Acta Biol. Univ. Daugavp. 11 (2) 2011
ISSN 1407 - 8953

EVALUATION OF WINTER HARDINESS IN DIFFERENT CULTIVATED *TILIA* TAXA – EXPERIENCE OF SOME MOST VALUABLE DENDROLOGICAL PLANTATIONS IN CENTRAL LATVIA (VIDZEME) AFTER EXTREMELY HARD WINTER IN YEAR 2009/2010

Gunta Evarte-Bundere, Pēteris Evarts-Bunders

Evarte-Bundere G., Evarts-Bunders P. 2011. Evaluation of winter hardiness in different cultivated *Tilia* taxa – experience of some most valuable dendrological plantations in Central Latvia (Vidzeme) after extremely hard winter in year 2009/2010. *Acta Biol. Universit. Daugavpil., 11 (2): 119-125.*

Level of winter hardiness of arboreal plants directly depends on different climatic factors, most important of them – extremely low winter temperatures, long-term average temperature of January – coldest winter month in Latvia, as well as daily amplitudes of temperatures during winter season. Winter of season 2009./2010. is considered as one of the most coldest during the last 20 – 25 years, most critical temperatures was recorded in Vidzeme (Central Latvia). The research was carried out in summer, 2010., and 12 most valuable dendrological objects were inventoried in Central Vidzeme. Our research based on analysis of some of the most common cultivated *Tilia* taxa in Vidzeme shows a tendency to increase of winter damages in Northern and North-eastern part of Vidzeme - territory with lowest long-term average temperatures in January. Insignificant frost damages were observed in territories with untypically low winter temperatures during winter season of 2009./2010. even for such overall winter-resistant species as *T. euchlora* and *T. platyphyllos*.

Key words: *Tilia* L., Latvia, dendrological plantations, winter hardiness.

Gunta Evarte-Bundere, Pēteris Evarts-Bunders, Daugavpils University Institute of Systematic Biology, Vienibas Str., 13, Daugavpils, LV-5401, Latvia; e-mail: gunta.evarte@biology.lv, peteris.evarts@biology.lv

INTRODUCTION

Since the end of the 18th century, when wide introduction process of woody plants was started in Baltics, professionals had to deal with winter-resistance problems of woody plants. First observations on winter-resistance of cultivated woody plants in the territory of Latvia was carried out by J. Cigra after extremely hard winters of 1798/1799, 1799/1800, when orchards were frozen out in whole territory of the Baltic states. An extensive observation on winter-resistance of introducer arboreal plants was carried out by famous landscape architector and gardener G. Kufalds at the end of the 19th century and beginning of the 20th century.

Winter hardiness of introduced trees and shrubs

in the territory of Latvia after extremely hard winters of 1939/1940, 1955/1956 and 1978/1979 have been explained by different authors (Gailis 1960, Lange 1957, Ozols et al. 1959, Mauriņš 1962, Igaunis 1983, Cinovskis et al. 1987).

The previous investigations suggested, that winter resistance of arboreal taxa is associated with a very wide range of ecological conditions. Level of winter hardiness is directly affected by different climatic factors, most important of them – late spring and early autumn frosts, extremely low winter temperatures, continuance of low temperature during winter season and daily amplitude of temperatures (Mauriņš 1962, Zvirgzds 1964), depth of snow cover during the time of extremely low temperatures e.o. In addition, winter resistance of woody plans is determined not only by winter climate conditions, but also by weather of previous summer and fall, too. After warmer and drier summer and longer autumn as typically, cultivated trees and shrubs are better tolerate on winter minimum temperatures.

Intensity of photosynthesis during vegetation season and polysaccharide accumulation at the end of season are strictly depends from condition of vegetation season, and it directly affects the tolerance of trees against low temperatures during winter time. Amount of temperatures during vegetation season and seasonal precipitation can be characterized objectively by hydrotermical factor (HTF) – ratio between amount of rainfall during the period, when average daily temperature does not exceeded +10 °C, and the sum of active temperatures during this period. This factor indicates intensity of vaporization, and annual rainfall quantity, especially quantity of rainfall during vegetation season exceeds evaporation intensity in Latvia (Rasiņš 1962).

