CHANGES IN HUMIDITY DURING OUTDOOR STORAGE OF SEEDLINGS IN STYROFOAM CONTAINERS ON RACKS COVERED WITH DIFFERENT MATERIALS

Damian Mordas¹, Roman Wojtkowiak², Marian Wiśniewski³, Wojciech Ratajczak⁴

¹Lubin Forest District, Regional State Forest Directorate Wrocław
²Poznań University of Life Sciences
³Babimost Forest District, Regional State Forest Directorate Zielona Góra
⁴Bolewice Forest District, Regional State Forest Directorate Szczecin

Abstract. The study was to provide information on changes in humidity during short-term storage of seedlings on shelves in containers covered with different materials. Collected results made it possible to specify how the type of material of loading space coverings influences changes in the interior humidity. This made it possible to determine the effect of this factor on quality of seedling material under the specific conditions produced under the covering. Analyses in the loading space were conducted using temperature and humidity sensors by Vaisala, recording humidity changes for conditions found under the covering. Sensors were placed under different levels in the loading space. Some of them were equipped with fans enforcing air circulation, facilitating measurements of humidity over a larger space. Using a KNE Data Logger measurements were registered and the results were recorded on a PCMCIA memory card. Measurements were taken over a 24-hour period, facilitating analyses of the effect of a direct action of external conditions during the day and night on changes in humidity in containers covered with coverings made from different materials. It results from the conducted analyses that humidity changes occurred in each of the measurement points. These changes were more marked during intensive operation of sunlight, when a distinct drop in humidity was observed under loading space coverings. It was stated that the material, from which rack coverings were made, has a significant effect on the course of changes in interior humidity, which could have a significant effect on the quality of stored seedlings.

Key words: Douglas fir, covering, agroteextile, short-term storage, transport, seedlings, racks, humidity
INTRODUCTION AND AIM

Transport of seedlings in the process of afforestation and forest regeneration constitutes an important element in the operation chain in this technological sequence. It needs to be stressed that reforestation success is influenced by the entire technological process in the reforestation production. It is not only the material used in reforestation that is important and it is not only the fact whether it meets quality standards in visual inspection that we need to focus on. Conditions under which it was stored upon completion of its production in a forest nursery and under which it was transported onto the regeneration plot determine its viability and chances for adequate reforestation success. The final effect obviously depends on many factors. However, it is the transport of seedling material that seems to be underestimated, as evidenced by the very limited resources on this subject in research and literature sources, and which – despite changing conditions under which it is presently provided – has an undisputed considerable impact. Studies were conducted at the Department of Forestry Engineering, the Poznań University of Life Sciences in cooperation with the Industrial Institute of Agricultural Engineering in Poznań in view of the need to investigate this problem at present conditions [Dubowski et al. 2009, 2011]. Analysis of this subject also showed that American researchers point to all actions performed in relation with operations from the beginning of works at the nursery and ending with outplanting. It clearly results from their observations that transport and storage of seedlings constitute important elements in the chain of dependencies in the seedling transport process [Landis et al. 2010].

The State Forests transport over different distances more than 1 billion seedlings produced for their needs connected with artificial forest regeneration. There are no standards or principles under which conditions this transport should be provided. Applied solutions frequently result from the approach to this problem developed in current practice. This is performed using their own resources, as convenient for the service provider, which accepts seedlings from the nursery and delivers them to the forest area as they see fit.

The presently observed direction of changes in the Polish model of forest nursery production clearly indicates a trend towards an increase in the distances over which seedlings are transported. Thus their forwarding and shipment gain in importance, which makes it absolutely essential to gather information on its performance and on what elements we need to focus to achieve assumed objectives. Storage conditions and transport of seedlings are modified depending on the used resources.

Transport of seedlings in multipots is connected with certain complications due to the relatively large area occupied by the root ball, which results first of all from the size of multipots adapted to the requirements of forest nursery production. This pertains both to styrofoam and plastic multipots. They are transported on special racks (frames) facilitating their efficient loading and unloading. In view of changing weather conditions, particularly wind, during their shipment they are protected by a covering. The specific microclimate produced over such a loading space is a factor influencing in various ways the transported load, both during travel and when parking. Coverings are made from diverse materials, e.g. cotton textiles, rubber, plastics, wood or metal sheets, which makes it crucial to gain insight into the conditions found under the covering.

Kowalski [2007] stated that it is unacceptable to inappropriately handle the seedling material, particularly to store it under conditions potentially leading to root-ball overdrying.
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Szabla and Pabian [2009] also reported that during transport of seedlings on racks from the nursery to their destination they may be overdried. For this reason the loading space of vehicles used in seedling transport needs to be covered.

Studies focused on the effect of the type of used load covering on the transported seedling material in order to develop a new approach to the transport of seedlings in styrofoam containers placed on racks (frames) on a specially designed semi-trailer.

No reports have been found in the available literature related to investigations concerning changes in humidity observed under covering (commonly, but erroneously called canvas cover) during transport, which indicates that such studies have not been conducted to date. Analogously, no results have been obtained on research concerning the effect of long-term seedling storage under covering on their survival rates. From the point of view of the analysed problem it is essential considering that under exceptional conditions racks with seedlings are used for short-term storage (several days) prior to their outplanting.

Seedlings on racks are not always prepared for transport from the nursery in tightly closed, roofed facilities. Conditions, under which seedlings are prepared for shipment, kept before being transported and stored until outplanting may vary greatly: it may be in the rain, i.e. high humidity, and in dry air, in windless weather and at intensive movements of air masses.

EXPERIMENTAL MATERIAL AND THE SCOPE OF STUDY

Analyses aimed at the assessment of the effect of cover type on changes in humidity inside the racks, in which multipots with 1-year old Douglas fir seedlings were placed on four shelves. Seedlings of Douglas fir were produced in a 1-year long production cycle using styrofoam boxes by ROBIN (France) of 650 × 312 mm and 200 cm³ round cells tapering towards the bottom. Used coverings were made from agrotextile coming in three colours: white, green and black, as well as typical covering material (commonly, but erroneously called vehicle canvas covers), the so-called canvas cover material.

The scope of investigations described in this paper covered measurements of changes in humidity taken using special sensors by Vaisala, registered in a continuous manner, with the recording of results averaged at every 15 minutes and data recording in the electronic memory on memory cards, registered for 1 day.

METHODOLOGY

Analyses were conducted during storage of 1-year old Douglas firs shielded with coverings made from different materials, stored outdoors at an eastern wall of a warehouse so that at 1 p.m. the sun set behind the building wall and from that moment racks were in the shade.

Styrofoam containers with seedlings were placed in racks on shelves. Humidity sensors were arranged so that a sensor equipped with a fan was mounted under the ceiling in the immediate contact with the covering. Another thermocouple with a fan was placed in the needle zone of seedlings placed on the second shelf. Also on that shelf thermocouples (without fans) were placed in the substrate with seedlings.
The rack on the left was covered with a covering made from white agrotextile (B), the central one with black agrotextile (C), while the right – with green agrotextile (Z). Properties and structure of agrotextiles used in the analyses were presented in a paper by Mordas et al. [2012]. A rack covered with a canvas covering (P) was placed in the central row on the right. Technical parameters of this material were also reported in a publication by Mordas et al. [2012].

