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SPIS TREŚCI

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BIOENERGY WILLOW: PROTECTION FROM THE NEGATIVE IMPACT OF BIOLOGICAL FACTORS

WODA BIOENERGETYCZNA: OCHRONA PRZED NEGATYWNYM WPŁYWEM CZYNNIKÓW BIOLOGICZNYCH

Abstract: In the chapter are presented the results of the study of bacterial and fungal pathology of willow, pests and weeds, which lead to the death of plants or to significant decrease in the yield of biomass of energy plantations. Here are given the methods of protection and prevention.

Key words: bioenergy crops, willow, phytopathogenic bacteria and fungi, weeds, insects, methods of protection and prevention.

As it was noted in section 1 concerning the bioenergy wood, the key place in its receiving is taken by the fast - growing species and cultivars of willow (*Salix* L.) [1,10,16], main diseases [4,26], weeds [17], pests of this crop [17,18] and methods of protection of its plantings, which we give below.

Bacterial wilt of the willow

Spread of mass dieback of willow family in England at the beginning of the twenties of the last century contributed to the detailed study of this disease. For some time in literature prevailed the opinion that disease is caused only by fungi (Long, 1918; Hubert, Ernest, 1920; Poova, 1921; Moss, 1922 - all quoted after Day, 1924 [24]). However, Day (1924) studied symptomatology of disease in detail, called it "watermark disease" (disease of watermarks), isolated bacteria, received the same symptoms at artificial inoculation of trees. As the causative agent of disease turned out to be the new bacterial species called by Day (1924) the *Bacterium salicis*. Dowson (1937, 1939) continued works, started by Day,

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and confirmed the pathogenicity of *B. salicis*, which was subsequently called *Erwinia salicis* (Day) Chester (Breed E.A., quoted after Gvozdyak, Yakovleva, [4]). The bacterial nature of disease is confirmed also by Falck (1926) and Metcalfe (1940, 1941) - quoted after [4]. This disease also was studied in detail in the Netherlands, however as its causative agent was called *Pseudomonas saliciperda* [2,4],which pathogenicity for willows is experimentally - confirmed. Later was shown its identity to *E. salicis* [32,33]. During studying and taxonomic improvements the *E. salicis* species since 1999 was transferred to the new genus *Brenneria,* nowadays - *Brenneria salicis* (Day, 1924) Hauben et al. 1999 [4,5,20-22,27-29].

At the beginning of disease development (in spring) the causative agent of *E. salicis* is isolated in pure form [4,24,25]. In autumn pathogenic bacteria can't be isolated [4]. Later as the representatives of biome of affected areas often become the accompanying yellow - pigmented, fluorescent bacteria *B. aerogenes. Cytospora chrysosperma* settles down in the affected areas of plants that forms a lot of pycnidia [4,11,25]. The fungus accelerates die - back of tissues, but it can't cause disease of healthy trees by itself. The ratio between the causative agent and saprophyte depends on the extent of injury and the season [11]. The accompanying microbiome separately and in mixture doesn't cause the disease, however its role in pathological process is still unclear. It is interesting to note that at artificial inoculation of willow by *E. salicis*, at first in pure culture is also isolated the causative agent and over the course of time is established the same ratio of pathogen and other accompanying microorganisms-saprophytes, as in naturally affected areas [25].

The large number of saprophytic bacteria in affected areas complicates isolation of causative agent. The causative agent of disease is easily isolated from exudate [3,4,8,14,25,31].

The symptoms of infection of willow appear in May - at the end of June in the form of wilt. Wilted leaves become brown or red (but for some time remain on the tree. Due to the reddening of leaves the disease is sometimes called the "red leaf" [4,25]. In the first year of disease is observed the premature mass fall of leaves, though the shoots externally look healthy, leaves sometimes dieback even when they are green and for some time they dangle on the tree [4,25,30].

Infected trees of goat willow had orange (red-brown) leaves and stood out sharply against the green background of not infected trees (fig. 1) of other species. The nature of injury indicated that pathological process started in the early spring, even before formation of leaves on the shoots, during the opening of downy male inflorescences ("catkins"), which at the moment of examination in July had already been completely died together with the shoots [12,19,23]. After formation of leaves on the new shoots the intake of aqueous solutions by xylem vessels stopped abruptly again, which caused wilt, dieback, rolling and redtop of already formed leaves (fig. 2). On the thin branches of the canopy was observed the active display of drops of liquid exudate of muddy white, dirty white colors, sometimes with yellowness, exuding (sweating) on the surface of periderm. Later exudate darkens, thickens, getting brown or cherry color, spreads and, dripping over the surface of shoots, it dries in the form of film. At bending the thin branches also appear the drops of exudate of milking color in the place of bending (fig. 3a, 3b). On the miter cross cuts of shoots and thicker 2 - 4 - year old branches of the canopy was observed abundant overall flooding of wood within the last annual ring or such flooding that took completely whole xylem part,

which had the darker color in comparison with not infected wood and which sparkled in glassy manner (fig. 4a, 4b). Liquid appeared during the pressing on the watercore using the knife blade.

