of the fruiting period for blossomed species in Julian days (JD) - finishing

Species	Planting type	Year	10% fruit of bearing (JD)	100% of fruit bearing (JD)	Fruiting duration (days)
***Vitex agnus -castus* L.**	**Planting into pots**	2012	$Ag_{17\ (230)}$	$S_{28\ (272)}$	42
		2013	$Ag_{7\ (219)}$	$S_{2(245)}$	26
	Planting into ground	2012	$Ag_{8\ (221)}$	$S_{28\ (272)}$	51
		2013	$Jl_{24(205)}$	$Ag_{19\ (231)}$	26
***Ziziphus jujuba* L.**	**Planting into pots**	2012	$Jl_{16\ (198)}$	$Ag_{15\ (228)}$	30
		2013	$Jl_{24\ (205)}$	$Ag_{18\ (230)}$	25
	Planting into ground	2012	-----------	----------	-------
		2013	$Ag_{7\ (219)}$	$S_{5\ (248)}$	29
***Callistemon laevis* Ball**	**Planting into pots**	2012	$A_{28\ (119),}$ $My_{25\ (146)}$	$Jn_{15(\ 167)}$ $O_{8\ (282)}$	48, 136=184
		2013	$M_{5\ (064)}$ $My_{30\ (150)}$	$Jn_{24\ (175)}$ $S_{28\ (271)}$	111, 121=232
	Planting into ground	2012	--------------	--------------	----------
		2013	-----------------	---------------	-----------

4.4.7 Leaf discolouration periods and duration in deciduous woody species

According to the discolour part of the Table 16 showes the differences between the species, the planting types and the individual years. *Lagerstroemia indica* planted into pots it started in O_8 and ended in O_{22} during the year 2012; while during the year 2013 the leaf discolouration started in S_{20} and ended in O_{10}. The period of leaf discolouration was 14 days in 2012 and its duration increased to 20 days in 2013. The variation among species in their phenology is an important mechanism for maintaining the species coexistence in diverse plant communities, by reducing competition for pollinators and other resources the timing of growth onset and senescence also determine growing season length (RATHCKE and LACEY, 1985). In 2012 *Vitex agnus –castus* planted into pots started the leaf discolouration in O_{14} and it ended in $O_{25,}$ this period was 11 days, while in 2013 it started in O_{11} and ended in $O_{16,}$ when this period was 16 days.

Ziziphus jujuba 2012 planted into pots started the leaf discolouration in S_{17} and it ended in S_{28}, this period was 11 days, while in 2013 the period decreased to 8 days. During 2012 *Lagerstroemia indica* which was planted into ground started leaf discolouration in S_{10} and ended in O_{22}, the duration was 42 days, whereas in 2013 the duration increased to 9 days. During 2012 *Vitex agnus –castus* into ground it started in O_{15} and ended in $O_{30,}$ the period was 15 days, but during 2013 it decreased to 8 days. In the year 2012 *Ziziphus jujuba* into ground started the leaf discolouration in S_{20} and it ended in O_8, its duration was 18 days, while in the year 2013 it started in S_{29} and ended in $O_{10,}$ this period was 11 days (see Tab. 16 and Fig. 3-6).

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Table 16 Observation of leaves discolouration in deciduous species in Julian days

Species	Planting type	Year	10% of leaves discolouration (JD)	100% of leaves discolouration (JD)	Leaves discolouration duration (days)
Lagerstroemia indica	**Planting into pots**	2012	$O_{8(282)}$	$O_{22\ (296)}$	14
		2013	$S_{20\ (263)}$	$O_{10(283)}$	20
	Planting into ground	2012	$S_{10(254)}$	$O_{22(296)}$	42
		2013	$O_{9(282)}$	$O_{18\ (291)}$	9
Vitex agnus -castus	**Planting into pots**	2012	$O_{14\ (288)}$	$O_{25\ (299)}$	11
		2013	$O_{11\ (284)}$	$O_{27(300)}$	16
	Planting into ground	2012	$O_{15\ (289)}$	$O_{30(304)}$	15
		2013	$O_{22(295)}$	$O_{30\ (303)}$	8
Ziziphus jujuba	**Planting into pots**	2012	$S_{17\ (261)}$	$S_{28\ (272)}$	11
		2013	$S_{20\ (263)}$	$S_{28\ (271)}$	8
	Planting into ground	2012	$S_{20\ (264)}$	$O_{8(282)}$	18
		2013	$S_{29\ (272)}$	$O_{10\ (283)}$	11

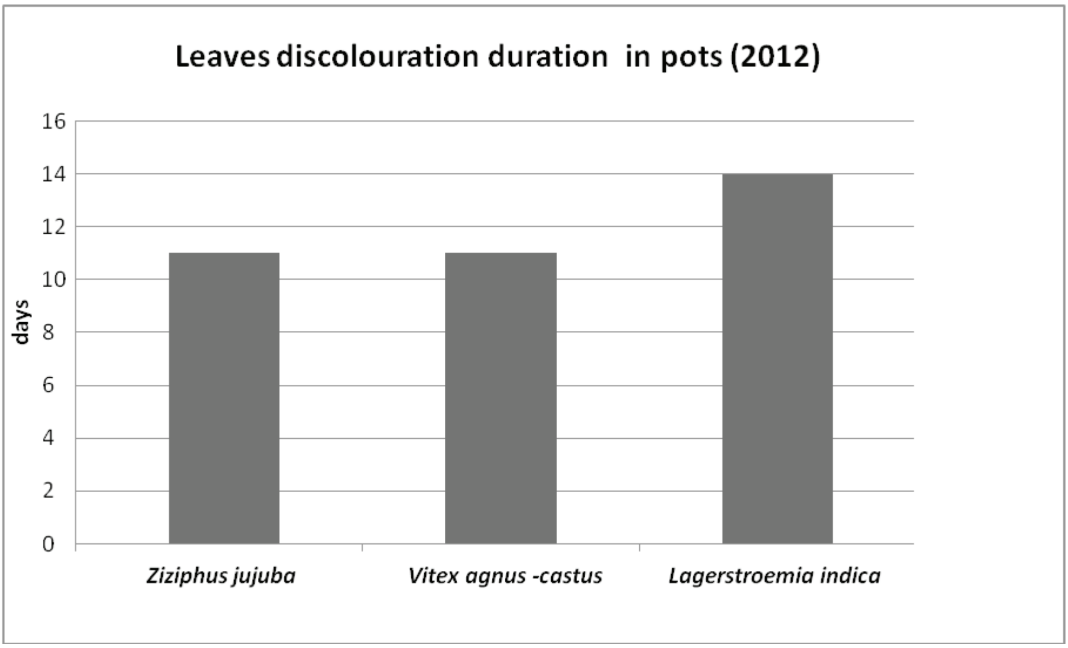

Figure 3 Leaves discolouration duration for deciduous species those were planted into pots (2012) according to number of days

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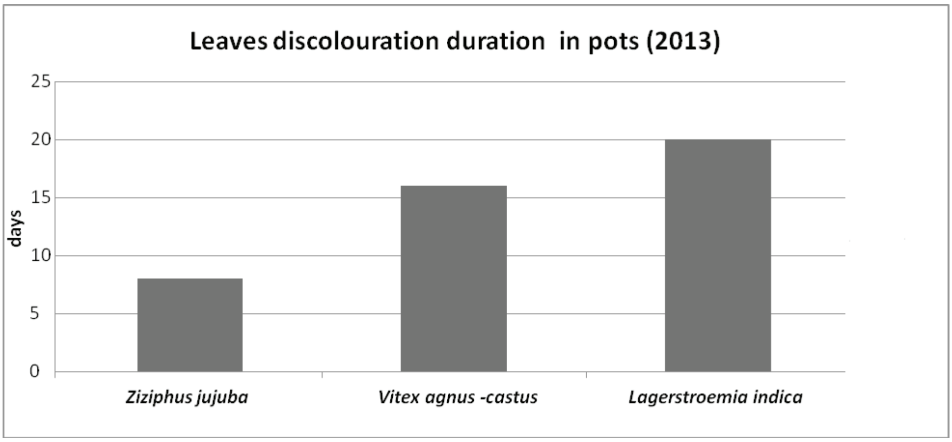

Figure 4 Leaves discolouration duration in deciduous species which were planted into pots (2013) according to number of days

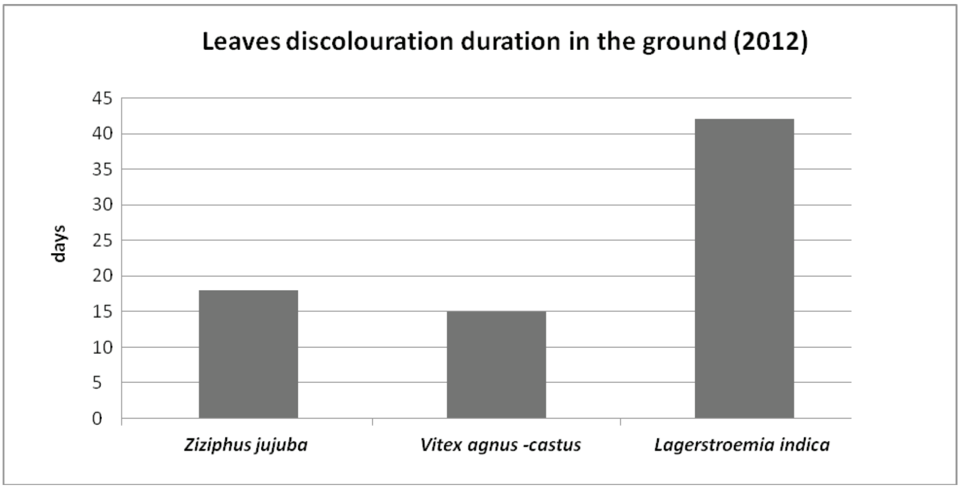

Figure 5 Leaves discolouration duration for deciduous species those were planted into ground (2012) according to number of days