According to the manufacturer of the STRADOMAGRO agrotextiles they guarantee adequate water permeability thanks to their structure, and thus they have one of the highest indexes offered on the market. This is due to the ideal water penetration (no puddles on mats) and it also guarantees adequate release of moisture from the substrate.

STRADOMAGRO agrotextiles are applied in forest and ornamental plant nursery production, rack and soil cultivation, in orchard production, in strawberry growing and establishment of gardens and green areas. To date the manufacturer did not consider the use of these textiles as coverings for racks in the transport of seedlings, particularly forest trees.

Materials commonly referred to as canvas cover materials used in the production of vehicle covers are produced on the basis of a polyester net covered with PCV and they differ in terms of basis weight, width and colours. They have exceptionally high tear and rupture strength, as well as resistance to adverse weather conditions. They meet waterproof requirements and they are not permeable to vapour.

Coverings were prismatic with a rectangular bottom so that they fit the shape of the racks and their size fit accurately that of the racks. They were installed by pulling onto the metal rack structure from the top. At such a placement of the covering its bottom constituted the ceiling of the rack. The lower shelf in the racks (shelf 1) was a shield against intensive exchange of air or temperature from the bottom.

A covering set (made from either white, green or black agrotextile, or from a canvas material) was modified so that one of the longer sides was not sown along all its length and it was attached to the rest of the cover by pulling two cover walls together using a rubber string. On one of the walls a row of typical canvas cover hooks was adequately attached to the covering wall. In the other, parallel wall one row of holes was made, through which a row of hooks was extended.

Encircling the hooks with the rubber string resulted in the attachment being relatively tight (thanks to the overlapping of both fabric layers), elastic and first of easy to provide. Such a divided covering wall facilitates relatively easy partition of the covering for loading and unloading of styrofoam containers with seedlings.

Measurements were taken using thermocouples (sensors of humidity) by Vaisala. Some of them were equipped with fans, which enforced air circulation in their surroundings. These measurements of humidity need to be taken over a larger area and not only in the immediate vicinity of the sensor. Some of them were not equipped with fans. Results were recorded using a KNE Data Logger with 32 signal inputs, i.e. facilitating a simultaneous measurement of up to 32 humidity values. The frequency of measurements was arbitrary, ranging from every 5 s to any frequency, while the recorded value is averaged by the device within the tested time interval. Results are recorded on a PCMCIA memory card, on which 440 000 rows of results with 32 results in each row may be recorded.

Sensors were arranged in all the four racks (under the white, green and black covering, and for comparative purposes under the canvas cover material) under the ceiling of racks (immediately at the upper covering wall). In those places sensors with fans were
Changes in humidity during outdoor storage of seedlings in styrofoam containers...

placed, which task was to enforce a jet of air and measurements of its greater volume. Thermocouples mounted in the needle zone of seedlings in styrofoam containers placed on the second shelf in the same racks were also equipped with fans. In order to investigate the distribution of moisture content and substrate overdrying at individual racks covered with selected materials, thermocouples without fans were mounted in the substrate.

Humidity was measured under the ceiling of the rack covered with the tested materials and in the needle zone, while moisture content was recorded in soil of root-ball seedlings grown in styrofoam containers placed on shelves in racks covered with different types of coverings and kept outdoors. The objective was to verify which changes in humidity take place in individual places when a styrofoam container is exposed to the long-term action of weather factors, i.e. sunlight, wind or rain.

RESULTS

In the course of the conducted investigations it was found that changes in root ball moisture content in racks standing outdoors were conspicuous. Observed changes initially indicated a downward trend in moisture content, followed by stabilisation of this parameter (Fig. 2).

In the rack covered with a black covering initially slight changes were observed in soil moisture content with a marked reduction in moisture content in the noon and afternoon hours, when the effect of sunlight was observed. The greatest stability, resulting from the maintenance of an almost identical soil moisture content, was found for a rack covered with the green material. In turn, similar results were observed in racks covered with...
Fig. 2. Changes of moisture content in root balls of Douglas fir seedlings occurring during outdoor storage of styrofoam multipots kept on racks covered with different materials.

Rys. 2. Zmiany wilgotności brzegi korzeniowej sadzonek daglezji zachodzące podczas przetrzymywania na wolnym powietrzu wielodoniczek styropianowych na stelażach ośnionytych różnymi materiałami.

with canvas material covering and the white covering material, manifested in the course of changes in soil moisture content with an initial decrease and next the maintenance of constant moisture levels.

Observed changes in soil moisture content indicate a reduction progressing in time, i.e. a phenomenon occurring during storage of seedling material kept under cover.

The situation was different for the course of moisture content changes in needles of seedlings in racks covered with different types of coverings and kept outdoors (Fig. 3).

The course of recorded changes is similar when using all types of coverings. A characteristic finding was connected with a reduction of moisture content at the time of intensive sunlight operation and even shortly after sunset. We need to stress here similar courses of moisture content for black and green coverings.

Similar results were found when observing humidity under the ceiling of racks covered with black, green and canvas covers (Fig. 4). In this case the effect of sunlight was also conspicuous, as in the period from 10:30 to 4:30 a considerable decrease was recorded in humidity and maintenance of its low level. Among the applied rack covers the canvas material used as covering caused the greatest amplitude of changes in humidity under the ceiling.

Considerable losses of humidity (Fig. 4) could have influenced the observed discolouring of needles in seedlings stored in styrofoam containers kept on shelves in racks covered with black, green and canvas materials (Fig. 5) over a longer time period.
Fig. 3. Changes in humidity in the needle zone of Douglas fir seedlings occurring during outdoor storage of styrofoam multipots covered with different materials.

Rys. 3. Zmiany wilgotności powietrza w strefie igliwia sadzonek daglezji zachodzące podczas przetrzymywania na wolnym powietrzu wielodoniczek styropianowych osłoniętych różnymi materiałami.

Fig. 4. Changes in humidity under the ceiling of racks holding Douglas fir seedlings during outdoor storage of styrofoam multipots covered with different materials. Humidity was not recorded under white covering.

Rys. 4. Zmiany wilgotności powietrza pod stropem stelaża z ustawionymi sadzonkami daglezji zachodzące podczas przetrzymywania na wolnym powietrzu wielodoniczek styropianowych osłoniętych różnymi materiałami. Nie zarejestrowano wilgotności pod opończą koloru białego.
DISCUSSION AND RESULTS

Based on these analyses it may be stated that the material, from which rack covers were made, had a considerable effect on changes in humidity in their interior. Covering made from white agrotextile had the best properties. Humidity inside a rack covered with the white cover material was most stable. No marked discolouring was observed in needles of the examined seedlings during long-term storage of seedlings in styrofoam containers on shelves of racks covered over a longer period (3 days) under this covering.