Winter resistance of woody plans is also affected by different other factors – relief depressions, too wet soils, which is unsuitable for species ecological requirements for growth, or uncorrected re-planting – as a result plants are declining and weakened (Lange 1957). It was observed, that severe winters more affected young and old trees (Gailis 1960). Also noted, that woody plants during the first and second year after replanting are less resistant, because plants in the new location has not yet developed a normal root system (Igaunis & Bandere 1983). Similarly, the extremely low temperatures are more vulnerable for trees, which is abundantly produced seeds during last season, as well as pest and diseases damaged specimens (Ozols et al. 1959).

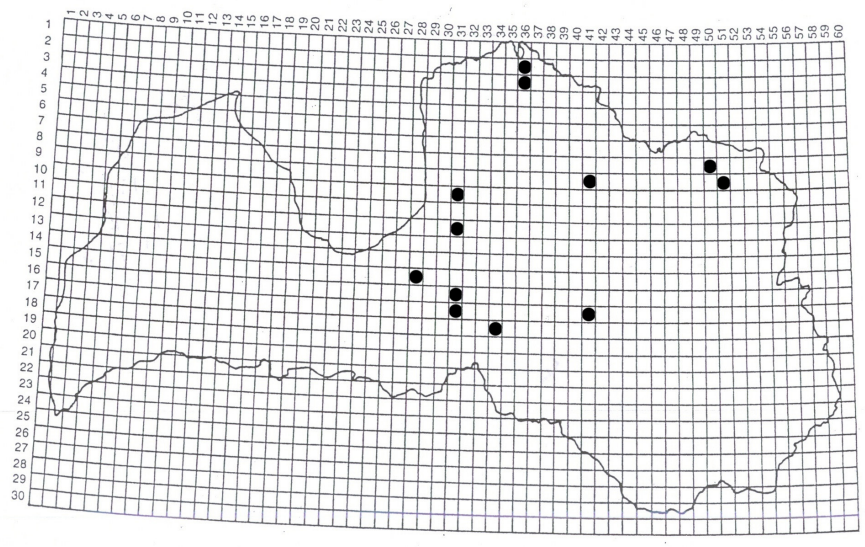

Fig. 1. Location of inventoried dendrological objects in central part of Latvia.

MATERIAL UN METHODS

Field studies and plant material collecting was carried out by applying previously developed methodology (Звиргз, Циновскис, Кнапе 1977), during August, 2010. Inventoried dendrological objects in Vidzeme: Skrīveri dendrarium (18/34 – here and below the geobotanical cell grid number are given); Kalsnava arboretum (17/41); National Botanical gardens (15/28); Lēdurga dendrarium (10/31); Tome, fragments of park (16/31); Alūksne park (8/50); Alūksne region, „Dārznieki" (9/51); Silva dendrarium (9/41); Inčukalns, Garden of artists (12/31); centre greenery in Endzele (3/36); Ķoņi elementary school (2/36) and centre greenery in Ķegums (17/31) (see fig. 1.). These major dendrological objects belong to 12 geobotanical cell grid quadrates.

Characteristics of meteorological conditions

Winter of season 2009/2010 is considered as one of the coldest during the last 20 – 25 years. December of 2010 was characterized by extremes of temperatures: during the first decade +4 to +8$^{o\,0}$ C, for example, on the 2nd December maximal recorded temperatures in central Latvia – Skrīveri: +7,1 ^{o}C and Zosēni: +6,2^{o}C. Already on the 18th December in Zosēni was recorded –21,8^{o} C, in Rūjiena –20,3^{o} C and Alūksne –19,7 ^{o}C. While in the third decade in whole territory of Latvia was thaw, and maximal recorded air temperature reach from 0^{o} C to + 4^{o} C.