Fig. 1. Watermark disease of willow (causative agent - *Brenneria salicis*) [23]

Fig. 2. Spring dieback, redtop and rolling of leaves of the willow [23]

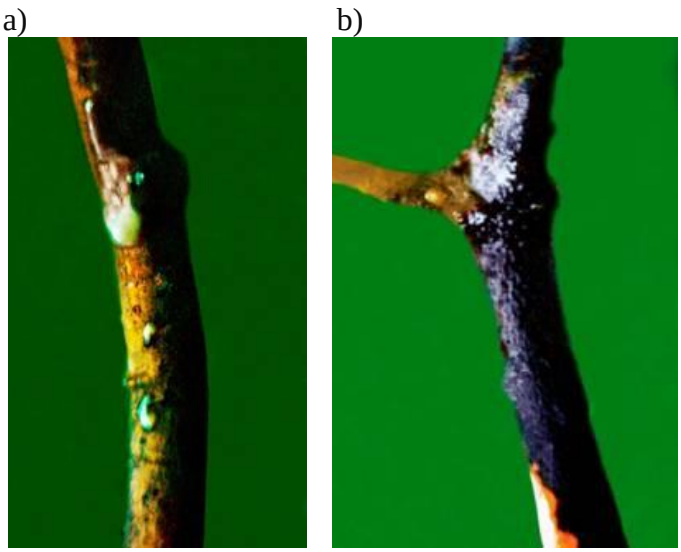

Fig. 3. a) Drops of the milky - white exudate, appearing on the shoots, b) The exudate, appearing from the fork of the shoot spreads over the surface in the form of film [23]

Fig. 4. The watercore of xylem within the annual ring (a) and it completely took all annual rings (b); orange spots of "watermarks", infection of cambium and parenchyma of bark of the goat willow [23]

Rather important symptom of disease - appearance of new, so - called water shoots, exudate and high flooding of infected tissues. Additional water shoots appear in any place: on the trunk, on infected and externally healthy branches. They die - back together with infected branches or die in the next season [24]. The infected branches, from which in the previous summer leaves has fallen down start to develop normally, but then suddenly they die-back, the bark falls down, the trunk of tree becomes bare [4,23,34]. On the fallen bark and the trunk is often visible the fungal mycelium, which develops after the bacterial inoculation.

From cracks and green wounds in the bark, the galleries [4,24] in warm humid weather, mainly in the first year of injury, appear not sticky liquid exudate, which spreads in form of strips, dries up and kind of lacquers the surface of bark. At first it is without color, then it becomes dark brown or black. The exudate sometimes doesn't appear from old wounds. It is toxic for the phloem, shoots and even for grass, which dies from the contact with it [4,23]. The saprotrophic microbiome settles down in the affected areas not at once due to toxicity of exudate [3]. Perhaps, the mass premature fall of leaves from externally healthy branches is explained by means of toxin formation of bacteria, especially as the causative agent isn't revealed in the vessels of leaves and leafstalks.

On the cuts is clearly visible brown zone of infection, which by exposure to the air darkens even more, gets dark brown or black color [4,23-25]. The central rings of the wood, including the heart, are overflowed with liquid. Mainly infected are the passages of the system of branches and trunk [23]. The dissolution of cell walls, tissue cells was never observed [4,23]. As a result of infection of vessels the movement of substances in infected plants is blocked, vessels darken, blacken till the autumn; gas is formed in the vessels of tree [4]. Bacteria gather in the main vessels and radial rays, but they aren't always viable. The parenchyma part and bark aren't damaged, bark dies, obviously as a result of termination of access of water to it [23,24]. The spread of infection along the branch and trunk is happening by the type of stretched-out spiral and it is faster in downward direction, than in upward direction, especially in spring [4].

Spread of causative agent happens extremely slowly in the radial direction and during the vegetative period it probably can't move forward even by the thickness of annual ring [4,24]. Perhaps, reinfection of rings of wood is happening at the end of the vegetative period [23]. Sometimes all branches aren't infected during one year, however the tree may die within one or two-three years [24]. It is characteristic that in the next years the extent of spread of disease decreases.

Strains *E. salicis,* allocated from different species of Salix don't differ from each other. They cause diseases of *Salix alba, S. caerulea, S. fragilis, S. cinerea* і *S. caprea, S. viminalis, S. bakko, S. purpurea , S. viridis, S. russeliana, S. triandra, S. sachalinensis, S. alba subsp. caerulea* [4,23,24,29]. However, *S. fragilis* can't infect with any strain, taken from the trees of other types. Infection of trees occurs during the period between October and March. In summer months plants are resistant to infection. The number of factors of external environment also has influence on the susceptibility of willow to the pathogenic agent The disease more often occurs on the swampy soil with stagnant water, in the thickened forest stands. It is shown that plants are resistant on the well - drained soil [24].