Also a relatively high amount of sunlight penetrates through the canvas material, from which coverings of e.g. lorries are made. PCV coating of canvas covers has a low capacity to reflect selected light lengths. Covering made from canvas material has a better protection potential against changes in humidity, which was confirmed by DeYoe et al. [1986] indicating very good insulation properties of this material. However, during intensive heating as a result of the action of sunlight a highly adverse microclimate is formed inside the rack covered with a covering made from this material. Its waterproofing capacity and even steam tightness are advantages in the case of maintenance of a relatively constant humidity or protection against penetration of moisture inside. However, as a result of a lack of such an exchange, particularly at an increase in temperature, intensive heating of water vapour inside the rack is observed. In this way a greenhouse effect is created. It was aptly observed by Ratajczak [2010] that irrespective of the type of used coverings seedlings need to be always stored in shaded places. Although no seedling scalding was observed due to the relatively short observation period, the microclimate produced under such conditions shows that it may pose a considerable threat to their further viability, which was manifested in needle discolouring. These changes may have a negative effect on seedling survival rates at later dates, since studies conducted on the subject show a lack of effects of stress factors immediately after outplanting, which the seedling material was exposed to [Landis et al. 2010].
This is also confirmed in other studies, which show that inappropriate seedling handling has a considerable effect on their quality [Adams and Patterson 2004].

CONCLUSIONS

Based on the conducted investigations the following conclusions may be formulated:
1. Coverings made from agrotextile relatively effectively protect seedlings against changes in humidity/moisture content during their outdoor storage in the summer period.
2. Racks covered with a white agrotextile covering provide the most effective protection for Douglas fir seedlings during their further outdoor storage.
3. Coverings made from black and green agrotextile and from canvas cover material should not be used in the case of a potential longer parking or probable outdoor seedling storage extended over a longer period.

REFERENCES


ZMIANY WILGOTNOŚCI PODCZAS PRzechowywania sadzonek w kontenerach styropianowych w kontenerach osłoniętych różnymi materiałami w wystawionymi na wolnym powietrzu

Streszczenie. Transport sadzonek, ze względu na istotny wpływ rodzaju użytego okrycia przestrzeni ładunkowej, jest bardzo istotnym zagadnieniem w procesie odnawiania lasu poprzez sadzenie. Z punktu widzenia hodowcy materiał użyty do odnowień powinien spełniać określone normy jakościowe oraz cechować się dużą żywotnością. Warunki, w jakich odbywa się transport nie są bez znaczenia, dotychczas nie prowadzono jednak szczegółowych badań odnownie zmian wilgotności zachodzących pod opońcami podczas transportu, a także ich wpływ na materiał sadzeniowy. Osłonienie przestrzeni ładunkowej opończą wpływa w różnorakim sposób na transportowany towar, nie tylko podczas przejazdów, lecz również na postoju (ze względu na klimat, który może się wytwarzać pod opończą). W takich warunkach dochodzi do zmian wilgotności i temperatury powietrza, co stwarza ryzyko przesuszania sadzonek bądź „zaparzenia” ich pędów w wyniku niekorzystnego oddziaływania obu tych czynników. Zbadanie przebiegu zmian wilgotności w zależności od rodzaju zastosowanego okrycia – w trakcie przechowywania sadzonek podczas całego procesu załadunku, transportu i rozładunku łącznie z okresem przestojów – umożliwi podjęcie właściwej decyzji co do wyboru materiału, z którego będzie wykonana opońca. Wyniki badań pozwolą ustalić, że materiał, z którego produkuje się okrycia ładunkowych ma bardzo duży wpływ na przebieg zmian wilgotności powietrza wewnątrz przestrzeni ładunkowej. Ponadto zastosowanie niewłaściwego materiału doprowadziło do uszkodzenia pędów sadzonek, powodując ich odbarwienia. Nie zaobserwowano zaparzania się sadzonek, ale występujące warunki mogły stworzyć duże zagrożenie dla żywotności materiału sadzeniowego. Transport sadzonek drzew leśnych – z uwagi na rozwój i zmiany w podejściu do produkcji sadzonek, ale również i modelu szkółkarsztwa leśnego – z pewnością wpłynie istotnie na głębsze zainteresowanie się tą tematyką. Zbadanie pewnego zakresu tego zagadnienia, wbrow pozorom istotnego i złożonego, wskazuje na dalszą potrzebę analizowania tematu. Wiadome jest, że sadzonki transportowane w warunkach niewłaściwych, nawet po kilku latach od założenia, w wyraźny sposób obniżają jakość oraz udatność uprawy. Zbadany aspekt warunków wilgotnościowych w przestrzeni ładunkowej, zmieniających się w zależności od rodzaju zastosowanego okrycia, ze względu na wydłużanie się odległości transportowych, czyli również czasu przewozu, wpływa znacząco na konieczność dokładnego rozpoznania zagadnienia.

Słowa kluczowe: dąb, wielodoniczki, opońce z agrotkaniny, przechowywanie, transport, stelaże, sadzonki, wilgotność

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CHANGES IN TEMPERATURE DURING SEEDLING STORAGE IN STYROFOAM MULTIPOTS KEPT ON SHELVES IN OUTDOOR CONTAINERS UNDER DIFFERENT COVER MATERIALS

Damian Mordas¹, Roman Wojtkowiak², Marian Wiśniewski³, Krzysztof Zembrowski⁴

¹Lubin Forest District, Regional State Forest Directorate Wroclaw
²Poznań University of Life Sciences
³Babimost Forest District, Regional State Forest Directorate Zielona Góra
⁴Industrial Institute of Agricultural Engineering in Poznań

Abstract. The aim of this study was to determine changes in temperature found during short-term seedling storage on shelves kept on racks under different cover materials. Analyses assessed the effect of different materials for covering of loading space on interior temperature changes. Collected results were to supply information on the effect of this factor on the quality of seedling material in view of specific conditions produced under the cover. Analyses were conducted under conditions found in the loading space using temperature and humidity sensors by Vaisala. The distribution of sensors at different levels in the loading space and the fact that some of them were coupled with fans enforcing air circulation made temperature measurements possible over a larger space. Results were recorded using a KNE Data Logger, recording the results on the PCMCIA memory card. The device recorded data collected from the measurements taken over any selected period. This facilitated analysis of the effect of a direct impact of external conditions on temperature changes in containers under covering made of different materials. It results from the conducted investigations that air temperature in each measurement site fluctuated. During intensive solar radiation a marked increase in temperature was observed under container covering. It was found that the covering material for the racks has a very big effect on the course of changes in temperature inside the racks.

Key words: agrotextile, Douglas fir, canvas cover, storage, seedlings, frame, transport, temperature
INTRODUCTION

Transport of seedlings constitutes an important element in the afforestation and regeneration of forests. Although the final effect, i.e. reforestation success, depends on many factors, the shipping of the seedling material and its importance seem to be underestimated, as it is confirmed by scarce literature data concerning this problem. The studies were conducted at the Department of Forest Engineering, the Poznan University of Life Sciences in cooperation with the Industrial Institute of Agricultural Engineering in Poznań that identified this problem [Ratajczak 2010, Dubowski et al. 2009, 2011]. Also American scientists indicated the importance of transport of deciduous tree seedlings in multipots (in Poland incorrectly called containers). They were of an opinion that reforestation success is attainable only when the entire production process is perceived as a series of interdependent operations from the production of seedlings at a nursery to their outplanting, taking into consideration all intermediate procedures and measures. For this reason transport is equally important as any other operation concerning the production process of establishing a new plantation.