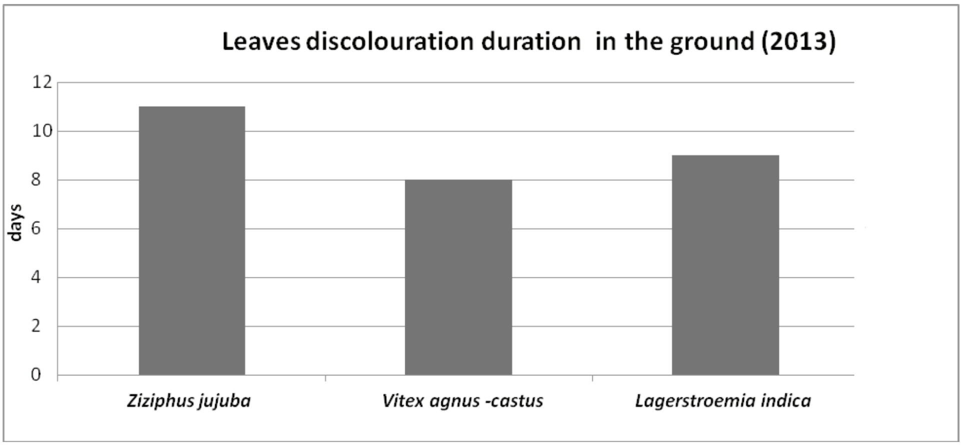

Figure 6 Leaves discolouration duration for deciduous species those were planted into ground (2013) according to number of days

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4.4.8 Growing periods and duration in deciduous woody species

Data in Table 17 show that the growing period was affected by the species, the planting type and the years. *Lagerstroemia indica*, planted into pots, started 10% of buds swelling in F_{10} and ended with 100% of defoliation in N_{14} during the year 2012. During the 2013 10% of buds swelling started in F_{26} and 100% of defoliation was in O_{22}; the growing period duration was 278 days in 2012 and this duration decreased to 238 days in 2013. The switch timing between the vegetative and reproductive phases that occurs in concept with flowering is crucial to optimal seed set for individuals and populations (BERNIER, 1988). During 2012 *Vitex agnus–castus,* which was planted into pots started 10% of buds swelling in J_{20} and 100% of defoliation was in $N_{7,}$ this period was 292 days; while in 2013 10% of bud swelling started in F_{26} and 100% of defoliation was in N_{12}, when this period was 259 days.

In the year 2012 *Ziziphus jujuba* planted into pots started 10% of buds swelling in F_8 and 100% of defoliation was in O_{22}, this period lasted 257 days, while in the year 2013 the period decreased to 234 days (see Fig. 7, 8, 9, 10). During 2012 *Lagerstroemia indica*, planted into ground, started 10% of buds swelling in A_{15} and 100% of defoliation was in $N_{16;}$ its duration lasted 215 days in 2012, but in 2013 this duration increased to 240 days. During 2012 *Vitex agnus –castus* into ground started 10% of buds swelling in A_8 and 100% of defoliation was in $N_{27,}$ when this period was 233 days, while during 2013 it decreased to 228 days. During 2012 *Ziziphus jujuba* into ground started 10% of buds swelling in A_{18} and 100% of defoliation was in O_{23}, and his duration lasted 188 days. During 2013 for the same plant 10% of buds swelling started in A_{10} and 100% of defoliation was in O_{22}, when this period was 195 days (see Fig. 7, 8, 9, 10).

Table 17 Observation of growth duration for deciduous species according to Julian days (JD)

Species	Planting type	Year	10% of leaf bud swelling (JD)	100% of leaves defoliation (JD)	growth duration (days)
Lagerstroemia indica	**Planting into pots**	2012	$F_{10\ (41)}$	$N_{14\ (319)}$	278
		2013	$F_{26\ (57)}$	$O_{22(295)}$	238
	Planting into ground	2012	$A_{15(106)}$	$N_{16(321)}$	215
		2013	$M_{24(55)}$	$O_{22\ (295)}$	240
Vitex agnus -castus	**Planting into pots**	2012	$J_{20(20)}$	$N_{7\ (312)}$	292
		2013	$F_{26\ (57)}$	$N_{12(316)}$	259
	Planting into ground	2012	$A_{8\ (99)}$	$N_{27(332)}$	233
		2013	$A_{6(96)}$	$N_{20\ (324)}$	228
Zizyphus jujuba	**Planting into pots**	2012	$F_{8\ (39)}$	$O_{22\ (296)}$	257
		2013	$F_{26\ (57)}$	$O_{18\ (291)}$	234
	Planting into ground	2012	$A_{18\ (109)}$	$O_{23(297)}$	188
		2013	$A_{10\ (100)}$	$O_{22(295)}$	195

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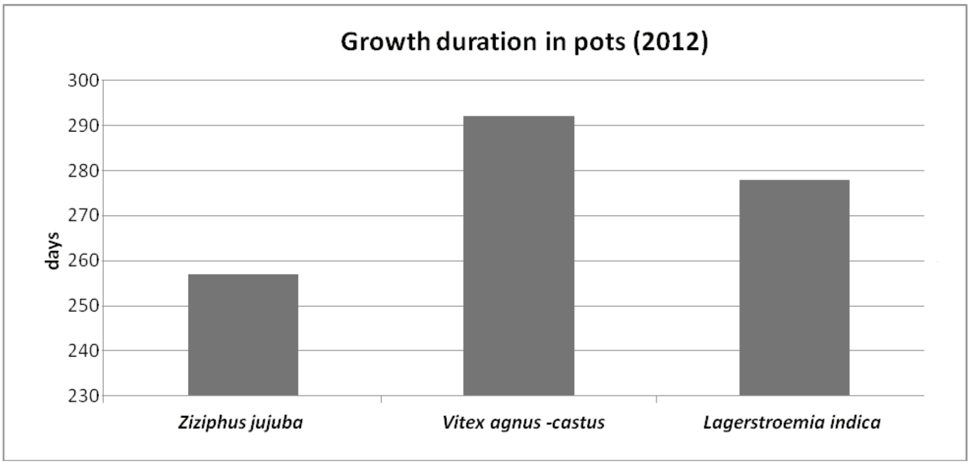

Figure 7 Growth duration for deciduous species those were planted into pots (2012) according to number of days

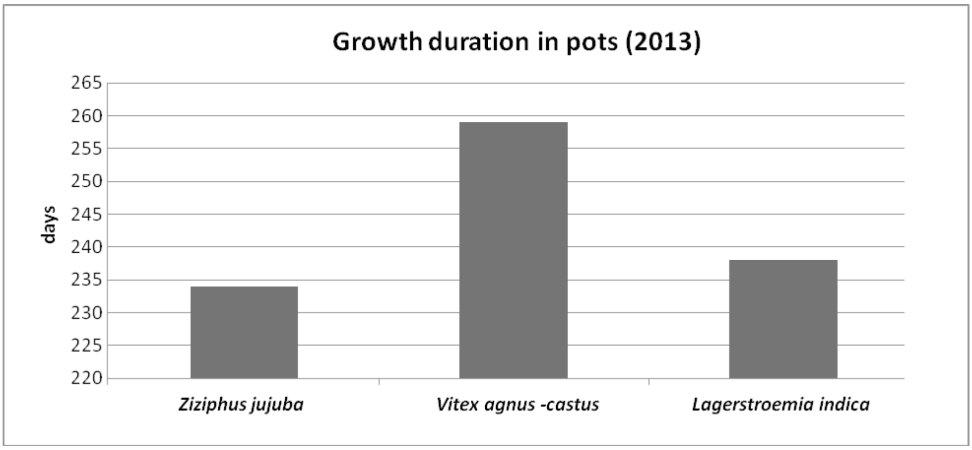

Figure 8 Growth duration for deciduous species those were planted into pots (2013) according to number of days

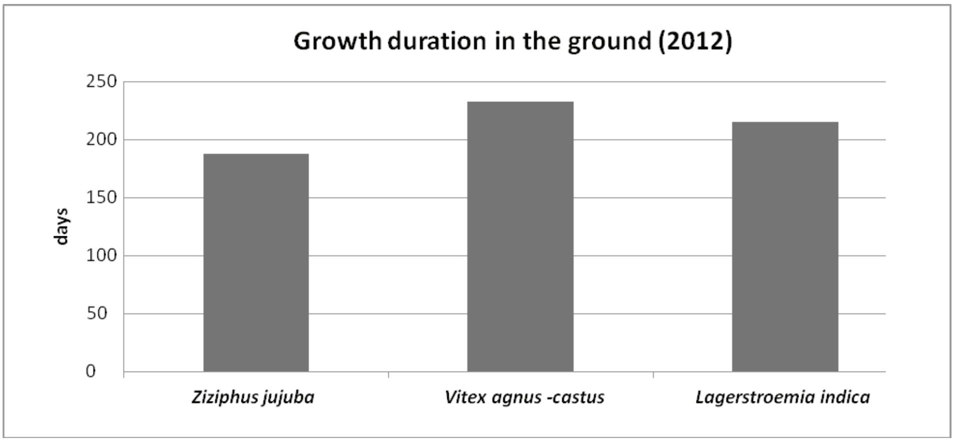

Figure 9 Growth duration for deciduous species those were planted into ground (2012) according to number of days