The pathogenic agent is transmitted by insects, wind and rain helps its spread [4,24].

Spread and harmfulness Bacterial disease of willows is described in the Northern Europe countries [4,23,24] and USA [4]. The infected trees of willow even at the very beginning of disease lose their value due to the staining of wood [4,23].

Fungal diseases of willow

Willow plants at the energy plantations can be affected by leaf rust, brown and black cytospora canker and other diseases [2,6,7,15].

***Leaf rust of willow*.** Disease is caused by parasitic rusty fungi of the genus *Melampsora*. Intermediate hosts of the rust are the pine, larch, different species of onions, celandine, etc.

Disease affects leaves, and in some cases - young terminal shoots, and that leads to their premature fall, and later - to death of plants (fig. 5).

Fig. 5. Leaf rust of willow [15]

The rust is especially dangerous for young plantings with the low location of canopy. The first symptoms of disease can be observed at the end of June - at the beginning of July, when on leaves appear yellow - orange spots (urediniospores), from which appear spores in the powder form. The dark spots – teliospores - also appear on the leaves in the autumn.

The infection by means of rust that systematically repeats during several years, leads to the great weakening of young trees of willow. The primary sources of infection in most cases are larchen plantations and pinery.

Brown cytospora canker - the causative agent - fungus (*Cytospora chrysosperma (Rers.)* Fr.) - infects the bark of shoots, slowly spreading in it to the phloem. An external part of the bark is turned into red - brown color (fig. 6).

Fig. 6. Brown cytospora canker [15]

Black cytospora canker - the causative agent - fungus (*Cytospora foetidae* Vl. et. Rr.) - infects the trunks and shoots of willow. The canopy and external layers of sapwood are turned into green-brown color. Externally the color of bark changes seldom. The sources of infection are the infected trees (fig. 7).

Infection is performed by means of spores, which are spread by rain, wind, insects and planting material. The spores, which appear from pycnidia in the form of orange - red drops or flagella, are formed on a massive scale in the spring (May - the start of June) and in the autumn (the end of August - September).

Fig. 7. Black cytospora canker [15]

At autumn infection trees are infected stronger, than at spring, as low temperatures are more favorable for development of causative agent. The portal of entry of infection in stool beds and nursery gardens are long stumps, which remain at stalk cutting, mechanical damages at tending, frost cracks, etc. For disease is characteristic the latent period during the first year of injury, which helps in transmission of infection to the new areas with the use of hidden infected shoots.

Resistance of certain species and forms of willow depends on conditions of their growth. The fungus develops more actively if the stalks were dried during the storage, or planted into the dry or cold soil [15].

Protection measures of plantations of willow from diseases

Watermark disease (causative agent is *Brenneria salicis*) - is the serious disease of willows, possibly also the other species, which leads to dieback and their death. Diagnostics has great difficulties due to quiescent lesion. Among the control measures effective are: the early detection of disease, the salvage felling of infected trees and the trees, which are adjacent to the focus of disease with the obligatory stumping and subsequent burning of all logging slash and stumps.

The main measure of disease prevention of energy willow is the selection of species and cultivars with intensive growth and high resistance to causative agents.

At cultivation of this crop it is necessary to consider that willows of subgenus *Salix* are more often affected by brown rust, and the species of subgenus *Vetrix* - by yellow rust and powdery mildew [1]. It should not be allowed to locate willow near the plantings of pine and larch [18].

Felling of shoots is recommended to perform in the early spring in the year of planting from the healthy parent bushes. During the stalk cutting the lower parts of shoots are destroyed, as they may contain considerable reserve of the hidden infection of cytospora

canker. It is necessary to conduct the preplant chemical treatment of stalks. For this purpose the cut stalks are soaked in suspension of fungicides during the day and they are planted without washing.

It is possible to conduct the spring or late autumn spraying of nursery gardens and young crops in the strong focuses of cytospora canker by means of fungicides [18].

At appearance of the first formations of uredospores on the leaf and the threat of strong infection by means of rust and cytospora canker, it is recommended to perform spraying of plants with fungicides within the consumption rates, recommended for perennial plantings, using the aircraft.

Willows also may be infected by the scab, powdery mildew, spotting. At the high level of infection, it is necessary to use the chemical measures of protection, which include exterminative and protective (preventive) spraying with fungicides. Spraying can be performed not only in late autumn, but also in the early spring. The protective sprayings prevent the penetration of causative agents into tissues of the plant and they also prevent the development of diseases. They are conducted in the vegetation period, within the time limits of mass spread of infection. The spraying of plants from the powdery mildew, rust and spotting should be started at appearance of the first symptoms of diseases. One - two retreatments are conducted with an interval of 2 - 3 weeks. For protection of willow from the scab the first treatment is conducted right after unfolding of leaves, the second - in 10 - 12 days [15, 18].

