5. ЗАХИСТ ЛІСІВ І МИСЛИВСЬКЕ ГОСПОДАРСТВО

UDC 630.4

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VERTICILLIUM WILT ON NORWAY MAPLE (*ACER PLATANOIDES* L.) IN THE EAST OF UKRAINE

Massive Norway maple decline was registered in forest and ornamental stands of the East of Ukraine. The pathogen was identified as Verticillium dahliae. It infects different maple species and some other forest trees. The main symptoms of disease are wilt, foliage and xylem discoloration, defoliation, long green streaks in sapwood, dieback. Crown damage decreases with stem diameter. It is the highest in the forest (78.5%), the lowest in the street (21.5%) and intermediate in the park (44.9%). In the streets foliage damage was 59.4% and 30.5% in the maple trees with and without mechanical wounds in the lower part of stem, which were caused during weeding. Such wounds were absent in the forest. Weather conditions of 2016 (early beginning of sap flow, fluctuation of temperature, high maximal air temperature and low precipitation) were favorable for wilt development. Preventive measures of wilt spread can be used only in nurseries. Removal of affected maple from mixed oak stand may be unfavorable for oak growth.

Key words: *Norway maple, Verticillium wilt, symptoms, crown damage*

Introduction. Norway maple (*Acer platanoides* L.) is widespread in Europe up to Ural Mountains, and is naturalized in USA and Canada [5]. This fast-growing species is able to grow in a wide range of soils and habitat conditions. It is important that the part of oak stands grow in fresh and humid sites [1]. Norway maple is also planted as ornamental and shade tree, due to its colorful foliage, large crown and resistance in urban conditions [2, 5]. The wood of maple is used for music instruments, furniture and marquetry.

Different fungal species cause leaf spots, dieback of branches, wood cankers of Norway maple, but usually such diseases do not lead to tree mortality [9].

In 2016 massive Norway maple dieback was registered in forest and ornamental stands of the East of Ukraine. Characteristic symptoms were observed in leaves, branches and stems as well as in their cross sections. Sometimes affected trees died, and in other cases water shoots developed after premature leaf abscission. Over 80% of trees had the same symptoms in inspected stands with different level of damage (from 21.5 to 100%).

Observed symptoms of Norway maple decline resemble *Verticillium* wilt – the disease caused by soil-borne fungi of the genus *Verticillium*, *V. dahliae* Kleb. [3]. This disease in maple was not studied in Ukraine yet. However, high attention was paid to it in other plants in the 80s of the last century in Europe and USA [8, 9].

Verticillium wilt spreads fast in the East Ukraine, therefore we can expect accumulation the large amount of infection in the soil and plant debris. *V. dahliae* survives in soil as microsclerotia, which are formed in the dying tissues of the host plant, especially leaves. Microsclerotia germinate, within a week the hyphae penetrate the cortex of young roots and spread in the xylem vessels which cause the water stress, wilting and dieback [4]. The pathogen can survive over 10 years in the soil over a quite wide range of soil moisture and temperature [3] and be vectored to new plants or sites with soil, plant debris or planting material as a result of activity of soil organisms and management, as well as by wind, dust, water, and wind-blown leaves, which contain microsclerotia and hyphae [7]. It can be spread also with scions, buds or rootstocks of infected plants and during pruning [3].

Though Norway maple is seldom the main forest-forming species, it often makes up considerable part of oak stands [1]. Therefore mortality of Norway maple would have negative influence on oak growth in the region.

The aim of this research was to identify the pathogen which causes Norway maple decline, and to carry out

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preliminary analysis of its occurrence and development on Norway maple in the forest and ornamental stands of the East Ukraine, as well as to try to develop the strategy of its management.

Objects and methods. Forest stands were inspected in the State Forest Enterpises "Vovchanske Forestry", "Zhovtneve Forestry", "Chuguevo-Babchanske Forestry", "Skrypaivske Training & Experimental Forestry" of Kharkiv National Agrarian University named after V. V. Dokuchaev ("Skrypaivske TE Forestry"), and Kharkiv Forest Research Station of Ukrainian Research Institute of Forestry and Forest Melioration named after G.M. Vysotsky ("Kharkiv FRS"). Ornamental stands in Kiev and Shevchenko districts of Kharkiv as well as the Veterans Park and Arboretum of Kharkiv National Agrarian University named after V. V. Dokuchaev were also inspected.