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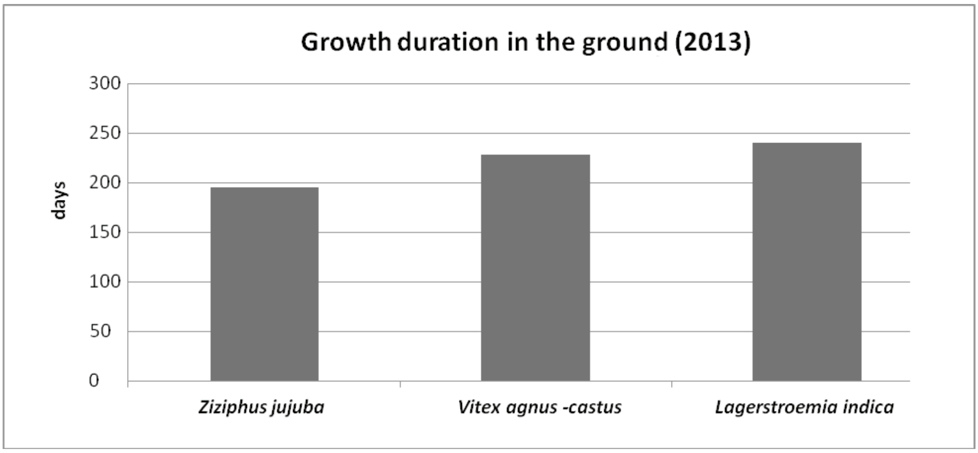

Figure 10 Growth duration for deciduous species those were planted into ground (2013) according to number of days

4. 5 Soil properties assessment of the experimental plots from the point of nutrient regime view

We evaluated of the nutrient system in soil samples, those were taken from the experimental area. Sampling was realized from the direct to soil planted plants and plant planted into pots, collected from the depths of 5 cm and 30 cm in December of 12th in 201211. By evaluation the elements into the samples taken from the experimental area it was found the acceptable nutrient content according to Mehlich III. By determining the trace elements have been identified: copper, zinc, manganese and iron in the extract according to Lindsay and Norvel (see Tab. 18, 19, 20, 21, 22, and 23). The elements values of the soil analysis from the experimental area were compared within the assessment analysis criteria results of soil Mehlich III method and according to Lindsay and Norvel under Annex no. 5 to Decree no. 338/2005 (Coll Ministry of Agriculture of the Slovak Republic on 6 July 2005 on the procedure for the collection of soil samples, the manner and extent to which agrochemical soil testing, survey the soil properties of forest land management and soil and fertilizer accounts nutritional status of plants on agricultural land and forest land). The limit risk elements values in relation to the agricultural land and plant (critical values) were evaluated in accordance with Act no. 220/2004 (Coll. of 10 March 2004 on the conservation and use of agricultural land and amending Act no. 245/2003 Coll. concerning integrated pollution prevention and control environment and on amendments to certain laws). We categorized the soil as medium heavy soil, containing the soil structure according to grain size listed in Slovak law 220/2004 (Coll. whose fraction of < 0.01 mm is in the range 20-45% (see Tab. 24, 25, 26 and 27)).

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Table 18 The evaluation criteria results of soil leaching by Mehlich III analyze method for arable land - a-Phosphorus (Decree no. 338/2005 Coll.) **- beginning**

Value	**Phosphorus (mg.kg^{-1})**		
	Soils		
	Light soils	**Medium heavy soils**	**Heavy soils**
Very low	up 30	up 25	up 20
Low	31 – 60	26 – 50	21 – 40
Suitable	61 – 95	51 – 85	41 – 70
Good	96 – 145	86 – 125	71 – 100
High	146 – 200	126 – 165	101 – 135
Very high	above 200	above 165	above 135

Table 18 The evaluation criteria results of soil leaching by Mehlich III analyze method for arable land - b-Potassium (Decree no. 338/2005 Coll.) - continuing

Value	**Potassium (mg.kg^{-1})**		
	Soils		
	Light soils	**Medium heavy soils**	**Heavy soils**
Very low	up 45	up 65	up 85
Low	46 – 90	66 – 130	86 – 170
Suitable	91 – 150	131 – 200	171 – 260
Good	151 – 230	201 – 300	261 – 370
High	231 – 350	301 – 400	371 – 500
Very high	Above 350	Above 400	Above 500

Table 18 The evaluation criteria results of soil leaching by Mehlich III analyze method for arable land - c-Magnesium (Decree no. 338/2005 Coll.) - finishing

Value	**Magnesium (mg.kg^{-1})**		
	Soils		
	Light soils	**Medium Heavy soils**	**Heavy soils**
Very low	up 40	up 55	up 70
Low	41 – 80	56 – 110	71 – 145
Suitable	81 – 135	111 – 175	146 – 220
Good	136 – 200	176 – 255	221 – 340
High	201 – 300	256 – 340	341 – 470
Very high	Above 300	Above 340	Above 470

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Table 19 The evaluation criteria of the micronutrient contents into soils (Decree no. 338/2005 Coll.)

Value	Micronutrients content (mg.kg^{-1})			Micronutrients content (%)	
	N_{an}	Ca	S	Humus	Cox
Very low	up 5	up1000	up10	up 1.0	up 0.6
Low	5.1 – 10	1001 – 2000	10.1 – 20	1.0 – 2.0	0.6 – 1.16
Suitable	10.1 – 20	2001 – 3000	20.1 – 40	2.0 – 3.0	1.16 – 1.74
Good	20.1 – 40	3001 – 5000	40.1 – 70	3.0 – 4.0	1.74 – 2.32
High	40.1 – 80	5001 – 7000	70.1 – 110	4.0 – 5.0	2.32 – 2.90
Very high	Above 80	Above 7000	Above 110	Above 5.0	Above 2.90

Table 20 The evaluation criteria of trace elements into soils (Decree no. 338/2005 Coll.)

Element	Soil type	Content of micronutrients (mg.kg^{-1})				
		Very low	Low	Medium	High	Very high
Boron	**L M H**	-	Down 0.4 0.6 0.8	0.4 – 0.7 0.6 – 0.1 0.8 – 1.5	Above 0.7 1.0 1.5	-
Molybdenum	**L M H**	-	Down 6.4 6.8 7.2	6.4 – 7.0 6.8 – 7.8 7.2 – 8.2	Above 7.0 7.8 8.2	-
Copper	**L,M, H**	**< 0.3**	0.3 – 0.8	0.8 – 1.6 1.6 – 2.7	2.7 – 5.0	> 5.0
Manganese	**L,M, H**	**< 4.0**	4.0 – 10.0	10.0 – 50.0 50– 100	100 – 300	> 300
Zinc	**L,M, H**	**< 0.4**	0.4 – 1.0	1.0 – 1.7 1.7 – 2.5	2.5 – 10	> 10
Iron	**L,M, H**	**< 3.0**	3.0 – 8.0	8.0 – 40.0 40.0 – 75.0	75 – 250	> 250

Explanation: Soil type= L- light, M- medium, H- heavy

Table 21 Risk elements limit values in relation with the agricultural land and plant - critical values (in mg.kg^{-1} dry matter in the extract of 1 mol / l ammonium nitrate) (Act no. 220/2004 Coll.)

Element	Critical value
Arsenic (As)	0.4
Copper (Cu)	1.0
Nickel (Ni)	1.5
Zinc (Zn)	2.0
Cadmium (Cd)	0.1
Lead (Pb)	0.1

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Table 22 Structure of soil under the SR (Act No. 220/2004 Z.z.)

Number	Soil texture	Part of fraction	Area		Soil types
		<0,01 mm (%)	ha	%	
1. **2.**	**Sand** **Loam**	< 10 10-20	39 136 171 220	1.6 7.0	
		0-20	**210 356**	**8.6**	**Light soil**
3. **4.**	**Sandy loam** **Loam**	20-30 30-45	420 711 1 298 824	17.2 53.1	
		20-45	**1 719 535**	**70.3**	**Medium heavy soil**
5. **6.** **7.**	**Clay loam Loamy Clay**	45-60 60-75 Above 75	428 049 80 718 7 338	17.5 3.3 0.3	
		>45	**516 105**	**21.2**	**Heavy soil**

Table 23 The evaluation criteria of the soil reaction (pH) (Decree No. 338/2005 Coll)

Rate pH	Soil reaction
under 4.5	Extremely acidic
4.6 – 5.0	Strongly acidic
5.1 – 5.5	Acidic
5.6 – 6.5	Slightly acidic
6.6 – 7.2	Neutral
7.3 – 7.7	Alkaline
Above 7.7	Strongly alkaline

Table 24 Nutrients and trace elements content into soil samples (Department of Soil Science FAaFR, SAU Nitra, 2013) according to Mehlich III

Planting type	Depth mm	pH	N_{an} mg.kg^{-1}	The nutrient content in mg.kg (Mehl.III)				S mg.kg^{-1}	Cox %	Zn mg.kg^{-1}	Fe mg.kg^{-1}	Mn mg.kg^{-1}	Cu mg.kg^{-1}	Cd mg.kg^{-1}
				P	K	Ca	Mg							
Plants planted into ground	0-50	6.86	13.5	162.5	700	4710	952	2.5	2.76	8.55	1	4.72	2.93	0.073
Plants planted into ground	0-300	6.88	8.6	111.25	537.5	4665	981.5	1.3	2.46	7.94	0.3	6.20	3.36	0.073
Plants planted into pots	0-50	5.87	27.6	465	900	6700	1369	11.00	9.23	81.77	27	76.64	3.80	0.124
Plants planted into pots	0-300	6.41	25.35	350	712.5	6635	1219	13.25	9.39	43.90	21.7	65.28	5.11	0.115