Long-term average temperature of January in Latvia is determined as –4,7^{o} C, after hard winter of 2009/2010 it reached –11,5^{o} C. Lower average temperatures of January were observed in central part of Latvia - Vidzeme, for example, in Madona and Alūksne –13,7^{o} C, but in Rūjiena –15,6^{o} C. In its turn, minimal temperatures, which were observed during this winter in Vidzeme reach –30,5^{o} C in Rūjiena (26.01.2010), –28,8^{o} C in Madona, –28,2^{o} C in Alūksne and Skrīveri (27.01.2010). During this month a period of 27 days, when average daily temperature is remarked below zero, was observed, which is the longest period since 1956.

Average air temperature of February in Latvia was approximately 1^{o} C below normal: –5,6^{o} C. During the first decade of February thaw was observed for a few days. Air temperature was decreasing during the second decade. Minimal recorded temperatures on the 17th February - Ainaži –22,5^{o} C, Alūksne –21,5^{o} C, Rūjiena –19,5^{o} C , although the end of February was warmer and reached +1^{o} C to +6^{o} C. Average depth of snow cower in Rīga and Alūksne during February was 53 cm.

Average air temperature in March was –0,8^{o} C (0,7^{o} C below normal). Low temperatures were observed in Vidzeme even during the first decade of March, e.g., –23,4^{o} C in Ainaži (06. 03. 2010), –20,2^{o} C in Rūjiena (07.03. 2010) and –19,7^{o} C (17.03.2010.) (http://www.meteo.lv; http://www.ncdc.noaa.gov/oa/ncdc.html).

Evaluation of winter hardiness.

Winter hardiness of Tilia taxa was determined by S. J. Sokolov scale:

I – plant is completely winter-resistant, no damages are observed.

II – insignificant winter damages are observed

II_0 - frost damages are observed on evergreen leaves and needles

II_1 – frost damages are observed on shoots of last year, as well as on vegetative and generative buds;

II_2 - shoots of last year are destroyed by frost completely;

II_3 - shoots of last two years are destroyed by frost;

II_4 - shoots of last three years are destroyed by frost;

III - trunks are damaged by frost or plants got frozen completely;

III_1 - arboreal plants are damaged by frost till snow cover;

III_2 - arboreal plants are damaged by frost till ground level or root collar, but form new shoots during the next vegetation season;

III_3 - plants are damaged by frost completely.

Introduced taxa of *Tilia* is grouped according to their level of winter hardiness, for some taxa different levels of winter damages were observed at the same dendrological object (e.g., *Tilia tomentosa* in Skrīveri dendrarium - $II_2 – II_3$). This can be explained by different places of origin of seed material, used in the biggest dendrariums. In such cases, the species is listed twice or even more in different cold resistance groups.

RESULTS AND DISCUSSION

List of Tilia taxa, sorted by level of winter-resistance

(I) - completely winter-resistant, no damages are observed:
Tilia americana L. (Kalsnava arboretum).
Tilia x *euchlra* C.Koch (National Botanical gardens; Skrīveri dendrarium; Kalsnava arboretum; Inčuklns, garden of artists; Silvas dendrarium).
Tilia amurensis Rupr. (Kalsnava arboretum; Inčuklns, garden of artists).
Tilia dasystyla Stev. (Kalsnava arboretum).
Tilia x *moltkei* Späth (Kalsnava arboretum).
Tilia platyphyllos subsp. *cordifolia* (Besser) C.K.Schneid. (National Botanical gardens, Kalsnava arboretum, Skrīveri dendrarium, Silvas dendrarium).
Tilia platyphyllos ‘ Rubra’ (Kalsnava arboretum, Lēdurga dendrarium).
Tilia platyphyllos ‘Vitifolia Saldus’ (National Botanical gardens).
Tilia x *vulgaris* Hayne (National Botanical gardens, Kalsnava arboretum, Ķegums center plantations, Skrīveri dendrarium, Alūksne park, Tome, park fragments, Silva dendrarium).