In each stand 50–100 Norway maple trees were inspected with registration of such visual symptoms: wilt, foliage discoloration, defoliation, drying or necrosis on leaves; dieback and death of branches or the whole tree [3]. Randomly we examined the cross-sections of branches between alive and dead parts of them and registered the presence of discoloration of xylem or vascular discoloration (vascular symptoms).

Weather parameters from meteorological station Kharkiv were used.

In August 2016, leaves and chips of discolored sapwood from 50 affected trees were examined for presence of *Verticilium dahliae* and other pathogens. These trees have showed serious symptoms of maple wilt during the summer. 100 petioles from symptomatic trees were also collected to identify *Verticilium dahliae* or other pathogens. All samples were immediately cleaned for identification on microsclerotia [3]. After cleaning, all samples were sterilized in 1% sodium hypochlorite for 1 min, washed in sterile water. Removing the bark and cutting of sapwood discs done. Five discs or pieces of petioles were placed on PDA (potato dextrose agar) using sterile forceps. Petri dishes were incubated at 22°C.

Results and discussion. *Fungus identification and mycological study.* After incubation at 22°C, presence of *Verticillium dahliae* Kleb was determined (Fig. 1). Isolates formed globose or oval to elongate microsclerotia without chlamydospores. Aerial mycelium generally abundant, floccose, or appressed to the agar and appearing water-soaked. Aerial hyphae smooth-walled, (1.5–) 2–3 µm wide. Conidiophores on mycelium erect or slanted, colorless, branched swollen whorled at an angle up the branches, often somewhat swollen at the base. They formed disjointedly throughout the colonies, hyaline, 80–700 µm in length, 3–4 µm wide, narrowing towards the apex, transversely septate, septa spaced more narrowly towards the apex. Conidiogenous cells are phialides, arranged in whorls along conidiophores, arising below transverse septum). Phialides subulate, tapering from 1 µm at the base to 2 µm at the tip, terminal phialides 40–60 µm long, lateral phialides 25–50 µm long. Conidia were also colorless, hyaline, smooth-walled, non-septate, cylindrical with rounded apices to oval, 2.5-11.5 x 1.7-3.5 µm. Inflated cells were also detected in mycelium after 4 weeks on PDA up to 9 µm wide. The absence of melanised mycelium was observed for some isolates. All isolates fitted in these descriptions, except three ones, were classified as *V. dahliae*. Other two were identified as *Fusarium* sp. and *Penicillium* sp.

Fig. 1. Colony of *Verticillium dahliae* Kleb after 2.5 weeks incubation (on the left), conidiophores after 15 days (in the middle) and microsclerotium of isolates (on the right)

Field investigations. Verticillium wilt was observed in *Acer platanoides*, *A. campestre* L. and *A. negundo* L. in all inspected stands. It is consistent with the published data, according to which *Verticillium* wilts affect a wide range of plants in many parts of the world between latitudes 60°N and 50°S with the exception of tropical lowlands [3]. The list of host-plants of this fungus cover fruits, nuts, vegetables, herbs, woody and herbaceous ornamentals, some shade and amenity tree species [9]. Among forest trees of temperate zone, *Acer, Aesculus, Fraxinus, Robinia, Tilia* and *Ulmus* as well as shrubs from genera *Berberis, Buxus, Elaeagnus, Ligustrum, Lonicera* are shown to be susceptible to the pathogen. At the same time, *Alnus, Betula, Fagus, Populus, Quercus* and *Salix* seem to be resistant [7].

It was found, that some tree species like ash recover from disease, because their cambium is able to produce new layers of tissue around damaged xylem. Ash wood has also a sheath of marginal parenchyma between successive growth rings. It serves as barrier zone

between latewood vessels of one growth ring and early wood vessels of the next growth ring. Robinia, oak and ash are ring-porous trees. Their water transport is mainly in the current year's wood. Hence, as the cambium retains its ability to form a new growth ring, loss of water transport capacity of the current year's xylem poses no problem for survival of the tree. Unlike them, maple is diffuse-porous tree. Its xylem vessels in each growth ring remain functional for several years, so that the loss of the transport capacity of one (or more) of these rings limits water conduction in following years [7].

In some trees, rapid wilting of leaves was observed. They desiccated and turned brown, dead leaves usually remained on the branches. New sprouts did not develop, and the trees died. It was so called acute form of disease [4].

The leaves of other trees became discolored and desiccated, usually from the margins inwards (Fig. 2) and prematurely fall off.