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Table 25 Evaluation of the soil analyzes for arable land (nutrients content in $mg.kg^{-1}$) according to Mehlich III

Planting type	Depth mm	The nutrient content in $mg.kg^{-1}$ (Mehl.III)			
		P	K	Ca	Mg
Plants planted into ground	0-50	Very high	Very high	Very high	Very high
Plants planted into ground	0-300	Very high	Very high	Very high	Very high
Plants planted into pots	0-50	Very high	Very high	Very high	Very high
Plants planted into pots	0-300	Very high	Very high	Very high	Very high

Table 26 Evaluation of soil analyzes (humus content, trace elements, inorganic nitrogen, and total nitrogen) according to Mehlich III

Planting type	Depth mm	N_{an} $mg.kg^{-1}$	S $mg.kg^{-1}$	Cox %	Zn $mg.kg^{-1}$	Fe $mg.kg^{-1}$	Mn $mg.kg^{-1}$	Cu $mg.kg^{-1}$
Plants planted into ground	0-50	Suitable	Very low	High	High	Very low	Low	High
Plants planted into ground	0-300	Low	Very low	High	High	Very low	Low	High
Plants planted into pots	0-50	Good	Low	Very high	Very high	Medium	Medium	High
Plants planted into pots	0-300	Good	Low	Very high	Very high	Medium	Medium	Very high

Table 27 Soil pH assessment according to Mehlich III

Planting type	Depth (mm)	pH
Plants planted into ground	0-50	Neutral
Plants planted into ground	0-300	Neutral
Plants planted into pots	0-50	Slightly acidic
Plants planted into pots	0 -300	Neutral

4. 6 Content of carbohydrates, pigments and dry matters into leaves of investigated woody plants as the potential metabolic markers for adaptability assessment of the changed environment conditions

4.6.1 Starch content into leaves

Data in Table 28 show that planting into ground led to starch decrease content into leaves; its value was (2.79% in dry matter). The plants planted into pots and protected during the winter time had recorded the highest value of starch content into leaves (4.18% in dry matter). Temperature effects at different organization, biochemical, physiological, morphological, agronomic and systems levels are considered as changing in the enzyme activities during fall, winter and spring in relation to the changes in starch content and frost hardiness. Starch levels were negatively correlated with frost hardiness whereas the most positively were correlated soluble sugars in grapevines (JONES et al., 1999). According to data (see Tab. 28) the highest value of starch content into evergreen shrub leaves was in *Cupressus sempervirens* (4.91% in dry matter) and this difference was significant also within other species. The lowest starch content into leaves was in *Trachycarpos fortunei* (1.25% in dry matter).

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In this study we found that *Cupressus sempervirens* planted into pots had the highest starch content (6.37% in dry matter) and this difference was significant comparing to other species planted into the different planting types. The lowest content of starch was found in *Trachycarpos fortunei* planted into ground (see Fig. 11). The data show also that there are no significant differences between *Laurus nobilis* planted into ground and *Viburnum tinus* planted into pots (see Tab. 28). It was probably caused due to the low temperature occurences, those affected the plants in several ways, e.g.temperatures near minimum for plant growth reduced the plants' metabolism and growth rate. Strikingly linear relationship between starch breakdown and temperature were observed in *Populus x canadensis* according to SAUTER (1988).

4.6.2 Total sugar content into leaves

According to presented data in Table 29, the plants into pots had higher total sugar content (6.70% in dry matter) and the lowest total sugar content had plants into ground (4.16% in dry matter), these differences were significant. The soluble sugar concentration (sucrose, glucose, and fructose) in the shoot was not affected by the temperature treatments (PRESSMAN et al., 1994). The results agree with PRESSMAN et al., (1989) who obtained that the long duration of low temperature treatment led to a sharp decrease into the sugar content in *Asparagus*. The highest total sugar content in leaves was found in *Laurus nobilis* (8.85% in dry matter) and these differences were significant with *Trachycarpos fortunei, Nerium oleander, Viburnum tinus* and *Cupressus sempervirens,* however the differences were not significant with *Pittosporum tobira* (see Fig. 12). Among *Nerium oleander, Viburnum tinus* and *Cupressus sempervirens* there were no significant differences (see Tab. 29). Data in Table 29 display that the highest value of total sugar was found in *Pittosporum tobira* those were planted into pots (12.92% in dry matter) and the lowest was in *Trachycarpos fortunei* those were planted into ground (0.40% in dry matter). According to the data in the same table, there are no significant differences among *Cupressus sempervirens* into ground*, Nerium oleander* into ground, *Viburnum tinus* into ground and *Laurus nobilis* into pots. There are no significant differences among *Trachycarpos fortunei, Nerium oleander, Viburnum tinus* planted into pots. *Pittosporum tobira* into ground and *Cupressus sempervirens* into pots showed that there are no significant differences between them. The results agree with REJŠKOVA et al. (2007) who obtained that the low temperature lead to an increase of the refines family oligosaccharides (RFO) proportion in total carbohydrate in *Olea europaea.* Temperature factor influence all plant growth processes such as photosynthesis, respiration, transpiration, breaking of seed dormancy, seed germination, protein synthesis, and translocation. During high temperatures the translocation of photosynthetic is faster.

Table 28 Starch affected by species and planting type (% in dry matter)

Starch		Factor species						Mean Planting Type
		Viburnum tinus	***Trachycarpos fortunei***	***Nerium oleander***	***Pittosporum tobira***	***Laurus nobilis***	***Cupressus sempervirens***	
Factor Planting Types	**Planting into ground**	2.93^{c-g}	0.86^{g}	4.34^{b-e}	2.41^{e-g}	2.76^{d-g}	3.46^{b-f}	2.79^{b}
	Planting into pots	2.72^{d-g}	1.65^{fg}	4.73^{a-c}	4.5^{a-d}	5.12^{ab}	6.37^{a}	4.18^{a}
Mean species		2.82^{c}	1.25^{d}	4.53^{ab}	3.46^{bc}	3.94^{a-c}	4.91^{a}	3.49

*Means not followed by the same letters are significant at 5% level of probability

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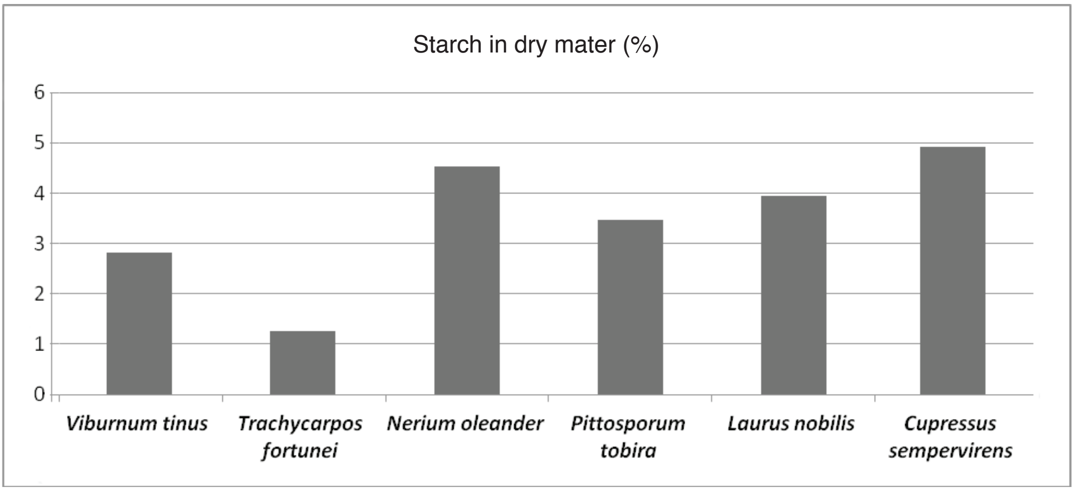

Figure 11 Mean starch content into ever green leaves of the assessed woody plants

Table 29 Total sugar content affected by the species and the planting type (% in dry matter)

Total sugar		Factor species						Mean Planting Type
		Viburnum tinus	*Trachycarpos fortunei*	*Nerium oleander*	*Pittosporum tobira*	*Laurus nobilis*	*Cupressus sempervirens*	
Factor Planting Types	**Planting into ground**	6.23[c]	0.40[e]	7.39[c]	2.26[de]	9.83[b]	6.13[c]	4.16[b]
	Planting into pots	2.63[d]	2.99[d]	3.72[d]	12.92[a]	7.86[c]	2.26[de]	6.70[a]
Mean species		4.43[b]	1.69[c]	5.56[b]	7.59[a]	8.85[a]	4.47[b]	5.43

*Means not followed by the same letters are significant at 5% level of probability