One of effective measures of controlling Erwinia and other bacterial and fungal diseases (at the insignificant volumes) is the early detection of disease, removal of infected plants and the plants, which are adjacent to the focus of disease with the obligatory stumping and subsequent burning of them. Effective measures of protection from causative agents of diseases of willow aren't yet developed. The justified measures are the ones that directed toward removal of the rotted dry trees, which are stricken with disease, from plantation. It is necessary to select soils with the well - drained soil for planting of willow, in addition, it is necessary to avoid high - density plantings.

Weeds in the plantation of willows and protection from them

In the structure of weed infestation of energy plantations of willows the significant share is occupied by dicotyledon species: the pale persicaria, lamb's - quarters, charlock and others. Among cereal species the most problem weed is the couch grass. It is also often may be met the yellow - foxtail grass, cockspur grass and others [10]. Expansion of weeds leads to retardation in growth and development of plants of willow and, as a result, to essential decrease in the yield of biomass.

At creation and cultivation of energy plantations of willow, as a rule, is used the combined system of their protection from weeds. It is used at the areas with high level of weed seeds in the soil and upon the condition of insufficient level of material support. This system provides obligatory application of herbicides into the soil, which act in the moist soil through the root system, and performance of the following sprayings of sprouts.

The most difficult is to control the complex of dicotyledon species of weeds, therefore the main attention during the choice of soil herbicides should be paid to the drugs, which work against them.

The main task of herbicides - is to provide the necessary protection of plantings from the weeds till the moment, when the shoots of willow reach the height, which is higher than the height of weeds.

Right after planting of stalks of the willow (before their germination) is used the STOMP soil herbicide with the rate of application equal to 5 l/ha. Post - emergence sprayings are expedient to start at appearance of weeds. The first treatment of plantations of willow is conducted in the cotyledonary stage of weeds, applying the Panther 40 herbicide with the rate of application equal to 2 l/ha. At appearance of the new wave of spring dicotyledon species and cereal weeds, it is expedient to repeat the treatment of plantation with the same rate of this herbicide. For this time the plants of willow should have not less than four - five leaves. The spraying with graminicides is conducted irrespective of the phases of development of willow plants (approximately in May). The complex of protection of plantations from the weeds, at accurate observance of operating procedure with herbicides, doesn't give side effects.

The ground spraying is conducted in the dry weather at the wind speed up to 5 m/sec and at the air temperature, which is not exceeding 24°C and is not below 15°C. In the hot dry weather it is expedient to conduct the treatment of areas after 5 pm. The permissible tolerance of the actual rate of hydraulic fluid consumption from calculated during application of herbicides shouldn't exceed ±5 %.

Weather conditions significantly influence on application of post - emergence herbicides. Thus, cool cloudy weather with precipitation during 5 - 7 days before spraying helps the plants of willow and weeds to form on their leaves the thin and nondense layer of epicuticular waxes, through which the active ingredients of herbicides are easily penetrating. Plants after such weather are more sensitive to the drugs. After the dry, sunny and windy weather the plants are more protected, their leaves are covered with the thicker and more dense layer of waxes, which seriously interfere with penetration of herbicides into the tissues and leading systems of leaves and stalks. All this needs to be considered during determination of the rates of application of herbicides [15,32].

The mechanized works after application of herbicides can be conducted only on the fourth day, and manual - on the eighth day after spraying. On the heavy soils, where the soil crust is easily formed, it is necessary to conduct the interrow tillage, even when they will reduce the protective effect of herbicides. On the soils, which density doesn't exceed 1.1 - 1.2 g/cm^3 the interrow tillage isn't conduct, so as not to provoke the appearance of new wave of sprouts of weeds [7,15].

Protection of energy plantations of willows from pests

Most often willows and poplars are damaged by the leaf beetles, cockchafers and white grubs, caterpillars of various butterflies, aphids, mites. The most widespread among them are the following.

Poplar leaf beetle (*Melasoma populi* L.) - is the beetle 10 - 12 mm long, with reddish elytra and bluish-green pronotum and the lower part of body. On the top of elytra it has one black spot at each side (fig. 8).

Aspen leaf beetle (*Melasoma tremulae* F.). External appearance and biology of aspen leaf beetle are similar to the poplar leaf beetle. The beetle is a little less in size than poplar

leaf beetle (the length is 7 - 10 mm) and it has no black spots on elytra (fig. 8).