Fig. 2. Damaged foliage of *Acer campestris* (left) and *Acer platanoides* (right)

Some weeks after defoliation, extensive dieback of branches was often followed by the formation of adventitious shoots below the level of dieback, especially from the stem base (Fig. 3). It was chronic form of disease [4].

Fig. 3. Formation of adventitious shoots in damaged trees

Cross-sections of branches between alive and dead parts of them demonstrated dark dots, strips or rings (Fig. 4). It appears because gel plugs and tyloses are formed in the vessels, which brings to water transport impedance and wilt, desiccation and defoliation in result of it.

Fig. 4. Dark dots, strips or rings in the cross-sections between alive and dead parts of damaged branch

Preliminary analysis of crown damage level in different stands show its dependency from stem diameter at breath height ($r = -0.63$) (Fig. 5). It is consistent with the published data, according to which the small trees are damaged more, because root system covers large soil volume, each year major part of fine roots recovers, and roots are located not only in top layer [3].

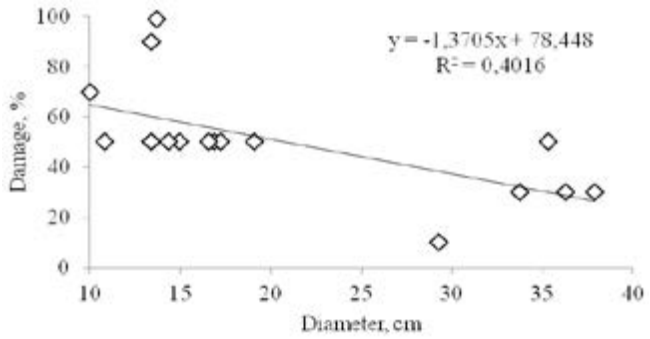

Fig. 5. Damage level (wilt damaged part of crown) in Norway maple depending on tree stem diameter

Positive role of foliage removal in the spread of *Verticillium* wilt can be seen (Fig. 6): damage level was the highest in the forest (78.5%), the lowest in the street (21.5%) and intermediate in the park (44.9%).

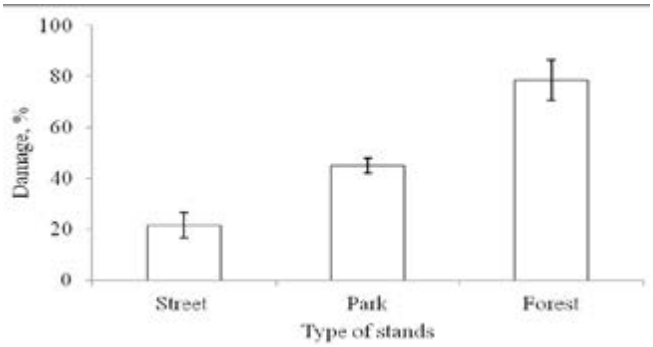

Fig. 6. Maple damage (wilt damaged part of crown) in different stands

It is known, that the wounds of roots, including caused by plant pathogenic nematodes, is important contributory factor to disease [6]. Our preliminary research show, that the foliage damage was 59.4% and 30.5% for the maple trees with and without mechanical wounds respectively in the lower part of stem, which were caused during weeding. Such wounds were absent in the forest.

As wilt development causes water stress in plants, it is severe in hot and dry summers [4].

Our research show, that daily air temperature in all months of vegetation period in 2016 was higher than by long-term data (Fig. 7).

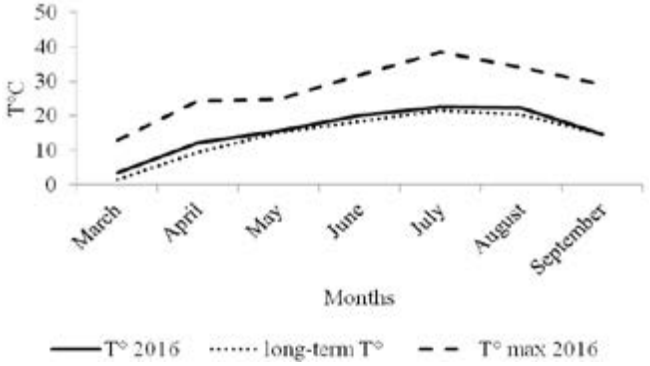

Fig. 7. Air temperature (T °C) in 2016 and for long-term data (meteorological station Kharkiv)

The most excess of daily temperature (164.7%) was calculated for March, when maximal temperature exceeded 12.8° C. Sap flow in maples started at the first days of March instead of the third decade of March (as it was by long-term data). This created the conditions for rapid penetration of infection into the roots and spread in the stems. Several waves of hot and cold weather the next weeks with significant fluctuation of precipitation had negative influence on rate of foliage and shoot growth. For example, in May air temperature was only 3.6% higher than long-term data, but precipitation was 202% (Fig. 8).