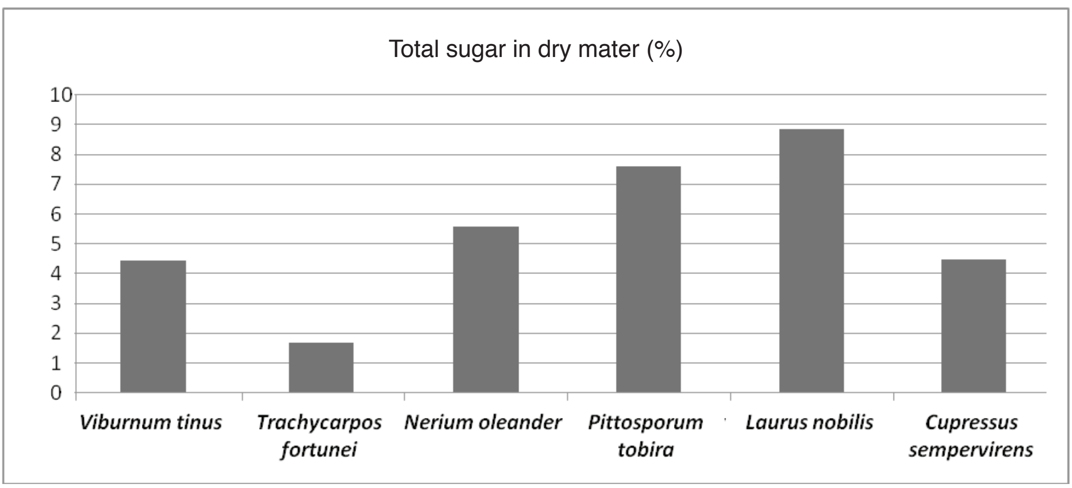

Figure 12 Total sugars mean content into ever green leaves of the assessed woody plants

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4.6.3 Chlorophyll a content in leaves

Data in Table 30 show that the highest content of chlorophyll *a* into leaves was in plants situated into ground (2.13mg.g^{-1}), while plants planted into pots had the lowest value of chlorophyll *a* into leaves (1.39mg.g^{-1}). Chlorophylls (Chl) and Carotenoids (Car) are the main pigments of green leaves. Carotenoids are usually represented by two (a- and b-) carotenes and five xanthophylls (lutein, zeaxanthin, violaxanthin, antheraxanthin and neoxanthin), those exhibit a strong light absorption in the blue part zone of the vible spectrum and they are nonuniformly distributed in photo-systems and individual pigment-protein complexes of chloroplasts. Chlorophyll (Chl) fluorescence is a tool, which is widely used to examine photosynthetic performance in algae and plants. It is a non-invasive analysis that permits to assess photosynthetic performance in vivo (BAKER, 2008; BAKER and ROSENQVIST, 2004; WOO et al., 2008). At the same time the light play an important role in chlorophyll. Its content into plants, those were situated the inside, had less light intensity. Photosynthetic rates are enhanced by higher concentration of CO_2 into the air. In C3 plants, the additional CO_2 reduces photorespiration by increasing the ratio of CO_2 to O_2. Similar as it is in a light case, the rate of photosynthesis increases with higher CO_2 concentrations up to a saturation point, beyond which photosynthesis remains constant. According to data in Table 30, there are no significant differences among *Viburnum tinus, Trachycarpos fortunei* and *Laurus nobilis*, whereas the lowest content of chlorophyll *a* was in *Cupressus sempervirens* (0.53mg.g^{-1}). Between *Nerium oleander* and *Pittosporum tobira* were no significant differences (see Fig. 13). It was caused probably because the leaves of *Cupressus* are scaly and its leaves area is smaller than in the other species. Studies that combine the energy budget of leaves with photosynthesis have assessed the optimal leaves size for a given environments. The dimension and shape of leaves is an example of a compromise between leaf energy exchange, leaf temperature and photosynthesis. The amount of chlorophyll into leaves differ by the influence of many environmental factors (KOPSELL et al., 2005). Chlorophyll (Chl) fluorescence analysis is widely used to estimate photosystem II (PSII) activity, which is an important indicator of a biotic stress. The photosynthesis is therefore a physiological process performed by the green leaves of the plants by which CO_2 absorbs from the air; the water absorbs it from the soil. Their mutual combination help to produce chlorophyll (green part zone of the visible spectrum), its presentation into chloroplast of the leaves mesophyll cells changed them to carbohydrate in the presence of sun light (sugar and starch) (BHAGAT, 1981). The data obtained on the base of Table 30 show, that the highest value of chlorophyll *a* was found in *Viburnum tinus* (3.45mg.g^{-1}), whereas its lowest value was in *Cupressus sempervirens* (0.44mg.g^{-1}) planted into pots. According to the same Table there are no significant differences between *Viburnum tinus* and *Laurus nobilis* planted into pots. There were also not the significant differences among *Trachycarpos fortunei* situated into pots, *Laurus nobilis* into ground and *Cupressus sempervirens* into ground.

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Table 30 Chlorophyll *a* affected by species and planting type (mg.g-1)

Chlorophyll *a*		**Factor Species**						**Mean Planting Type**
		Viburnum tinus	***Trachycarpos fortunei***	***Nerium oleander***	***Pittosporum tobira***	***Laurus nobilis***	***Cupressus sempervirens***	
Factor Planting Type	**Planting into pots**	1.33^{de}	1.84^{cd}	0.61^{ef}	1.13$^{d\text{-}f}$	1.39^{de}	0.44^{f}	1.39^{b}
	Planting into ground	3.45^{a}	3.02^{ab}	2.53^{bc}	1.48^{d}	1.90^{cd}	1.96^{cd}	2.13^{a}
Mean Species		2.39^{a}	2.43^{a}	1.57^{b}	1.30^{b}	1.64^{a}	1.20^{c}	1.76

*Means not followed by the same letters are significant at 5% level of probability

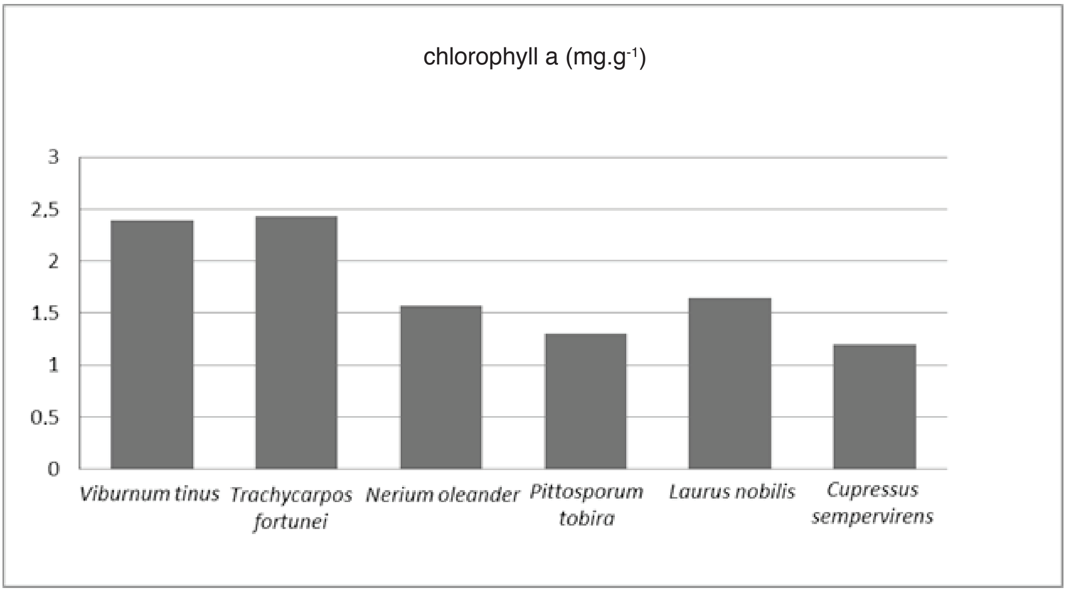

Figure 13 Chlorophyll *a* mean content in ever green leaves of the observed woody plants

4.6.4 Chlorophyll b content into leaves

Data on the base of Table 31 prove that the highest chlorophyll *b* content into leaves was in plants planted into ground (0.91mg.g^{-1}) comparing to plants cultivated into pots (0.61mg.g^{-1}). According to data in Table 31 the lowest chlorophyll *b* content into leaves was found in *Cupressus sempervirens* planted into ground (0.21mg.g^{-1}) and there was not a significant difference with *Pittosporum tobira.* The highest value of chlorophyll *b* content into leaves was found in *Nerium oleander* (0.98mg.g^{-1}) and there was not a significant difference with *Viburnum tinus*, *Laurus nobilis* and *Trachycarpos fortunei* (see Fig. 14). Many authors have assessed that chlorophyll synthesis is dependent on minerals volume, these results demonstrates also that plants chlorophyll content is related to nitrogen (TUNALI et al., 2012). Besides, the both observed plant species and their position influence on the leaves chloro-

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phyll content (GOND et al., 2012; ŞEVIK, et al., 2012). Data in Table 31 show that the highest value of chlorophyll *b* content into leaves was in *Trachycarpos fortunei* (1.33mg.g^{-1}) planted into ground and there was not a significant difference with *Trachycarpos fortunei* (1.30mg.g^{-1}) cultivated into pots. The lowest chlorophyll *b* content into leaves was in *Cupressus sempervirens* (0.17mg.g^{-1}) planted into pots. The data obtained according to the same Table indicate that there are no significant differences between *Viburnum tinus* and *Pittosporum tobira* planted into pots and at the same time there is not a significant difference between *Viburnum tinus* and *Laurus nobilis* cultivated into ground too.