![Fig. 1. Chain of dependencies connected with the transport of seedlings composed of interdependent operations [Landis et al. 2010]](image)

Rys. 1. Łańcuch zależności związanych z procesem transportu sadzonek składający się z operacji wzajemnie powiązanych [Landis i in. 2010]

What is the situation in the Polish State Forests, in which annually over 1 billion seedlings are transported? To date no standards have been established, which would concern seedling transport from forest nurseries to the plot allocated to regeneration. In practice it is arranged for the service provider to collect seedlings from the nursery and deliver them to the forest land as they see fit.

An increase in the distance during seedling transport results from changes occurring in the Polish forest nursery production. Thus it has become essential to gather information on the conditions under which storage, shipping and transport of seedlings are performed and their modification depending on the applied measures.

Transport of seedlings in multipots is relatively complicated due to their size. It poses a problem both in case of styrofoam and plastic multipots. To facilitate loading and unloading, as well as their transfer multipots should be transported on special racks (commonly called frames). In turn, due to the changing weather conditions, particularly wind, racks have to be covered with a canvas cover. A unique microclimate is produced.
under the canvas cover, being a factor influencing the transported seedling material both during the travel and when parking. Covers may be made from different materials, i.e. cotton fabric, rubber, plastic, wood or tin sheets, thus it is essential to determine the generated climatic conditions and their effect on the covered merchandise.

Some authors [Boetzelser 1984] reported that the temperature under a cover during seedling transport does not threaten their survival rates. A greater problem is connected with the stage of seedling loading, which, when executed manually lasts, 1 day.

In turn, Szabla and Pabian [2009] reported that transport of seedlings in multipots on frames from the nursery to their destination may result in their overdrying. What is important, the threat is much lower than in the case of bare-root seedlings; however, the use of fast cars during adverse weather conditions may lead to substrate and seedling overdrying. During transport, particularly at high speeds, freezing may occur and for this reason seedlings should be transported under covers. The load-carrying body closed in this way protects seedlings against the adverse effect of the weather.

The problem of substrate temperature is significant in the case of mycorrhizal seedlings, in which overheating or overdrying of the substrate ball has to be prevented [Kowalski 2007].

No detailed results have been found in available literature concerning changes in temperature occurring under covers during transport. It may be assumed that such studies have not been conducted to date. Similarly, no study results have been found on the effect of long-term seedling storage under covers on their survival rates. This is significant since racks with seedlings, generally designed for the transport of seedlings in styrofoam containers from a forest nursery to the outplanting site may in exceptional cases be used for short-term (several days) storage of loaded seedlings.

This problem is addressed in the studies on the development of transport conditions for seedlings in styrofoam containers in a specially designed semitrailer.

**EXPERIMENTAL MATERIAL AND METHODOLOGY**

Conducted analyses aimed at the assessment of the effect of the type of material, from which covers (rack covers) are made, on air temperature inside the frame. Used covers were made from agrotextile in three colours: white, green and black, as well as a typical material used in canvas covers, the so-called canvas material.

Analyses were conducted when keeping racks protected with covers, which were placed outdoors, at an eastern warehouse wall so that at 1 p.m. the sun set behind the building wall and from that moment racks were in the shade.

The scope of investigations covered measurements of changes in air temperature recorded continuously using special sensors, with data recording executed every 15 minutes and the recording in the electronic memory conducted for one day.

Styrofoam pots with 1-year old Douglas fir seedlings were placed on four shelves of each rack. Sensors taking measurements were arranged so that a temperature sensor equipped with a fan was placed under the rack ceiling in the immediate contact with the cover. Another thermocouple with a fan was placed in the needles of seedlings on the second shelf. Also on that shelf thermocouples (without fans) were placed in the substrate with seedlings.
Racks were arranged in a row. On the right there was a rack covered with a green agrotextile cover (Z), the middle one – black (C) and white agrotextile (B), while on the left there was a rack covered with a cover made from a silver canvas material (P).

![Image](image.jpg)

Fig. 2. Measurements of air temperature in racks and containers standing in open space

Rys. 2. Pomiary temperatury powietrza w regałach i pojemnikach stojących na odkrytej powierzchni

Agrotextile covers were produced by STRADOM S.A. from STRADOMAGRO Premium 100 agrotextile, typically used in agriculture, orchard production and horticulture.

According to the manufacturer, STRADOMAGRO agrotextile due to its structure guarantees adequate air circulation and water permeability at one of the highest indexes in commercially available materials (Table 1). This ensures good water permeability (no puddles on mats) and guarantees adequate release of moisture from the subsoil.

To date these textiles have not been used as covers for racks in the transport of seedlings, particularly forest trees.

Canvas materials used in the production of vehicle canvas covers are produced using polyester net covered with PCV. They differ in basis weight, width and colour, while having extremely high rupture and tear strength, as well as resistance to adverse weather conditions (Table 2). This material meets the waterproof and steam tightness requirements, thus a cover produced from such material does not breathe.

Prismatic covers with rectangular bottoms were made to fit ideally the rack size. Each cover was not completely sawn in one of the longer sides to facilitate its placement over the racks. The cover could be tightened using a rubber puller (in the form of strings) pulling together two cover sides. On one of them two rows of typical canvas hooks were attached, while on the other one row of holes was made, through which a row of hooks was protruding. Such a divided wall of the cover facilitated a relatively easy separation of the cover for loading and unloading of the racks of seedlings in styrofoam multipots.
Table 1. Technical parameters of STRADOM AGRO Premium 100 agrotextile (http://www.stradom.com.pl/oferta/Geotkaniny.html)

<table>
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<th>Item Lp.</th>
<th>Parameter</th>
<th>Cecha charakterystyczna</th>
<th>Value of parameter</th>
<th>Standard Norma</th>
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<td>basis weight – gramatura</td>
<td>100 g·m⁻²</td>
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<td>2</td>
<td>widths – szerokości</td>
<td>1.6 m, 3.2 m, 4.57 m, 5.25 m</td>
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<tr>
<td>3</td>
<td>colours – kolorystyka</td>
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<td>water permeability</td>
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</table>

Table 2. Basic properties of canvas material

<table>
<thead>
<tr>
<th>Item Lp.</th>
<th>Characteristics</th>
<th>Cecha charakterystyczna</th>
<th>Value of parameter</th>
<th>Standard Norma</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>textile – tkanina</td>
<td>100% PES, 2 × 1100 dtex</td>
<td>DIN EN ISO 2286-2 BS 3424 method 5A BS 3424 metoda 5A</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>basis weight – gramatura</td>
<td>900 g·m⁻²</td>
<td>BS 3424 method 5A</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>composition – skład</td>
<td>textile – tkanina 260 g·m⁻², coating – powłoka 640 g·m⁻² PCV</td>
<td>DIN EN ISO 2286-2 BS 3424 method 5B BS 3424 metoda 5B</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>rupture strength – wytrzymałość na rozrywanie</td>
<td>warp – osnowa 4000 N/5 cm, weft – wątek 3500 N/5 cm</td>
<td>DIN 53 354 BS 3424 method 6A BS 3424 metoda 6A</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>tearing strength – wytrzymałość na rozdzieranie</td>
<td>warp – osnowa 600 N, weft – wątek 600 N</td>
<td>DIN 53 356 BS 3424 method 7A BS 3424 metoda 7A</td>
<td></td>
</tr>
</tbody>
</table>
Measurements of temperature were taken using sensors by Vaisala. Some of them were equipped with fans enforcing air circulation in their vicinity in order to measure air temperature over a larger area, and not in the vicinity of the sensor itself. Results were recorded using a KNE Data Loger with 32 signal inputs, which facilitated simultaneous measurements of 32 temperature values. Results were recorded on a PCMCIA memory card, with the capacity of 440,000 records of 32 results in each. Results recorded on the memory card were transferred to the computer and analysed in detail using the Excel programme. Thanks to the graphic tools of that programme they may be presented in graphs.