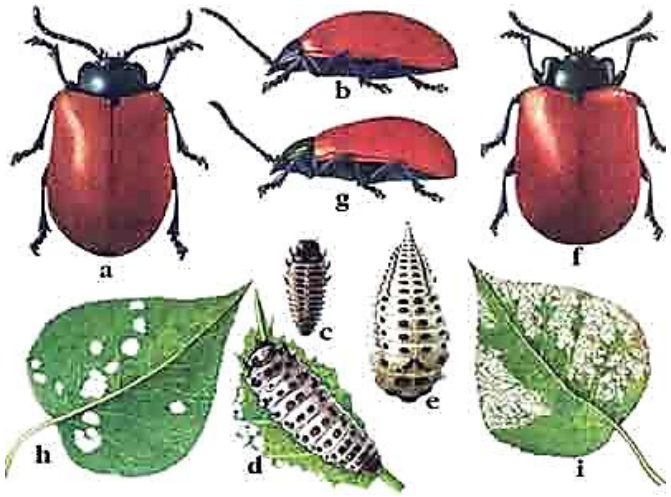

Fig. 8. Poplar leaf beetle: a - adult, b - adult side view, c - larva, d - mature larva, e - pupa, Aspen leaf beetle, f - adult, g - adult side view, h - damage on poplar leaves (by oviposition), i - damages of larvae [13]

Adult insects of leaf beetles and their larvae damage the leaves of different species of willows [15,17,18].

Willow leaf beetle (*Clytra laeviseula R.)* belongs to the family of leaf beetles - Chrysomelidae. The length of body of these beetles is equal to 8.3 - 12.0 mm, width is 4 mm. The body is black, cylindrical or oval, on the edges it is rounded. At the top body is bare. Very seldom the tops of elytra or pronotum are covered with hairs. The head is set deeply into pronotum. Pronotum is black, luster. Elytra are bright, red-orange or yellow and foxy. 3 spots are on each elytron. The spot on the front part of elytra is small and has black color. The back spots are often merged in the lumbal wide belt, which is narrowly discontinued at suture. The top of scutellum doesn't overhang the elytra (fig. 13). In addition to *Clytra laeviseula* in the plantings of willow may be met another leaf beetle - *Clytra quadripunctata*. This species has the back spot of smaller size and round - shaped. Besides, the pronotum of *C. laeviseula* is luster with smooth edges, and *C. quadripunctata* has dotting on it.

Fig. 13. Willow leaf beetle (*Clytra laeviseula* R.) [35]

They eat leaves of trees, mainly from the rose family - Rosacea, and they also intensively settle in willows, coarsely eating their leaves.

Cream-bordered green moth (*Earias chlorana* L.). Most often it damages plantations of basket willow and species and cultivars, which are close to it. Caterpillars of cream-bordered green moth roll the tops of leaves into the dense cocoon and eat the top of the shoot. The shoot starts to put out the side shoots, loses its technical qualities and the height and diameter increment.

Adult is the white butterfly with the wingspan of 44 - 55 mm (fig. 10a). Butterflies fly during June and July, then they lay eggs on bark of willow or leaves, and moreover, they glue the egg - laying using the silvery mass. Eggs pass the winter in this condition. Caterpillars are able to bite off the willow leaves very strongly, and at that the process of eating lasts for the night, and in during the day pests sit on tree branches without moving (fig. 10b).

a) b)

Fig. 10. Cream-bordered green moth [9]: a - butterfly, b - caterpillar

Pupation occurs inside the several leaves from the top of the shoot, fastened by means of cobweb. As a result the shoot loses its technological qualities. The butterflies, gathering in large quantities, sometimes make flights. If the caterpillars attack young tree, then it is doomed and dies. The butterflies select the highest and well developed willow plants on energy plantations for egg laying.

Cream - bordered green moth has enemies. They are: bats, parasitic flies, sparrows, parasitic wasps [15,18].

Satin moth (*Stilpnotia salicis* L.) - is the butterfly of 20 - 25 mm long with white wings. Caterpillar is woolly bear, has blue – and - yellow color with red dots (fig. 15). Eats willow leaves.

Willow ermine moth (*Yponomeuta rorellus Hbn.)* happens everywhere. It damages different species of willow. The butterfly with wingspan of 18 - 20 mm; hemelytrons are white with 25 - 30 black spots, located in three irregular rows, the top of the wing is dark gray; underwings are gray, single - coloured. The egg is equal to 0.8 × 0.4 mm in size; it is light yellow. Caterpillar is up to 20 mm long, dark gray, the head is black, posterior and anal scutellum are black - brown (fig. 12).

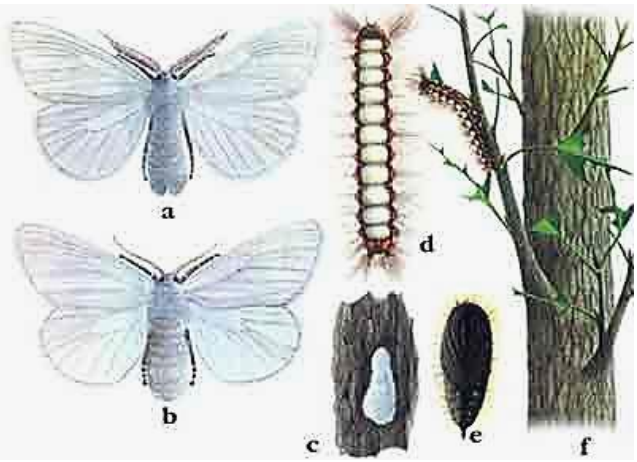

Fig. 11. *Satin moth Stilpnotia salicis* L.): a - male, b - female, c - oviposition, d - caterpillar, e – pupa, f - damage of leaves of black poplar by caterpillar [15,18]

Fig. 12. Willow ermine moth (*Yponomeuta rorellus* Hbn.) [15]

The pupa - is of 9 - 11 mm, ochre-yellow, the head, sacral covers and cremaster are dark-brown, on cremaster are six bristles.