Table 31 Chlorophyll *b* affected by species and planting type (mg.g-1)

Chlorophyll *b*		Factor Species						Mean Planting Type
		Viburnum tinus	*Trachycarpos fortunei*	*Nerium oleander*	*Pittosporum tobira*	*Laurus nobilis*	*Cupressus sempervirens*	
Factor Planting Type	Planting into pots	0.53^{c-e}	1.30^{a}	0.65^{b-d}	0.46^{c-e}	0.25^{de}	0.17^{e}	0.61^{b}
	Planting into ground	1.01^{ab}	1.33^{a}	0.86^{a-c}	0.63^{b-e}	1.03^{ab}	0.86^{a-c}	0.91^{a}
Mean Species		0.77^{a}	1.32^{a}	0.75^{a}	0.54	0.64^{a}	0.52^{b}	0.76

*Means not followed by the same letters are significant at 5% level of probability

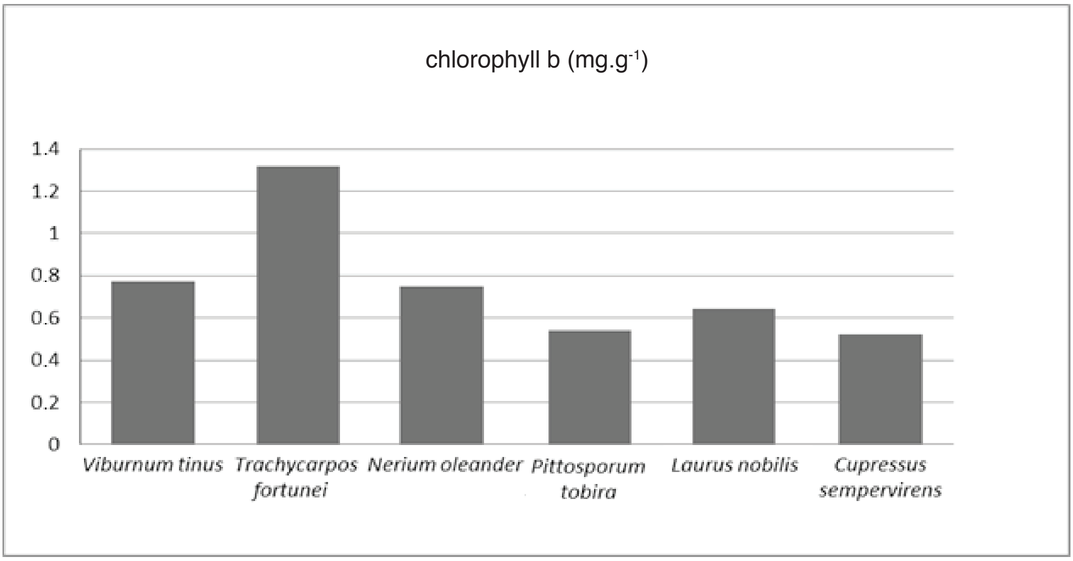

Figure 14 Chlorophyll *b* mean content into ever green leaves of the observed woody plants

4.6.5 Chlorophyll a+b content into leaves

Data displayed in Table 32 show that the highest chlorophyll *a+b* content into leaves was in plants those were planted into ground (3.04mg.g^{-1}) comparing to plants cultivated into pots (1.99mg.g^{-1}). According to the same data the highest chlorophyll *a+b* content was found into leaves of *Viburnum*

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tinus (3.56mg.g^{-1}) and there was not a significant difference with *Trachycarpos fortunei* (see Fig. 15). The lowest value of chlorophyll *a+b* content into leaves was found in *Cupressus sempervirens* (0.74mg.g^{-1}). Agreeing to data from Table 32 the highest value of chlorophyll *a+b* content into leaves was detected in *Trachycarpos fortunei* (4.46mg.g^{-1}) planted into ground and there was not a significant difference with *Viburnum tinus* (4.35mg.g^{-1}) cultivated into ground too. The lowest chlorophyll *a+b* content into leaves was obtained in *Cupressus sempervirens* (0.62mg.g^{-1}) planted into pots. According to the same Table the data show that there is not a significant difference among *Trachycarpos fortunei* with *Nerium oleander* and *Pittosporum tobira* cultivated into ground. There was also not a significant difference between *Nerium oleander* and *Cupressus sempervirens* situated into ground.

Table 32 Chlorophyll *a+b* content affected by species and planting type (mg.g-1)

Chlorophyll *a+b*		**Factor Species**						**Mean Planting Type**
		Viburnum tinus	***Trachycarpos fortunei***	***Nerium oleander***	***Pittosporum tobira***	***Laurus nobilis***	***Cupressus sempervirens***	
Factor Planting Type	**Planting into pots**	3.15^{b}	1.86^{cd}	2.05^{cd}	1.59^{ed}	0.86^{ef}	0.62^{f}	1.99^{b}
	Planting into ground	4.35^{a}	4.46^{a}	2.76^{bc}	2.10^{cd}	3.57^{ab}	2.82^{bc}	3.04^{a}
Mean Species		3.75^{a}	3.16^{a}	2.40^{b}	1.84^{c}	2.21^{ab}	1.72^{d}	2.52

*Means not followed by the same letters are significant at 5% level of probability

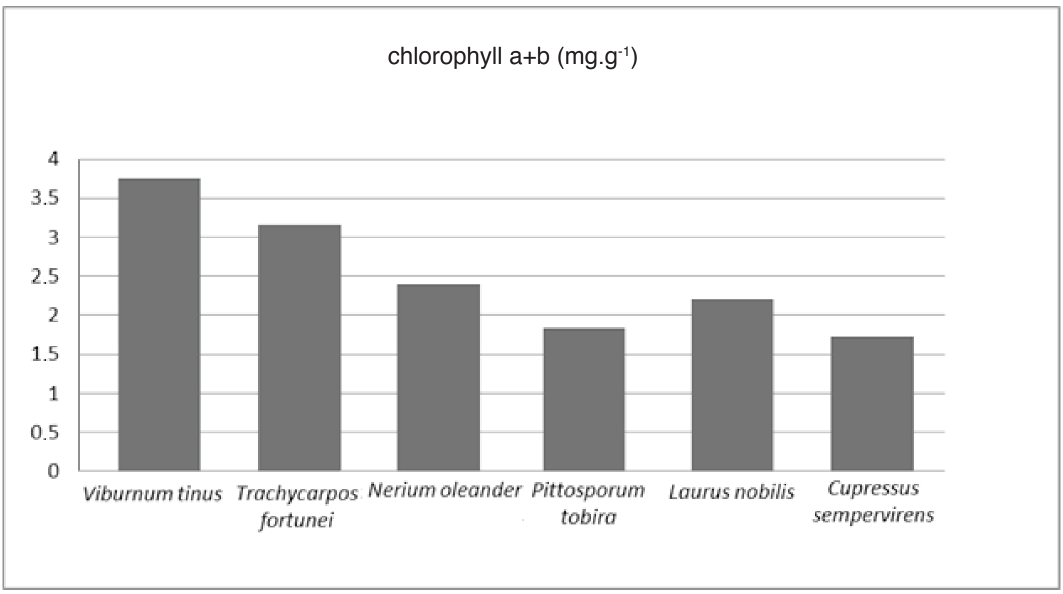

Figure 15 Chlorophyll *a+b* mean content in ever green leaves of the observed woody plants

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4.6.6 Chlorophyll a/b content into leaves

Data in Table 33 show that the highest chlorophyll a/*b* content into leaves was found in plants planted into ground (2.68mg.g^{-1}) comparing to plants cultivated into pots (2.37mg.g^{-1}), however the result was not a significant. According to the same data it was detected that the highest chlorophyll a/*b* content into leaves was obtained in *Pittosporum tobira* (2.98mg.g^{-1}) *and Trachycarpos fortunei* (2.97mg.g^{-1}), although there was not a significant difference between them. The lowest value of chlorophyll a/*b* content into leaves was found in *Nerium oleander* (1.82mg.g^{-1}), there was not a significant difference among *Cupressus sempervirens*, *Viburnum tinus* and *Laurus nobilis* (see Fig. 16). The highest value of chlorophyll a/*b* content into leaves was found in *Trachycarpos fortunei* (3.57mg.g^{-1}) cultivated into ground and there was not a significant difference with *Pittosporum tobira* (3.53mg.g^{-1}) planted into ground too. The lowest chlorophyll a/*b* content into leaves was assessed in *Nerium oleander* (1.13mg.g^{-1}) situated into pots. According to the same Table and its data was detected that there was not a significant difference among *Cupressus sempervirens*, *Viburnum tinus* and *Laurus nobilis* planted into ground and into pots. The ratio of chlorophyll a/*b* increased while chlorophyll *a* content decreased in response to planting type. These results agree with KITAJIMA and HOQAN (2003). Plant response of all species had the same trend, but they differed in their magnitude.

Table 33 Chlorophyll *a/b* affected by species and planting type (mg.g-1)

Chlorophyll *a/b*		**Factor Species**						**Mean Planting Type**
		Viburnum tinus	***Trachycarpos fortunei***	***Nerium oleander***	***Pittosporum tobira***	***Laurus nobilis***	***Cupressus sempervirens***	
Factor Planting Type	**Planting into pots**	2.45^{ab}	2.36^{ab}	2.13^{b}	2.43^{ab}	2.58^{ab}	2.27^{ab}	2.37^{a}
	Planting into ground	2.67^{ab}	3.57^{a}	1.51^{b}	3.53^{a}	2.53^{ab}	2.30^{ab}	2.68^{a}
Mean Species		2.56^{ab}	2.97^{a}	1.82^{b}	2.98^{a}	2.55^{ab}	2.28^{ab}	2.53

*Means not followed by the same letters are significant at 5% level of probability