(II_1) - frost damages are observed on shoots of last year, as well as on vegetative and generative buds:
Tilia americana L. (National Botanical gardens, Skrīveri dendrarium, Lēdurga dendrarium).
Tilia americana ‘Grandifolia’ (Lēdurga dendrarium).
Tilia dasystyla Stev. (Inčukalns, garden of artists)
Tilia x *euchlora* C.Koch (Lēdurga dendrarium, Dārznieki).
Tilia x *flavescens* A.Braun ex Döll (National Botanical gardens).
Tilia japonica (National Botanical gardens, Lēdurga dendrarium).
Tilia komorovii Ig. Vassil. (National Botanical gardens).
Tilia mongolica Maxim. (Kalsnava arboretum).
Tilia platyphyllos subsp. *cordifolia* (Besser) C.K.Schneid. (Alūksne park, Lēdurga dendrarium, Endzele dendrological plantations).

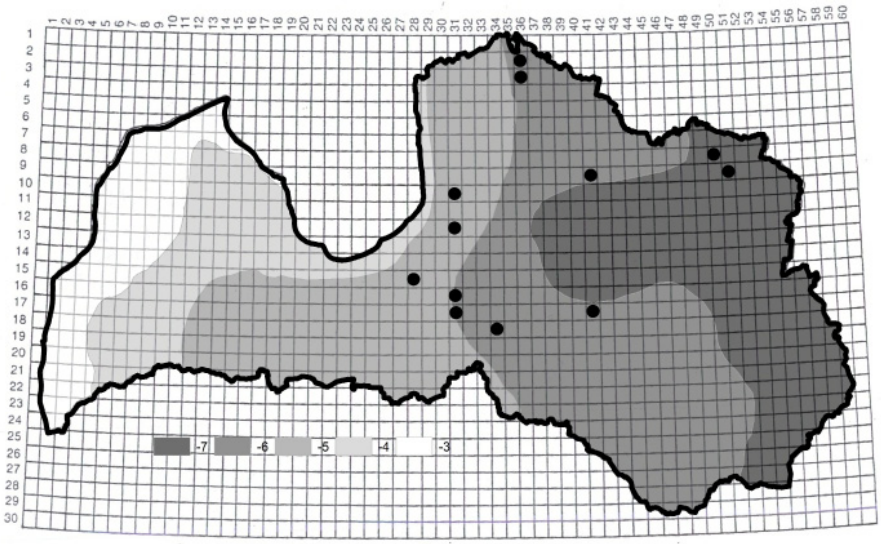

Fig. 2. Long-term average temperatures of January in Latvia (by Turlajs 2007) with inventoried objects in central part of Latvia.

Table 1. Comparison of winter resistance in different sites on example of two relatively frequently cultivated Tilia taxa in Central part of Latvia

No.	Locality	Winter hardiness	
		T. platyphyllos subsp. cordifolia	T. x euchlora
1.	National Botanical gardens	I	I
2.	Kalsnava arboretrum	I	I
3.	Skrīveri dendrarium	I	I
4.	Lēdurga dendrarium	II_1	II_1
5.	Inčukalns	-	I
6.	Silva dendrarium	I	I
7.	Endzele	II_1	-
8.	Malienas 'Dārznieki'	-	II_1
9.	Alūksne park	II_1	-

T. platyphyllos subsp. *platyphyllos* (Lēdurga dendrarium, Kalsnava arboretum, NBD).
Tilia platyphyllos 'Aurea' (Lēdurga dendrarium, Kalsnava arboretum).
Tilia platyphyllos ' Rubra' (Endzele centre greenery).
Tilia platyphyllos ' Vitifolia' (Lēdurga dendrarium, Kalsnava arboretum).
Tilia tomentosa Moench (National Botanical gardens, Kalsnava arboretum).
Tilia heterophylla Vent. (National Botanical gardens).