RESULTS

The analyses showed that fluctuations in soil air temperature on racks kept outdoors were very big. This was particularly evident in the late morning hours and around noon at the direct effect of the solar radiation (Fig. 3).

Fig. 3. Changes in soil air temperature in the root balls of seedlings in styrofoam multipots shielded with different materials and kept outdoors

Rys. 3. Zmiany temperatury powietrza glebowego zachodzące w bryle korzeniowej sadzonki w wielodoniczkach styropianowych, osłoniętych różnymi materiałami, podczas przetrzymywania na dworze
Starting from 9:00 a marked increase was observed in soil air temperature. It was greatest for the rack covered with the black cover, slightly lower for the container covered with the green cover and for the racks covered with the cover made from canvas cover material. At noon hours the temperature under the canvas cover exceeded that under the green canvas cover, to increase rapidly at 4:30 p.m. and exceed the temperature under the black cover. The lowest increments in soil air temperature were recorded in soil with seedlings in styrofoam multipots, in the container under a white cover.

Fluctuations in soil air temperature indicate that despite the low overall heat transfer coefficient of styrofoam, the substrate in multipots made from this material heats up under the influence of long-terms action of the sun. The most intensive heating was observed for the black cover and at a slightly lower level for the green cover, while it was lowest for the white cover and for the canvas material cover. However, for the latter cover a constant increase in air temperature may be observed despite the absence of sunlight operation.

Measurements of air temperature under the ceiling of the tested container covers are given in Figure 4.

![Figure 4. Changes in air temperature under the ceiling of racks with styrofoam multipots covered with different materials and kept outdoors](image)

Also in this case we may observe the effect of solar radiation on changes in temperature. This was particularly evident for black and green covers and for the one made from canvas material. For the canvas cover fluctuations in temperature were conspicuous. Air temperature under this cover fluctuated intensively. Even at night it cooled and heated up, similarly as during the day, which is characteristic of this cover. For the white cover the increase in air temperature under the ceiling was constant and relatively uniform and no effect of sunlight on the intensity of changes was observed.

The course of changes in air temperature in the seedling needle zone was quite similar, with a characteristic increase in temperature at the time of intensive sunlight operation. Temperature in the needles was similar for the black cover and for that made
from canvas material. Its minimal increase could be observed even at night. At the time of the initial intensive operation of sunlight a characteristic decrease in temperature may be observed, which after a certain time begins to grow successively even up to late afternoon hours, with no rapid peaks at noon hours, as it could have been observed for white and green covers. In turn, white and green covers cause slightly higher heating of air in needles of seedlings, particularly at noon hours (Fig. 5).

![Graph showing temperature changes in seedling needles](image)

**Fig. 5.** Changes in air temperature in seedling needles during outdoor storage of styrofoam multipots shielded with different materials

**Rys. 5.** Zmiany temperatury powietrza w iginaliach sadzonych zachodzące podczas przechowywania na dworze styropianowych wielodoniczek osłoniętych różnymi materiałami

**DISCUSSION AND RESULTS**

A detailed analysis of the results shows that the material, from which rack covers are made has a great effect on the course of interior temperature changes. The cover made from white agrotextile proved to be most effective. The smallest fluctuations in air temperature in each measurement point were recorded inside the rack shielded with the white cover. Similar conclusions were presented by American researchers, who experimentally stated very good insulating properties in covers made from white and silver-coloured Mylar, as it is shown in Figure 6. Irrespective of the used covers, seedlings should always be stored in shaded places [Ratajczak 2010]. As it was correctly observed by Landis et al. [2000], the necessity for seedling storage is not a physiological requirement of plants, but one of the operations in the transfer of seedlings from the nursery to the outplanting site.

The graphic illustration of the results indicates that black and green agrotextile do not protect seedlings as effectively as white agrotextile produced in an identical manner and from the same material. Temperature of the nursery substrate (Fig. 3) and temperature under the ceiling (Fig. 4) reach the highest values in the case of black and green agrotextiles.
Analyses showed that inappropriate seedling handling has a considerable effect on their quality [Adams and Patterson 2004], while the occurrence of extreme temperatures during seedling storage constitutes one of the three main stress factors to which they are exposed. In this case we have to stress following Paterson et al. [2001] that seedlings produced in a forest nursery and prepared for shipment reach their maximum value at that time point.

Moreover, results of the analyses show that a canvas material cover is more effective in protection against temperature changes. This was also pointed out by DeYoe [1986], who stated that canvas covers provide a much better insulation than standard green cloth. However, water tightness and even steam tightness of the canvas material, particularly during intensive activity of sunlight may produce a disadvantageous microclimate inside the rack. Water vapour heating inside the rack creates the greenhouse effect. Heating-up of seedlings was not observed using available research methods; however, the recorded microclimate may pose a considerable risk for their further viability, which was manifested in needle discolouring. Effects of stress influencing tree seedlings accumulate, causing a gradual reduction of their viability and capacity of appropriate growth after outplanting and as it is confirmed by studies in this respect their effects may be invisible even months after outplanting [Landis et al. 2010].
CONCLUSIONS

Based on the conducted analyses the following conclusions may be formulated:

1. The use of covers made of agrotextile as shields for seedlings in multipots transported on frames relatively effectively protects them against considerable temperature changes inside the loading space and in the nursery substrate.

2. Containers covered with the white agrotextile cover provide the most effective protection of seedlings during long-term outdoor storage.

3. Covers made from black and green agrotextile and particularly from canvas cover material should not be used in a situation of a potential extended parking period or a longer outdoor storage of seedlings.

REFERENCES


Streszczenie. Badania nad opracowaniem nowej koncepcji transportu sadzonek w pojemnikach styropianowych, przewożonych w kontenerach, na specjalnie do tego celu skonstruowanej naczepie, odnoszą się do problemu ze względu na istotny wpływ rodzaju użytego okrycia ładunku. Specyficznym mikroklimatem, wytwarzającym się w przestrzeni ładunkowej przykrytej opóźnicą, jest czynnikiem w różnoraki sposób wpływającym na przewożony towar zarówno podczas przejazdów, jak i na postoju. Bardzo istotne więc okazuje się zagadnienie warunków klimatycznych wytwarzających się pod opóźnicą w powiązaniu z rodzajem przewożonego towaru. Obejmuje transport sadzonek ze szkółki do miejsca przeznaczenia, przechowywanie na postoju, przygotowywanie do załadunku lub czas po rozładowaniu i opóźnionym wysadzeniu na powierzchni. Powstaje wówczas ryzyko przesuszenia sadzonek bądź ich przemarznięcia. Dlatego niezmiernie istotna staje się technologia transportu sadzonek, poczynając od ich przygotowania na szkółce, poprzez transport na miejsce przeznaczenia i dalsze postępowanie do momentu ich wysadzenia w grunt. Badania nad transportem sadzonek zmienną do oceny jak rodzaju materiału, z którego są wykonane okrycia przestrzeni ładunkowej, wpływa na zmiany temperatury w jej wnętrzu. Registrowanie pomiarów wykonywanych czujnikami temperatury i wilgotności firmy Vaisala, w warunkach istniejących w przestrzeni ładunkowej, pozwoliła zaobserwować przebieg zmian warunków, zachodzących pod stropem kontenera służącego do transportu, w igliwiu i w glebie transportowanych sadzonek. Poziom przebiegu zmian temperatury – w zależności od rodzaju okrycia i okresu przetrzymywania pod okryciem – ma duże znaczenie i pozwala na właściwe dopasowanie elementów składających się na wykonanie całego procesu spedycji. Wyeliminowanie rozpoznanych błędów ma znaczenie dla jakości dostarczonego materiału, związanej z tym udanąło się dopasowanie i płynących z tego korzyści ekonomicznych. Przeprowadzone badania pozwoliły stwierdzić, że materiał, z którego są wykonane osłony kontenerów ma bardzo duży wpływ na przebieg zmian temperatury i wilgotności powietrza wewnątrz przestrzeni ładunkowej.