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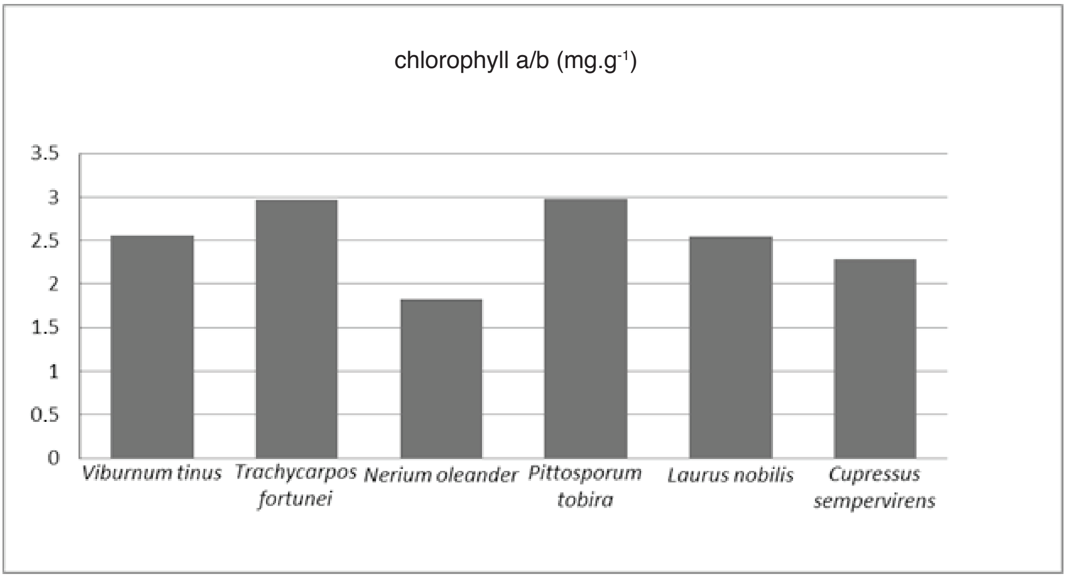

Figure 16 Chlorophyll *a/b* mean content into ever green leaves of the observed woody plants

4.6.7 Carotenoids content into leaves

According to data displayed into Table 34 it was found that the highest carotenoids content into leaves was in plants cultivated into ground (1.81mg.g^{-1}) comparing to plants situated into pots (0.56mg.g^{-1}). Carotenoids have two important functions in plants. Firstly they can contribute to the photosynthesis. They do it by transferring some of the light energy to absorb chlorophylls, those then they use as energy to drive photosynthesis. Secondly they can protect plants those are over-exposed to the sunlight. They do this by dissipating excess of the light energy harmlessly, which they absorb as heat afterwards. If it is an absence of carotenoids, the energy light excess can destroy proteins, membranes and other molecules. Carotenoids are lipid soluble yellow, orange, and red plant pigments. In plants the carotenoids have a function as light harvesting antennae of pigments, and they play role as an important free radical scavenger (TRACEWELL et al., 2001). According to data in Table 34 the highest carotenoids content into leaves was found in *Trachycarpos fortunei* (0.95mg.g^{-1}), however there was not a significant difference with *Viburnum tinus* (0.88mg.g^{-1}) and *Laurus nobilis* (0.87mg.g^{-1}). The lowest value of carotenoids content into leaves was found in *Cupressus sempervirens* (0.26mg.g^{-1}) (see Fig. 17). The highest value of carotenoids content into leaves was in *Viburnum tinus* (1.25mg.g^{-1}) planted into ground and the lowest carotenoids content into leaves was in *Cupressus sempervirens* (0.25mg.g^{-1}) cultivated into pots. According to the same Table, the obtained data prove that there was not a significant difference between *Laurus nobilis* planted into pots and into ground with *Pittosporum tobira*. There was also not a significant difference between *Trachycarpos fortune* situated into pots and *Cupressus sempervirens* planted into ground. The environmental factors as the air temperatures can have the significant impacts on plant development and metabolism. Exposing plants to low air temperatures can damage the photosynthetic apparatus, inhibit the synthesis and/or degradate proteins, damage the thylakoid membrane, and reduce the electron transfer capacity of plants (GUY and REID, 1986). Carotenoids have a very important task in photosynthesis. Carotenoids biosynthesis in plants is according to their genetic character, but the environmental plants conditions play an essential role as well (BOJOVIC and STOJANOVIC, 2005).

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Table 34 Carotenoids affected by species and planting type (mg.g-1)

Carotenoids		Factor Species						Mean Planting Type
		Viburnum tinus	*Trachycarpos fortunei*	*Nerium oleander*	*Pittosporum tobira*	*Laurus nobilis*	*Cupressus sempervirens*	
Factor Planting Type	**Planting into pots**	0.52^{ef}	0.79^{cd}	0.27^{g}	0.40^{fg}	0.65^{de}	0.25^{g}	0.56^{b}
	Planting into ground	1.25^{a}	1.09^{ab}	0.97	0.64^{de}	0.66^{de}	0.78^{cd}	0.81^{a}
Mean Species		0.88^{a}	0.94^{a}	0.62^{b}	0.52^{c}	0.66^{a}	0.51^{d}	0.69

*Means not followed by the same letters are significant at 5% level of probability

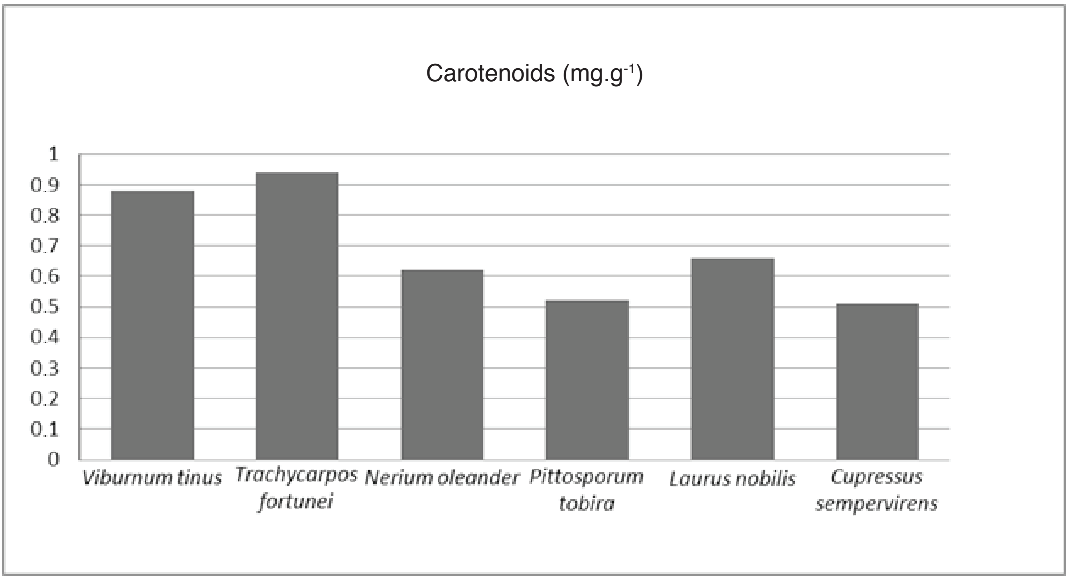

Figure 17 Carotenoids mean content into ever green leaves of the observed woody plants

4.6.8 Chlorophyll a-b/ Carotenoids content into leaves

According to data obtained from the Table 35 it is indicated that the highest chlorophyll *a-b*/carotenoids content into leaves was in plants those were planted into ground (3.68mg.g^{-1}) comparing to plants cultivated into pots (3.43mg.g^{-1}). With regard to data in Table 35 it influences that the highest chlorophyll *a-b*/carotenoids content into leaves was found in *Cupressus sempervirens* (4.05mg.g^{-1}) and there was not a significant difference among *Nerium oleander, Trachycarpos fortunei* and *Pittosporum tobira* (see Fig. 18). The lowest value of chlorophyll *a-b*/carotenoids content into leaves was found in *Laurus nobilis* (2.85mg.g^{-1}). The highest value of chlorophyll *a-b*/carotenoids content into leaves was in *Cupressus sempervirens* (4.16mg.g^{-1}) planted into pots and its lowest value was found in *Laurus nobilis* (2.44mg.g^{-1}) situated into pots.

The data obtained from the same Table prove that there was not a significant difference among Cupressus *sempervirens* and *Nerium oleander* into ground with *Viburnum tinus* into pots. There was not

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a significant difference between *Trachycarpos fortunei* and *Laurus nobilis* planted into ground and *Pittosporum tobira* cultivated into pots.

Table 35 Chlorophyll *a-b/carotenoids* affected by species and planting type (mg.g-1)

Chlorophyll *a-b/car.*		Factor Species						Mean Planting Type
		Viburnum tinus	*Trachycarpos fortunei*	*Nerium oleander*	*Pittosporum tobira*	*Laurus nobilis*	*Cupressus sempervirens*	
Factor Planting Type	Planting into pots	4.0^{ab}	3.58^{b-d}	3.11^{d}	3.27^{cd}	2.44^{e}	4.16^{a}	3.43^{b}
	Planting into ground	3.57^{b-d}	3.72^{cd}	3.96^{ab}	3.57^{b-d}	3.26^{cd}	3.99^{ab}	3.68^{a}
Mean Species		3.79^{ab}	3.65^{b}	3.53^{b}	3.42^{b}	2.85^{c}	4.08^{a}	3.56

*Means not followed by the same letters are significant at 5% level of probability