Caterpillars of the first instar pass the winter under the shells. In the second half of April they come out from under the shell and bite into the leaf parenchyma. They live in mines till the first molt, 10 - 14 days.

After leaving the mines the group of caterpillars of several dozens of individuals catches in the web 4 - 6 leaves, under which the feeding is started. From the damaged leaves remain only large veins.

With the growth caterpillars creep to the base of the branch, catching it in the dense web. In case of the mass reproduction of pest not only the branches, but also the trunks, and flora, which grows nearby, are caught in a web. When they complete their development, which lasts 40 - 45 days, caterpillars creep closer to the tree trunk for pupation. The pupas are settled with the head up in vertical rows under the common dense layer of web. After 12 - 15 days, at the end of June starts the flight of butterflies, which lasts till the end of August. Butterflies do not feed additionally. Females lay to 20 - 30 eggs in groups on the smooth bark of young branches near the buds. The female covers each laying of eggs with frothy excretion, which solidify in the form of elongated and oval shell (5 - 8 mm).

At first the shell is yellowish-green, over time it becomes dark gray, matching the color of the bark. After 15 - 20 days caterpillars rebirth and remain under the shell till the spring of next year. One generation develops in a year.

Small willow aphid (*Aphis saliceti* Kalt.). This pest strenuously ingest sap from the buds, leaves, and also from young shoots, and that inevitably leads to fall of leaves, retardation in growth of willow, and in some cases to full dieback of the tree (fig. 13). It often happens to young trees, which still haven't become well established.

Fig. 13. Small willow aphid (Aphis saliceti Kalt.) [15]

The aphid settles on the top part of leaves, and due to this leaves become distorted and rolled. The eggs of aphid pass winter in the cracks of willow bark, in the shoots. In the spring the aphid settles on leaves, shoots and starts to feed on their sap. Later appear the winged individuals of the aphid. About 10 generations of the aphid can be born in a year. In August the winged individuals come back to the willow to lay eggs in its bark for passing the winter.

Due to the mass reproduction of aphids, they considerably weaken the plants of willow, suppress their growth. During the feeding insects drop off excrements, on which bunt fungi are settled, and which interfere with photosynthesis.

Willow scale (*Chionaspis salicis L.*). It is very widespread pest (fig. 14).

Fig. 14. Willow scale (*Chionaspis salicis L.*) [15]

It passes winter on the bark of stems, scaffold branches in egg stage under the shell. In May of the next year larvae appear from the eggs and they creep on new young branches.

Shells are formed from the exuviae of larvae, and larvae live till the adult stage under the shells. At the end of July - beginning of August females complete their development and in September they lay the eggs under the shell. One female lays 40 - 120 eggs. The settling of the pest on the shoots and young branches suppresses their growth, the bark cracks on stems and branches, some branches dieback, and at considerable settlement - the whole trees and bushes dieback.

Two - spotted spider mite (*Tetranychus urticae* C.L.Koch.*)* - is very small insect (female - is 0.43 mm long, male - 0.25 mm).

Adults and their larvae live on the lower part of leaves under the dense web and consume cell sap of plants (fig. 15).

The cell dies off in the places of puncture, as a result of this the leaf becomes colourless, becomes marble, and at intensive settling of pest on the leaves, they dieback and fall down, young shoots don't give increment.

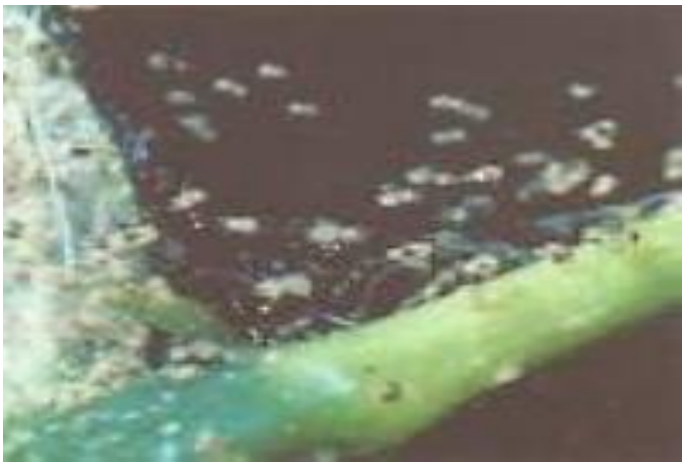

Fig. 15. Spider mite (*Tetranychus urticae* C.L. Koch.) [15]

It passes winter in imago stage on the trees in the cracks of the bark, under the vegetable remains. In the spring at the air temperature of 10 - 12°C they leave the wintering areas and start to feed, occupying the swollen buds, and with the appearance of leaves they move on them. One female is able to lay to 300 eggs. Under favorable weather conditions mite develops in 10 - 12 generations during vegetation.