Słowa kluczowe: agrotkanina, daglezja, opóźnica, przechowywanie, sadzonki, regały, transport, temperatura

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IMPRESSIVE LIME TREES IN THE LIPKA COMMUNE (WIELKOPOLSKA VOIVODESHIP)

Mariusz Szczepański, Dorota Wrońska-Pilarek, Magdalena Janyszek
Poznań University of Life Sciences

Abstract. In all, 105 impressive lime trees were inventoried in the Lipka commune of which Tilia cordata Mill. (95 trees) turned out to be the most numerous. The remaining taxa T. ×europaea L., T. platyphyllos Scop. and T. tomentosa Moench had only a very small share. Majority of valuable limes (67) were found to grow along district, local and dirt roads forming avenues. Lime trees in good and very good health condition predominated. From among the impressive lime trees, there were three current monumental trees as well as 55 trees with monument circumferences. Thanks to the elaboration of a comprehensive dendrological documentation, it will be possible to protect impressive lime trees which may become one of important touristic attractions of the Lipka commune.

Key words: Lipka commune, impressive lime trees, monumental trees

INTRODUCTION

Two lime species occur naturally in Poland, namely: Tilia cordata Mill. and T. platyphyllos Scop. T. cordata occurs in dispersion in the area of the entire country, whereas T. platyphyllos has its northern range boundary [Boratyński and Browicz 1976, Boratyńska and Dolatowski 1991]. Several lime species can be found growing in Poland. The most popular among them are: Tilia tomentosa Moench which derives from the Balkans and Tilia ‘Euchlora’, while Tilia ×europaea L., which is a hybrid of T. platyphyllos and T. cordata and Tilia americana, can be found much less frequently [Bugała 2000, Seneta and Dolatowski 2011].

Lime is a long-lived tree and in our country, it may live even 500 years [Pacyniak 1992, Seneta and Dolatowski 2011]. Pacyniak and Smólski [1973] maintain that in Poland, among trees considered as natural monuments, lime trees constitute 13% and occupy the second position after oaks. According to Zarzyński [2003 a, b], out of 104 998 monumental trees recorded in Poland in 2000-2002, lime trees constituted 35% (37 117 trees), of which 36 112 trees (97%) were Tilia cordata specimens and only
1005 trees (3%) were *T. platyphyllos*. Apart from lime trees, maple, elm and ash trees are also quite frequently nature monuments [Kapuściński 2011]. According to Pacyniak [1992], *T. cordata* is the oldest lime tree in Poland; its circumference measures 992 cm and it is 520 years old. This particular tree can be found in Cieľtník (Dąbrowa Zielona commune, in Silesian Voivodeship). The oldest *T. platyphyllos* of 851 cm circumference and 480 years of age is growing in the village of Czarny Potok (Łącko commune, Małopolska Voivodeship).

Names of many towns and villages in Poland derive from lime, e.g. Święta Lipka, Lipnica, Lipusz [Stypinski 1973]. Moreover, the name of the commune and the place itself is by no means accidental. Auer et al. [1999] claim that the name of the commune can be traced back to the Latin word *Lyppa* and derives from wide-stretching and impressive limes growing in the village and neighbouring areas. A documented history of the village Lipka goes back to 1376. A Latin chronicle in which this place is mentioned dates back to this period. The coat of arms of the Lipka commune presents a lime leaf and flower against yellow background.

The documentation of natural resources of Lipka commune mentions only one hornbeam avenue, as well as 22 individual trees considered as nature monuments, including three lime trees: two specimens of *Tilia cordata* and one specimen of *T. tomentosa*. The remaining monumental trees include: *Fagus sylvatica* (5), *Quercus robur* (4), *Q. petraea* (1), *Fraxinus excelsior* (4), *Acer platanoides* (3), and *Alnus glutinosa* (1) and *Abies procera* (1). Until now, the only information about impressive lime trees growing in this commune referred to the three monumental limes. This was the reason which motivated the authors to undertake this investigation whose prime objective was to inventory impressive lime trees found in the commune region. The aim was to find and describe in detail the most valuable limes and, ultimately, to place them under protection. An important aspect of the performed inventory was a planned development of didactic materials regarding the most valuable and interesting lime trees, for example, in the form of a guidebook, Internet site or education pathway. These materials could be used to promote the Lipka commune.

**OBJECT OF RESEARCH**

Lipka commune is situated in the northern part of the Wielkopolska Voivodeship and north-eastern part of Złotów district, 22 km north-east of Złotów (Fig. 1). Its capital is a small town Lipka (GPS: 53°29’48.83” N, 17°14’51.98” E). The area of the commune is 191.01 km², which constitutes 11.5% of the total area of Złotów district [Juchniewicz et al. 2004]. The Lipka commune borders with the following communes: Debrzno, Sępólno Krajeńskie, Zakrzewo, Złotów and Okonek [Juchniewicz et al. 2004]. It is a rural commune which consists of 18 village communities (http://www.gminalipka.pl). The following rivers flow through the commune: Debrzynka, Łobżonka and Stołunia (left tributary of Łobżonka). There are also five lakes of the total area of 103.97 ha: Łąkie, Kiełpińskie, Gogolin Wielki, Świdnik and Staw Myślniński Osowo [Juchniewicz et al. 2004] (Fig. 1).

The following two areas belonging to the Natura 2000 network are also situated in Lipka commune: Debrzynka River Valley (PLH300047) of 920.9 ha area and Łobżonka River Valley (PLH3015) of 5894.3 ha area (x).
Impressive lime trees in the Lipka commune (Wielkopolska Voivodeship)

Fig. 1. Lipka commune – distribution of the impressive lime trees
Rys. 1. Gmina Lipka – rozmieszczenie stanowisk okazałych lip
The prevailing soils in the commune include: podzol, sandy and sandy-clay soils [Juchniewicz et al. 2004].