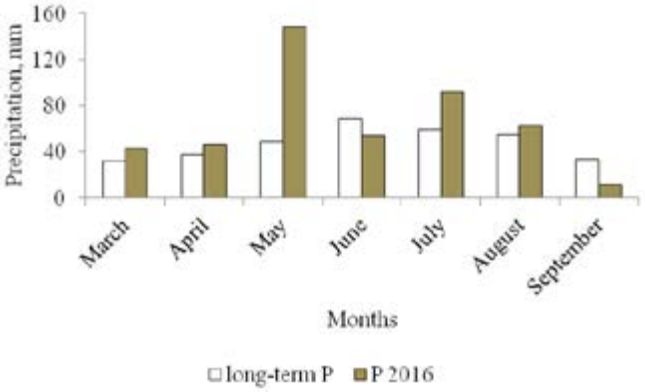

Fig. 8. Precipitation (P, mm) in 2016 and for long-term data (meteorological station Kharkiv)

In June air temperature 10.5% exceeded the long-term data, and precipitation was 21.7% less than long-term data. That is in June the first wave of disease began to develop. The second wave of disease started in July after maximal daily temperature over 30 °C. This wave of disease may be more dangerous because the growth of shoots and ability to regeneration became low. Dry and hot September with daily temperature 14.6 °C and maximum 29.1 °C and precipitation only 11 mm (67.6% from long-term data) may contribute to further development and spread of disease.

Disease management. The most of publications on *Verticillium* wilt management concern nurseries and include recommendations on irrigation, supply of additional potassium, soil disinfection, which is dangerous for environment, and use of resistant cultivars or rootstocks [3]. Use of former agricultural land infested with *V. dahliae* for nursery production caused wilt problem in the USA in the 1960s and 70s [9].

In the inspected oak stands of the East of Ukraine Norway maple exceeds 40% by number of trees and 20–30% by stock. In the case of high spread of *Verticillium* wilt removal of damaged maple trees from the stand would bring to considerable decrease the density of stocking. Natural regeneration of maple and other susceptible species would also be damaged by wilt, because the stock of infection is already high in the soil. Therefore damaged maple trees with water shoots must not be removed from the stand as long as possible, because sudden change of light regime would worsen conditions for the growth of oak (*Quercus*

robur L.) and its stem quality, especially in the age before growth culmination.

Conclusions. Massive decline of Norway maple was registered in forest and ornamental stands of the East of Ukraine. The pathogen was identified as *Verticillium dahliae*. It infects different maple species and some other forest trees. The main symptoms of disease are wilt, foliage and xylem discoloration, defoliation, vascular discoloration, dieback.

Crown damage decreases with stem diameter at breath height. It is the highest in the forest (78.5%), the lowest in the street (21.5%) and intermediate in the park (44.9%). In the streets foliage damage was 59.4% and 30.5% in the maple trees with and without mechanical wounds in the lower part of stem, which were caused during weeding. Such wounds were absent in the forest.

Weather conditions of 2016 (early beginning of sap flow, fluctuation of temperature, high maximal air temperature and low precipitation) were favorable for wilt development.

Preventive measures of wilt spread can be used in nurseries. Removal of diseased maple from mixed oak stand may be unfavorable for oak.

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ВЕРТИЦИЛЛЕЗНОЕ УВЯДАНИЕ КЛЕНА ОСТРОЛИСТНОГО (*ACER PLATANOIDES* L.) НА ВОСТОКЕ УКРАИНЫ

В 2016 г. зарегистрировано интенсивное увядание клена остролистного в лесных и декоративных насаждениях востока Украины.

Целью исследований была идентификация возбудителя увядания клена остролистного, предварительный анализ распространения и развития болезни в лесных и декоративных насаждениях Востока Украины, а также попытка разработки стратегии защиты от ее последствий.