(II_2) - shoots of last year are destroyed by frost completely:
Tilia americana 'Macrophyla' (National Botanical gardens).
Tilia americana L. (Skrīveri dendrarium, Lēdurga dendrarium).
Tilia dasystyla Stev. (National Botanical gardens).
Tilia maximowiciana (National Botanical gardens).
Tilia patyphyllos subsp. *pseudorubra* C.K.Schneid. (Ķegums centre plantations).
Tilia tomentosa Moench (National Botanical gardens, Skrīveri dendrarium).

(II_3) - shoots of last two years are destroyed by frost:
Tilia americana ' Macrophyla' (National Botanical gardens).
Tilia divaricata (National Botanical gardens).
Tilia insularis Nakai (National Botanical gardens).
Tilia x *moltkei* Späth (Lēdurga dendrarium, Endzele dendrological plantations).
Tilia mongolica Maxim. (National Botanical gardens).
Tilia tomentosa Moench (Skrīveri dendrarium).

(III_2) - arboreal plants are damaged by frost till ground level or root collar, but form new shoots during next vegetation season:
Tilia x *moltkei* 'Spectabilis' (Koņi elementary school).
Tilia sibirica Fisch. ex Bayer (National Botanical gardens).

Different long-term average temperatures of January were determined in 12 studied localities: –6 to –5° C – Lēdurga, Inčukalns, National Botanical gardens; –7 to –6° C – Endzele, Kalsnava, Ķegums, Ķoņi, Silva, Skrīveri, Tome; –8 to –7° – Alūksne and Dārznieki (see fig. 2). Nevertheless, averege temperature in January, 2010 in Alūksne is determined –13,7 ° C, but in Rūjiena –15,6 ° C, which is about 9 ° C lower than normal (see fig. 3.). Comparing winter of season 2009/2010 with the last 15-20 years, it has been colder with persistent frost and snow coverage, but not extremely harsh winter, as was, for example, winter of season 1978/1979, when minimal air temperature in some parts of Madona district in central Vidzeme reached -43 ° C (Šmaukstelis & Igaunis 1982).

Analysis of some of the most common cultivated Tilia taxa in Vidzeme show, that there is a tendency of increase of winter

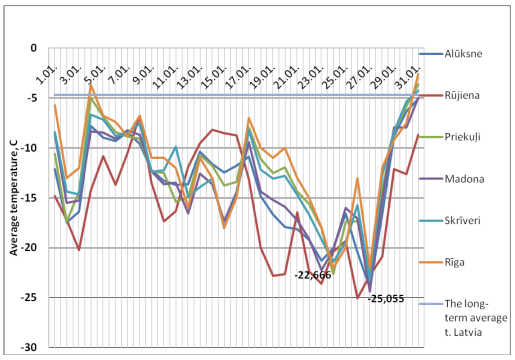

Fig. 3. Daily average temperatures during January 2010. in different meteorological stations in central part of Latvia comparing with long-term average temperature of January in Latvia.

damages in Northern and North-eastern part of Vidzeme (territory with the lowest long-term average temperatures in January). Insignificant frost damages were observed on such taxa as T. platyphyllos subsp. cordifolia and T. x euchlora, which is completely winter-resistant elsewhere in Latvia (see fig. 4.). Exception is winter resistance in Lēdurga dendrarium, where plantations of Tilia taxa are overloaded, and many trees grow with untypical, deformed canopies, not in bloom and weakened, so data from this site may be less reliable.

One of the oldest observed trees of *Tilia* genus are found in Skrīveri dendrarium, where the oldest trees were planted at the beginning of the 20th century, and *T. tomentosa* are more than 100 years old. Age of the other collections are from 30 – 50 years, and such young trees can best live through harsh winters.