The climate of the Złotów district and, consequently, of the Lipka commune is temperate with both ocean and continental influences. Masses of polar, arctic and tropical air intermingle. In the course of the year, 30-35 frosty days, approximately 107 days with frost and 38-50 days with snow cover occur in the area of Lipka commune. Mean annual precipitation is 546 mm and the length of the vegetation period varies from 210 to 215 days. Mean wind velocity amounts to about 3.4 m/s. In summer, easterly winds prevail, while in winter the prevailing winds blow from west or south-west directions. North winds are rare. Relative air humidity amounts to about 81% and cloud cover – about 56% [Juchniewicz et al. 2004].

MATERIAL AND METHODS

Investigations were carried out during the 2012 vegetation season. Tree species names are given after Seneta and Dolatowski [2011]. Each tree was allotted an inventory number. First, trees growing in the town of Lipka were allotted numbers and consecutive lime trees were numbered beginning from the western (Kiełpin) to eastern part of the commune (Białobłocie). Positions of individual limes were marked in the field and then their geographical coordinates were read from the www.geoportal.gov.pl Website. The distribution of inventoried trees is presented on the map (Fig. 1).

Circumferences (in cm) of all the described trees were measured using a measuring tape at the height of 130 cm. The most valuable trees were classified into the following five circumference classes (monumental circumferences after the Instrukcja... [1996], as well as Ruciński [1998]): 1 – trees with monumental circumferences (the assumed circumference was 314 cm); 2, 3, 4 – successively, trees with circumferences 10%, 20% and 30% smaller than the monumental ones and 5 – existing nature monuments.

Tree heights were measured with the assistance of a Suunto PM-5/1520 altimeter. Health condition of the examined lime trees was determined in accordance with the modified Kamiński and Czerniak [2000] classification. Trees were divided into five health classes: health condition: 0 – very good – trees completely healthy; 1 – good; 2 – moderate; 3 – bad, dry-wood up to 35% of the crown area; 4 – very bad, dry-wood more than 35% of the crown area; dying trees.

In addition, types of objects near which the examined lime trees were growing were also determined: roads (country, commune, local and dirt), sacred objects (churches, cemeteries – both Polish, as well as old – German or Jewish), early medieval settlements, old parks (with the exception of closed, private palace parks), railway station, forester houses, forest districts, forest parks, restaurants, former and new primary and secondary schools, education pathways or cycling routes.

Complete inventory data, as well as photographic documentation, can be found in Szczepański’s manuscript [2012].
In all, 105 impressive lime trees belonging to the following four taxons: *Tilia cordata* Mill., *T. platyphyllos* Scop., *T. ×europaea* L. and *T. tomentosa* Moench were identified in Lipka commune (Table 1). The most common lime species was *T. cordata* – 95 trees (90%). The proportion of the remaining limes was small: *T. ×europaea* (6 trees), *T. platyphyllos* (3 trees) and *T. tomentosa* (1 tree).

Table 1. List of the impressive lime trees (monuments of nature, trees with circumferences monumental and close to monumental) inventoried in the Lipka commune

<table>
<thead>
<tr>
<th>Number</th>
<th>Species</th>
<th>Circumference</th>
<th>State of health</th>
<th>Place</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>Tilia cordata</em></td>
<td>353 cm</td>
<td>2</td>
<td>Lipka</td>
<td>“Sezam” restaurant restauracja „Sezam”</td>
</tr>
<tr>
<td>2</td>
<td><em>Tilia cordata</em></td>
<td>247 cm</td>
<td>1</td>
<td>Lipka</td>
<td>St. Catherine Catholic Church kościół p.w. Św. Katarzyny</td>
</tr>
<tr>
<td>3</td>
<td><em>Tilia cordata</em></td>
<td>243 cm</td>
<td>1</td>
<td>Lipka</td>
<td>St. Catherine Catholic Church kościół p.w. Św. Katarzyny</td>
</tr>
<tr>
<td>4*</td>
<td><em>Tilia cordata</em></td>
<td>380 cm</td>
<td>2</td>
<td>Lipka</td>
<td>railway station dworzec PKP</td>
</tr>
<tr>
<td>5</td>
<td><em>Tilia cordata</em></td>
<td>333 cm</td>
<td>0</td>
<td>Lipka</td>
<td>Leśna Street ul. Leśna</td>
</tr>
<tr>
<td>6</td>
<td><em>Tilia cordata</em></td>
<td>351 cm</td>
<td>1</td>
<td>Lipka</td>
<td>railway station dworzec PKP</td>
</tr>
<tr>
<td>7</td>
<td><em>Tilia cordata</em></td>
<td>266 cm</td>
<td>1</td>
<td>Lipka</td>
<td>cemetery cmentarz</td>
</tr>
<tr>
<td>8</td>
<td><em>Tilia cordata</em></td>
<td>272 cm</td>
<td>1</td>
<td>Lipka</td>
<td>cemetery cmentarz</td>
</tr>
<tr>
<td>9</td>
<td><em>Tilia cordata</em></td>
<td>251 cm</td>
<td>1</td>
<td>Lipka</td>
<td>cemetery cmentarz</td>
</tr>
<tr>
<td>10</td>
<td><em>Tilia cordata</em></td>
<td>330 cm</td>
<td>2</td>
<td>Lipka</td>
<td>forest parking/educational path parking leśny/ścieżka edukacyjna</td>
</tr>
<tr>
<td>11</td>
<td><em>Tilia cordata</em></td>
<td>273 cm</td>
<td>1</td>
<td>Lipka</td>
<td>forest parking/educational path parking leśny/ścieżka edukacyjna</td>
</tr>
<tr>
<td>12</td>
<td><em>Tilia cordata</em></td>
<td>325 cm</td>
<td>1</td>
<td>Lipka</td>
<td>land route droga gruntowa</td>
</tr>
<tr>
<td>13</td>
<td><em>Tilia cordata</em></td>
<td>230 cm</td>
<td>1</td>
<td>Lipka</td>
<td>land route droga gruntowa</td>
</tr>
<tr>
<td>14*</td>
<td><em>Tilia cordata</em></td>
<td>353 cm</td>
<td>1</td>
<td>Kiełpin</td>
<td>district road no. 1026P droga powiatowa nr 1026P</td>
</tr>
</tbody>
</table>
Table 1 – cont. / Tabela 1 – cd.