In the summer the spider mite has greenish-yellow color, by autumn it gets the reddish-orange color.

Besides, mite pests in plantations of willows are also presented by *Aceria triradiatus*, poplar spider mite (Schizotetranychus populi) and aspen leaf mite (*Phyllocoptes populi*) [9, 13].

In addition, plantations of willows and poplars are damaged by rhizophagous pests - grub worms (fig. 16a, 16b, 17). and mole cricket (fig. 18).

Cockchafer is one of the main pests of forest plantings in the Forest-Steppe zone of Ukraine. In the years of mass reproduction, beetles can completely eat the leaves of the trees. The most serious damage is done by the second and third instars, which damage the root system of willow and the bark of the stalks since May till September.

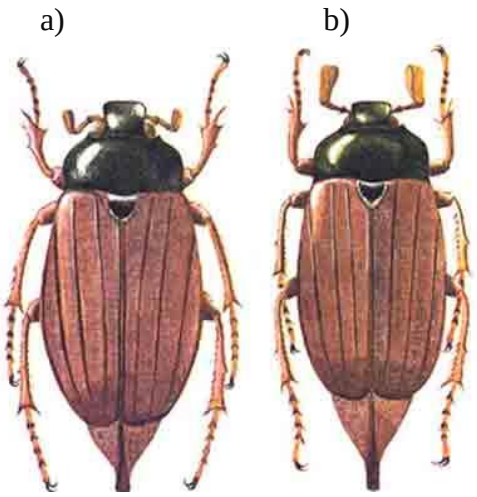

Fig. 16. Cockchafer (*Melolontha melolontha* L.): a - female, b - male [14]

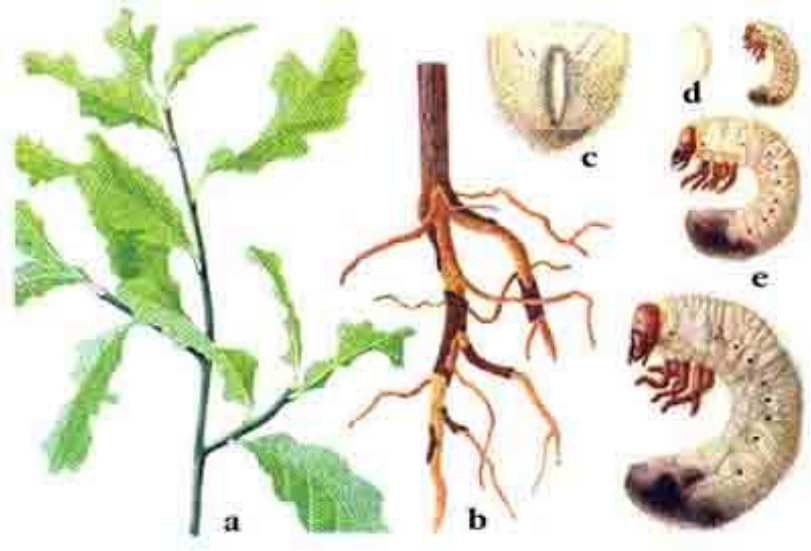

Fig. 17. Damages and white grubs: a - damages on young oak branch by adult beetles, b - damages on the roots of oaklet by larvae, c - the end of abdomen of white grub, d - egg of cockchafer, e - first, second and third instars [13]

Fig. 18. Common mole cricket (Gryllotalpa gryllotalpa L.) [35]

Young trees are most sensitive to damages, they often die after their damage. Cockchafers appear from the middle of May till the end of June. The first instars - have dirty - white color and are hexapod. Second and third instars - are white, large, arc - wise curved. Larvae of the last age reach length of 45 - 65 mm. Each generation of cockchafer lives from

three to five years. The age of life of each generation depends on the geographic latitude of the area, climatic conditions, in particular the temperature, and on the quantity of food.

In 1 - 1.5 months after the eggs were laid, larvae appear from them, and they live three - four years in the soil. Larvae are adapted for the life in the soil. They easily move in the soil due to their worm-shaped body.

Like the majority of animals, which live in the dark, white grubs have white coloring. They don't have eyes. By means of strong mandibles, similar to pliers, white grub shovels the ground and gnaws through the roots of plants, which it consumes. In the first year of their life white grubs feed on various vegetable remains, and in the second and especially in the third year of life – gnaw through the roots of various plants and cut at the base of root crops [15].