Of course, on the basis of such studies we cannot conclude, that the alien species are affected by climatic factors only or mainly. A very important factor is an available seedlings of different decorative arboreal species in plant nurseries, and, of, course, what is the gardener's subjective choice – 'fashion thing' of this moment in gardening. It should be noted, that during the past 20 years very poor range of offered *Tilia* taxa is observed in nearly all plant nurseries in Latvia, therefore, introduction and acclimatization of new and rare *Tilia* taxa have not occurred. For instance, no Far East *Tilia* species are offered in assortment of plant nurseries in Latvia during last years. Only during last few years such Tilia taxa as *T. americana, T. tomentosa* 'Varsaviensis' e.o. are available again in some nurseries, and winter hardiness of such young plants should be different from our studies.

However, some regularities can be observed on the basis of analysis of winter-resistance during winter season of 2009/2010 in Central Latvia. Less winter-hardy are considered these cultivated taxa of *Tilia* genus, whose natural range is North America – *T. americana*, *T. heterophylla*., as well as *T.* x *moltkei* and *T.* x *moltkei* 'Spectabilis' with level of winter hardiness II_1 – II_3.

Considered as completely winter-resistant after severe winter of 2009/2010 were the following taxa of *Tilia* genus: *T. cordata*, *T.* x *vulgaris*, *T. platyphyllos* subsp. *cordifolia*, *T.* x *euchlora*.

REFERENCES

Gailis J. 1960. Vietejo un introducēto sugu salcietība LPSR. - Mežsaimniecības problēmu un koksnes ķīmijas institūta Raksti. 20: 115 - 147 (In Latvian)

Igaunis G., Bandere D. 1983. Introducentu ziemcietiba 1978./79. gada ziemā MPS „Kalsnava" dendrārijā. – Jaunākais mežsaimniecībā. 25: 11 – 19 (In Latvian)

Lange V. 1957. Salīdzinoši dati par 1939./40. un 1955./56. gadu bargo ziemu sala ietekmi uz kokaugu sugām Latvijas PSR teritorijā. – LLA Raksti. 6: 467 – 476 (In Latvian)

Mauriņš A. 1962. Novērojumi par kokaugu eksotu ziemcietību Latvijas PSR teritorijā laikā no 1800. līdz 1960. gadam. - Augu ziemcietība, aukstumizturība un to kāpināšana iespējas. - Rīga: Latvijas PSR Zinātņu akadēmijas izdevniecība, 101 – 104 lpp. (In Latvian)

Ozols A., Pētersons E., Riekstiņš I. 1959. De-

korativo koku un krūmu ziemcietība bargajā 1955./56. gada ziemā. Daiļdārzniecība. 1: 47 – 83 lpp. (In Latvian)

Rasiņš A. 1962. Augu ģeogrāfijas, klimata un kokaugu apsalšanas sakarības Latvijas PSR apstākļos. - Augu ziemcietība, aukstumizturība un to kāpināšana iespējas. - Rīga: Latvijas PSR Zinātņu akadēmijas izdevniecība, 161 – 186 lpp. (In Latvian)

Šmaukstelis E., Igaunis G. 1982. Introducēto sugu kokaugu ziemcietība 1978.-1979. gada ziemā Madonas rajonā. – Jaunākais mežsaimniecība. 24. – Riga: Zinātne, 11 – 21 lpp. (In Latvian)

Turlajs J. (ed.) 2007. Latvijas ģeogrāfijas atlants. – Rīga: Jāņa sēta, 1 - 40 lpp. (In Latvian)

Циновскис Р. Кнапе Д. Кашкура А. Шмаукстелис Э. 1987. Повреждения деревьев и кустарников в Латвии вызванные суровой зимой 1978/79 г. - Ботанический сады Прибалтики. Зимостойкость деревьев и кустарникв в 197879 гг. - Рига: Звайгзне, 51-76. (In Russian)

Звиргзд А. Циновскис Р. Кнапе Д. 1977. Итоги инвентаризации старых сельских парков Латвии. - Ботанический сады Прибалтики. Охрана растений. - Рига: Звайгзне, 117-136. (In Russian)

http://www.meteo.lv

http://www.ncdc.noaa.gov/oa/ncdc.html

Received: 05.09.2011.
Accepted: 05.12.2011.