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td><em>Tilia cordata</em></td>
<td>250</td>
<td>1</td>
<td>Kielpin</td>
<td>district road no. 1026P droga powiatowa nr 1026P</td>
</tr>
<tr>
<td>16</td>
<td><em>Tilia cordata</em></td>
<td>296</td>
<td>1</td>
<td>Kielpin</td>
<td>district road no. 1026P droga powiatowa nr 1026P</td>
</tr>
<tr>
<td>17</td>
<td><em>Tilia cordata</em></td>
<td>281</td>
<td>1</td>
<td>Huta</td>
<td>district road no. 103002P droga powiatowa nr 103002P</td>
</tr>
<tr>
<td>18</td>
<td><em>Tilia cordata</em></td>
<td>336</td>
<td>1</td>
<td>Huta</td>
<td>district road no. 103002P droga powiatowa nr 103002P</td>
</tr>
<tr>
<td>19</td>
<td><em>Tilia cordata</em></td>
<td>318</td>
<td>1</td>
<td>Huta</td>
<td>district road no. 103002P droga powiatowa nr 103002P</td>
</tr>
<tr>
<td>20</td>
<td><em>Tilia cordata</em></td>
<td>291</td>
<td>1</td>
<td>Huta</td>
<td>district road no. 103002P droga powiatowa nr 103002P</td>
</tr>
<tr>
<td>21</td>
<td><em>Tilia cordata</em></td>
<td>310</td>
<td>1</td>
<td>Huta</td>
<td>district road no. 103002P droga powiatowa nr 103002P</td>
</tr>
<tr>
<td>22</td>
<td><em>Tilia cordata</em></td>
<td>298</td>
<td>2</td>
<td>Huta</td>
<td>district road no. 103002P droga powiatowa nr 103002P</td>
</tr>
<tr>
<td>23</td>
<td><em>Tilia cordata</em></td>
<td>282</td>
<td>1</td>
<td>Huta</td>
<td>district road no. 103002P droga powiatowa nr 103002P</td>
</tr>
<tr>
<td>24</td>
<td><em>Tilia cordata</em></td>
<td>272</td>
<td>1</td>
<td>Huta</td>
<td>district road no. 103002P droga powiatowa nr 103002P</td>
</tr>
<tr>
<td>25</td>
<td><em>Tilia cordata</em></td>
<td>320</td>
<td>1</td>
<td>Huta</td>
<td>district road no. 103002P droga powiatowa nr 103002P</td>
</tr>
<tr>
<td>26</td>
<td><em>Tilia cordata</em></td>
<td>355</td>
<td>3</td>
<td>Huta</td>
<td>district road no. 103002P droga powiatowa nr 103002P</td>
</tr>
<tr>
<td>27</td>
<td><em>Tilia cordata</em></td>
<td>291</td>
<td>1</td>
<td>Huta</td>
<td>district road no. 103002P droga powiatowa nr 103002P</td>
</tr>
<tr>
<td>28</td>
<td><em>Tilia cordata</em></td>
<td>305</td>
<td>0</td>
<td>Huta</td>
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| 67 | *Tilia cordata* | 311 | 1 | Mały Buczek | storehouse near the forest district  
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| 68 | *Tilia cordata* | 327 | 2 | Mały Buczek | early medieval settlements  
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Lime trees were found to grow near 11 different objects (Fig. 2). Majority of limes (67) grow along roads with some of them (39) forming avenues along roads. Four such avenues were identified. The first of them leads from Łąkic to Huta (16 Tilia cordata trees with circumferences of 272 – 475 cm) and the second one – from Debrzna Wies to Laskowo (10 Tilia cordata trees with circumferences of 306 – 413 cm). There are also two small avenues, one in Potulice (6 T. cordata trees with circumferences of 293 – 619 cm) and one in Scholastyków (3 T. platyphyllos lime trees and 2 T. ×europaea trees with circumferences of 270-359 cm). Apart from roads, impressive limes were also found to grow in the vicinity of forester houses, in old parks, in cemeteries, as well as in the neighbourhood of old schools, settlements and churches (Fig. 2).

From among the inventoried limes, trees assessed to be in good (49) or very good (13) health condition prevailed (Table 1). Health condition of numerous lime trees (29) was also classified as moderate and only some trees were evaluated to be in bad (9) or very bad (5) health condition.

The following three lime trees in Lipka commune are protected as nature monuments: Tilia cordata (circumference – 450 cm, height – 30 m), T. cordata (circumference – 410 cm, height – 18 m) and T. tomentosa (circumference – 515 cm, height – 30 m; Table 1). The first two trees grow in an old park in Mały Buczek and the third one – in the Białoblocie forest range.
Majority of the examined trees, i.e. 55 (52%) comprise limes with monumental circumferences. The circumference by 10% smaller than the monumental one was determined in 21 trees (20%), 20% smaller than the monumental one – in 17 limes (17%). The smallest number of trees, i.e. 12 trees (8-9%) comprised limes with circumferences 30% smaller than the monumental circumference (Table 1).

Most trees with monumental circumferences were found growing along district, local and dirt roads, in early medieval settlements and old parks (Table 1). In the case of limes with circumferences 10% smaller than the monumental circumference, majority of them occurred along district and local roads, as well as near forester houses. Trees with circumferences 20% smaller than the monumental circumference were identified mainly along district and local roads, as well as cemeteries, whereas limes with circumferences 30% smaller than the monumental circumference were most numerous along dirt roads and near churches.

The thickest lime trees growing in 17 places in the Lipka commune (Batorowo, Batorówek, Białałobocie, Czyżkowo, Debrzno Wieś, Huta, Kielpin, Laskowo, Lipka, Łąkie, Mały Buczek, Nowy Buczek, Osowo, Potulice, Scholastykowo, Stołuńsko, Wielki Buczek; Table 1) were identified. These trees undoubtedly constitute a tourist attraction. They usually grow along district or local roads. Their circumferences range from 250...
to 619 cm. The thickest of them include: *Tilia cordata* with the circumference of 619 cm, growing along the local road in Potulice and *T. tomentosa* of the circumference of 515 cm, which is situated in the old park in Mały Buczek.

When choosing the most valuable trees proposed to be placed under protection in the form of nature monuments, the following factors were taken into consideration: their circumference and height, health condition and attractiveness from the point of view of touristic location. In this way, six small-leaved limes were selected with circumferences ranging from 330 to 445 cm (Table 1).

**CONCLUSIONS**

105 impressive lime trees were inventoried in the Lipka commune. They belong to the following four taxons: (*Tilia cordata, Tilia ×europaea* L., *Tilia platyphyllos* Scop., *Tilia tomentosa* Moench). *T. cordata* turned out to be most numerous (95 trees) and was the only one in this region occurring within the boundary of its natural range. These trees were found to grow mainly in roadside avenues.

Prior to the performed inventory, the only data about impressive lime trees in this commune were associated with the information about three monumental trees. At the present time, thanks to comprehensive dendrological documentation, it will be possible to elaborate a protection strategy of impressive limes. In the case of the most valuable trees, it should be protection in the form of nature monuments and in the case of other trees which happen to be in a worse health condition, it would be advisable to carry out tending interventions. The total of 55 lime trees has the monumental circumference and many of them (26) are in good or very good health conditions which qualify them to be placed under protection in the form of nature monuments. In the first stage, six most beautiful lime tree specimens with circumferences from 330 to 445 cm were proposed to be placed under protection.

This publication has also another important aspect. Tourism and recreation are important economic domains in the Lipka commune supported and favoured by nature and cultural values of this commune. Promotion of these values is an important task and impressive lime trees may become one of important tourist attractions of the commune whose name derives from these very trees. That is why the most impressive limes with circumferences ranging from 250 to 619 cm were selected in 17 places in this commune. These trees should be marked out (they can be identified by special notices with appropriate descriptions). These plates should serve to draw attention not only of tourists but also of local communities (this would assure their informal protection). In the next stage, a dendrological guidebook “following the path of impressive lime trees of the Lipka commune” is to be prepared which should serve promotion of this commune.

**REFERENCES**


Impressive lime trees in the Lipka commune (Wielkopolska Voivodeship)


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dują się trzy istniejące pomniki przyrody oraz 55 drzew o obwodach pomnikowych. Dzięki pełnej dokumentacji dendrologicznej można będzie chronić okazałe lipy, które mogą stać się jedną z ważnych atrakcji turystycznych gminy Lipka.

Słowa kluczowe: gmina Lipka, okazałe lipy, pomniki przyrody

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