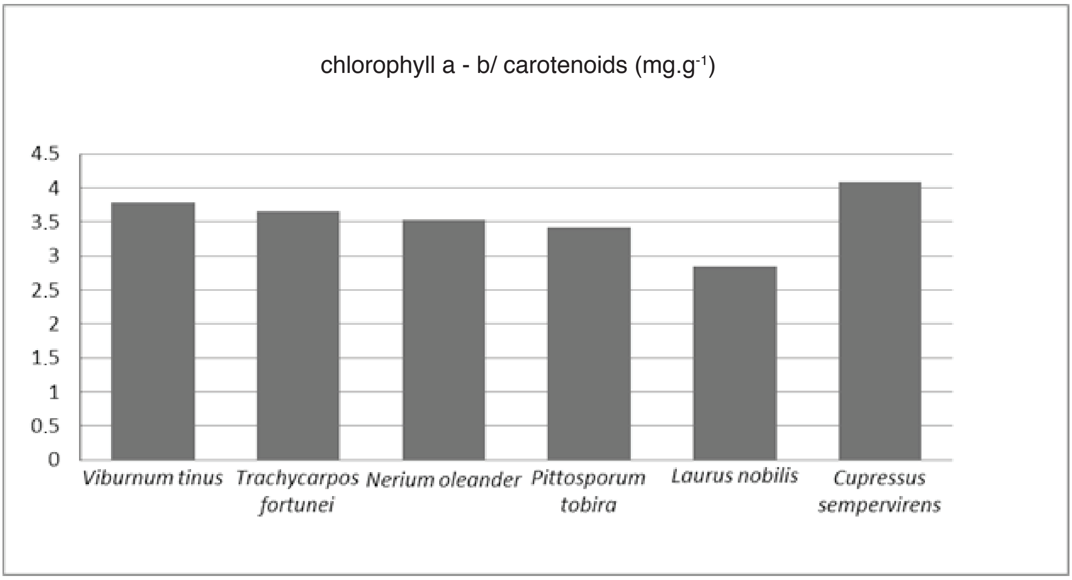

Figure 18 Chlorophyll *a+b / *carotenoids mean content into ever green leaves

4.6.9 Dry matter into leaves

According to data displayed in Table 36 it results that the highest dry matter content was in plants, those were planted into pots (92.69mg.g^{-1}) comparing to plants cultivated into ground (92.17mg.g^{-1}) (see Fig.19). The results agree with SAITO and KATO (1994). The low temperature and shading treatment reduce the dry matter production in soy bean. However several researchers declare that there is less dry matter into fruits growing at higher temperature (ADAMS et al., 2001). The climatic factors include rainfall and water, light, temperature, relative humidity, air, and wind. They are abiotic components; including topography and soil, as the environmental factors those influence plant growth and development. In generally, plants survive within a temperature range from 0°C to 50°C. Enzyme activity and the rate of the most of chemical reactions generally increase with temperature rise. Up to

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a certain point, there is double of enzymatic reaction with every 10°C temperature increase. Excessively low temperatures can cause limiting effects on plant growth and development (POINCELOT, 1980). According to data in Table 36 the highest dry matter content was found in *Laurus nobilis* (93.68mg. g^{-1}) and there was a significant difference with the other species. The lowest value of dry matter was found in *Pittosporum tobira* (91.8mg.g^{-1}) and there was not a significant difference with *Nerium oleander* (see Fig. 20). Plants are composed from a variety of compounds, besides water, certain plant organs have higher concentrations of carbohydrates, proteins and lipids that can vary in different organs into plants and between species. *Laurus nobilis* showed the highest value of dry matter content into plants cultivated into pots (94.46mg.g^{-1}), while the lowest dry matter content was in *Pittosporum tobira* situated into ground (91.39mg.g^{-1}). Data in Table 36 show that there was not a significant difference among *Pittosporum tobira, Cupressus sempervirens* and *Viburnum tinus* thosehich were planted into pots, and at the same time there was not a significant difference between *Viburnum tinus* and *Cupressus sempervirens* planted into ground. Among other changes, the cold-acclimated plants can better cope with the cold-impaired photosynthetic components such as: induced changes in pigment complexes, reduced net and maximal photosynthetic rates, induced losses of photochemical efficiency, restricted electron transport and enzyme activity or reduced carbohydrate metabolism.

Table 36 Planting type affected on dry matter content into the different ever green woody species (mg.g-1)

Dry matter		**Factor species**						**Mean Planting Type**
		Viburnum tinus	***Trachycarpos fortunei***	***Nerium oleander***	***Pittosporum tobira***	***Laurus nobilis***	***Cupressus sempervirens***	
Factor Planting Types	**Planting into ground**	92.22^{c-e}	92.59^{b-d}	91.85^{ef}	91.39^{f}	92.90^{b}	92.06^{c-e}	92.17^{b}
	Planting into pots	92.33^{b-e}	92.68^{bc}	91.98^{d-f}	92.34^{b-e}	94.46^{a}	92.39^{b-e}	92.69^{a}
Mean species		92.27^{bc}	92.63^{b}	91.92^{c}	91.86^{c}	93.68^{a}	92.23^{bc}	92.43

*Means not followed by the same letters are significant at 5% level of probability

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Figure 19 Dry matter mean content into leaves of the ever green woody plants according to planting ty

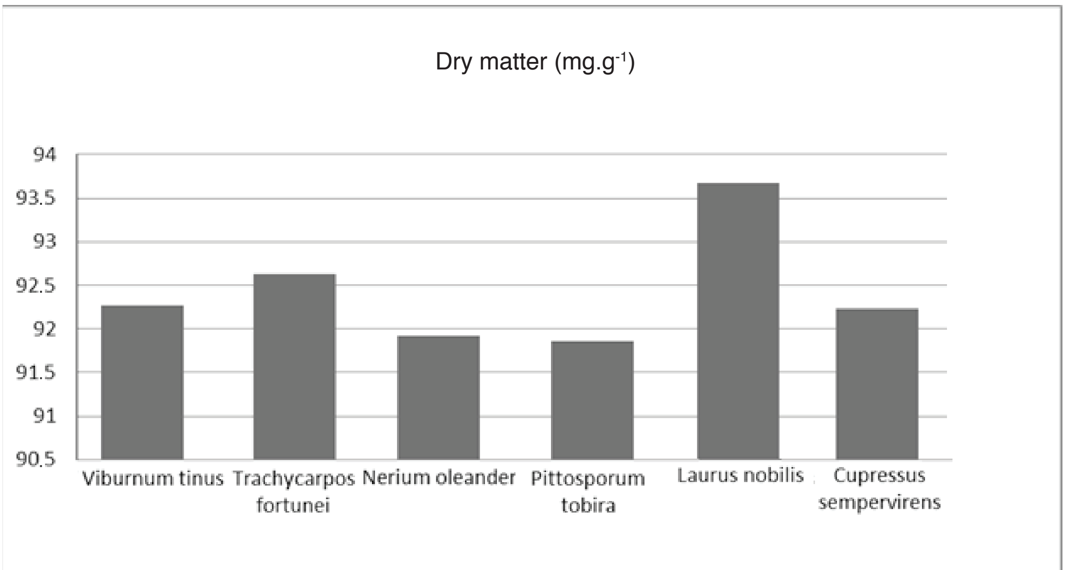

Figure 20 Mean dry matter content into ever green leaves according to woody species

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5. Conclusions

During the study time we found that the lowest winter hardiness was found in *Callistemon laevis* and the highest hardiness was for deciduous species. The deciduous species into ground started vegetation period later than the plants those were planted into pots. All *Pittosporum tobira* and *Nerium oleander* fresh shoots were damaged by the frost and during spring time they produced new shoots. *Lagerstroemia indica* and *Vitex agnus –castus* had flowers, fruits and produced germinable seeds in both planting types*. Ziziphus jujuba,* planted into pots and intoground, flowered and fruited, but the seeds were not germinable. In *Laurus nobilis*, *Cupressus sempervirens* and *Trachycarpos fortunei* both planting types were not flowered. The height of plants increased significantly in 2012 and 2013 for all species and minimum growth rate was found in *Trachycarpos fortunei* what was 2.3 cm during 2011-2012 and these values increased during 2012-2013 to 15 cm. The flowering phase start was a difference between planting types and species and it started from January to October. The plants growing in protected area during the winter time produced the higher content of starch comparing to plants growing in the open air. The highest value of starch was found in *Cupressus sempervirens* however the lowest value of starch was in *Trachycarpos fortune* comparing to other species. Plants growting in the protected area during the winter time produced the highest content of total sugar. The peak of the total sugar was found in *Laurus nobilis.* The interaction between species and planting type showed that *Pittosporum tobira* had the highest total sugar content when it is planted into pots and protected against cold weather, although *Trachycarpos fortunei* cultivated in the open air during the winter had the lowest value of total sugar. The highest value of chlorophyll *a* and *b* was found in *Trachycarpos fortunei* and the lowest value was in *Cupressus sempervirens.* The presented data showed that the highest carotenoid content was found into plants those were cultivated in the open air into ground, while plants planted into pots had the lowest carotenoid content and this difference was significant. *Trachycarpos fortunei* had the highest carotenoid content. The lowest content of carotenoid was found in *Pittosporum tobira.* Finally all evaluated plants from 10 observed woody species are recommended for park and garden design in A- climate area of Slovakia. Only *Pittosporum tobira, Nerium oleander* and *Callistemon laevis* should be moved into protected area, when the temperatures decrease to less than -5°C during the winter time.

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7. Apendix

Winter time

General view on plants covered with snow during winter time

Plants into ground at the end of winter time

Nerium oleander

Callistemon laevis into pots

Trachycarpos fortunei

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Spring time

General view of plants in spring time

Pot plants during spring time

Nerium oleander into pots

Viburnum tinus into ground

Trachycarpos fortunei

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Summer time

View of plants for each planting type

Vitex agnus –castus into ground during flowering time

Trachycarpos fortunei

Nerium oleander into pots

Lagerstroemia indica

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Autumn time

Discolouration of deciduous plants

Vitex agnus –castus started fruiting

Nerium oleander fruiting time

Ziziphus jujuba fruiting time

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