Common mole cricket (*Gryllotalpa gryllotalpa* L.) lives in the soil, digging long and quite deep holes. In the summer the galleries of common mole cricket lie at the depth of 10 - 20 cm, and by winter it digs in on the depth of 1 m and more deeply. Its brown body is covered with dense golden hairs [35].

They feed on the small roots, which leads to the weakening and death of plants, and also they feeds on the insects, which they meet underground. During the day common mole crickets sit in their galleries, and at night they go out to feed and fly: they fly quite well in the search of new places, suitable for the settlement [15].

Measures on protection of plantations of willow from the pests. At high settlement of plantations of willows with folivorous insects, such as cream - bordered green moth, satin moth and others, means of protection involve application of chemical, biological or hormone - like drugs, which allowed for use, with taking into account the area of the focuses, ecological situation and features of economic expediency. In the years of mass reproduction of leaf beetles plantations are sprayed with insecticides of the type ambush, 25 % emulsion concentrate with the dose of 0.02 - 0.04 kg/ha; deltamethrin, 2.5 % emulsion concentrate with the dose of 0.4 kg/ha; malathion, 50 % emulsion concentrate with the dose of 1.5 kg/ha, etc.

Overall application of insecticides into the soil, as the means of elimination of white grubs or decrease in their numbers to the safe level, is recommended for the most active focuses with the average number of larvae in the forest and forest-steppe zones of more than 5 individuals per 1 m^2 for older age or 8 - for younger age. Application of insecticides into the soil is performed simultaneously with the overall ploughing by means of devices for seed application in the plowed furrows, dosing devices of soil insecticides, cultivators - plant - feeders, etc. For these purposes are recommended the granular insecticides: Bazudin (diazinon), 10%, at the rate of discharge of 25 - 35 kg/ha; volaton (phoxim), 5% - 30 - 50 kg/ha (the maximum discharge at the number of larvae of more than 10 individuals/m^2).

One of effective ways of controlling the numbers of these pests is soaking of stalks in solution with insecticides. Before planting the stalks of willow are presoaked in solutions of systemic action with insecticides with various active agents (imidacloprid, thiamethoxam or clothianidin) during one day (24 hours) before their planting into the soil. It allows to preserve the necessary density of planting of these crops at considerable number of white grubs of older ages and larvae of summer chafer of older ages [15].

At soakings of stalks of willow in solutions of systemic action with insecticides is provided protection of root system of these plants from white grubs by means of creation of protective zone near the stalks after their planting into the soil, and also penetration of insecticides into the root system and preservation of their certain concentration in the roots during 30 days and more.

Protection of young plantations from white grubs is conducted by means of application of the above - mentioned granular insecticides into the furrows along the rows of plants at the rate of 40 kg/ha. The optimum time of application - is June, when white grubs are in the top layers of the soil.

For protection of willow from the scale is conducted the early - spring insecticide treatment of the dormant buds, and once more - right after appearance of larvae (observation over appearance of larvae should be made since April till May) using the recommended insecticides for perennial plantings.

In the years of mass reproduction of willow ermine moth in the period of coming out of caterpillars from the mines it is necessary to conduct the treatment by means of recommended insecticides or biologic drugs. The plantings, located in bottomlands near the rivers and lakes, should be treated only by means of biologic drugs. The recommended drugs for arboreal species with acaricidal activity are used against the spider mite [15].

Against the mouse - like rodents and common mole cricket is used the spreading of poisoned baits with zinc phosphide (3 - 5% in baits).

Conclusions

Among the bioenergy wood trees, the leading place is taken by fast-growing willow.However cultivation of willow is connected with considerable difficulties, as the wood trees are affected by diseases more often than other species. Bacterial and fungal diseases of willow, pests and weeds lead to the death of plants or to significant decrease in the yield of biomass of energy plantations.

The most dangerous diseases that lead to economical losses and decreasing of quality of wood are bacterial wilt (watermark disease), leaf rust of willow, brown and black cytospora canker. The harmfulness of diseases lies not only thinning of the crown, reduction in leaf numbers, nonresistance of affected trees to wind, in the fast and large - scale dieback of trees, but also in decrease of wood. Definition of diseases and their pathogens will allow developing methods of disease limitation, which will lower the extent of injury and reduce the economic losses.

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WIERZBA BIOENERGETYCZNA: OCHRONA PRZED NEGATYWNYM WPŁYWEM CZYNNIKÓW BIOLOGICZNYCH

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Streszczenie: W rozdziale przedstawiono wyniki badań patologii bakteryjnych oraz grzybicowych wierzby, oraz szkodników i chwastów, które prowadzą do zaginięcia roślin lub znacznego spadku plonu biomasy plantacji energetycznych. Wyświetlono metody ochrony i zapobiegania.

Słowa kluczowe: uprawy bioenergetyczne, wierzba, bakterie fitopatogenne i grzyby, chwasty, owady, metody ochrony i zapobiegania