Обследованы насаждения лесного фонда государственных лесохозяйственных предприятий “Волчанское ЛХ”, “Октябрьское ЛХ”, “Чугуево-Бабчанское ЛХ”, “Скрипаевский учебно-опытный лесхоз” ХНАУ им. В.В.Докучаева, Харьковской ЛНИС УкрНИИЛХА им. Г.Н. Высоцкого, а также декоративные насаждения Киевского и Шевченковского районов г. Харькова, парка Ветеранов и Дендропарка ХНАУ им. В.В. Докучаева.

В каждом насаждении обследовали по 50-100 деревьев клена остролистного, выборочно осматривая срезы ветвей между живой и мертвой частями и регистрируя наличие увядания, дехромации листьев, ксилемы или сосудов, отмирания ветвей. В анализе погодных условий использованы данные метеостанции Харьков.

Произведенный в августе микологический анализ листьев, черешков и фрагментов дехромированной заболони и культивирование на картофельно-декстрозном агаре при 22°С позволили определить возбудителя как *Verticillium dahliae*.

Установлено, что поврежденность кроны уменьшается по мере увеличения диаметра ствола на высоте груди. Она наиболее высока в лесу (78,5%), наиболее низка в уличных посадках (21,5%) и промежуточная в парках (44,9%). В уличных посадках повреждение листвы кленов составило 59,4 и 30,5% среди деревьев с наличием и отсутствием механических повреждений нижней части ствола. Такие повреждения отсутствовали в лесу. Погодные условия 2016 г. (раннее начало сокодвижения, колебания температуры, высокая максимальная температура воздуха и низкое количество осадков) были благоприятны для развития вилта. Меры профилактики распространения болезни могут быть применены только в питомниках. Удаление больных деревьев клена из смешанных дубовых насаждений может неблагоприятно отразиться на росте дуба.

Ключевые слова: клен остролистный, вертициллезное увядание, симптомы, повреждение крон

В.Л. Мєшкова, К.В. Давиденко

ВЕРТИЦИЛЬОЗНЕ В'ЯНЕННЯ КЛЕНА ГОСТРОЛИСТОГО (*ACER PLATANOIDES* L.) НА СХОДІ УКРАЇНИ

У 2016 р. зареєстровано інтенсивне в'янення клена гостролистого в лісових і декоративних насадженнях сходу України.

Метою досліджень була ідентифікація збудника в'янення клена гостролистого, попередній аналіз поширення й розвитку хвороби в лісових і декоративних насадженнях Сходу України, а також спроба розробити стратегію захисту від її наслідків.

Обстежені насадження лісового фонду державних лісогосподарських підприємств "Вовчанське ЛГ", "Жовтневе ЛГ", "Чугуєво-Бабчанське ЛГ", "Скрипаївський навчально-дослідний лісгосп" ХНАУ ім. В.В. Докучаєва, Харківської ЛНДС УкрНДІЛГА ім. Г.М. Висоцького, а також декоративні насадження Київського й Шевченківського районів Харкова, парку Ветеранів і Дендропарку ХНАУ ім. В.В. Докучаєва.

У кожному насадженні обстежували по 50-100 дерев клена гостролистого, вибірково оглядаючи зрізи гілок між живою та мертвою частинами та реєструючи наявність в'янення, дехромації листя, ксилеми або судин, відмирання гілок. В аналізі погодних умов використані дані метеостанції Харків.

Виконаний у серпні мікологічний аналіз листків, черешків і фрагментів дехромованої заболоні й культивування на картопляно-декстрозному агарі за 22°С дав змогу визначити збудника як *Verticillium dahliae*.

Установлено, що рівень пошкодження крони зменшується у міру збільшення діаметра стовбура на висоті грудей. Пошкодження найбільш інтенсивне в лісі (78,5%), найнижче у вуличних посадках (21,5%) і проміжне у парках (44,9%). У вуличних посадках пошкодження листя кленів становило 59,4 і 30,5% серед дерев із наявністю та відсутністю механічних пошкоджень на нижній частині стовбура. Такі пошкодження були відсутні у лісі. Погодні умови 2016 р. (ранній початок сокоруху, коливання температури, висока максимальна температура повітря й низька кількість опадів) були сприятливі для розвитку вілту. Заходи профілактики поширення хвороби можуть бути застосовані лише у розсадниках. Вилучення хворих дерев клена із мішаних дубових насаджень може несприятливо позначитися на рості дуба.

Ключові слова: клен гостролистий, вертицильозне в'янення, симптоми, пошкодження крон