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Assessment of damage caused by leaf-beating insects to plantings in the Lower Volga region

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Abstract. In forest plantations located in the plantations of the Lower Volga region, outbreaks of mass reproduction of many forest insects often occur, causing weakening and drying out of woody plants over large areas. It has been revealed that pests are capable of causing significant environmental and economic damage through their damage and reducing the environmental protection and environment-forming properties of plantings. Defoliation of crowns leads to loss of tree growth, which ultimately affects the quality and quantity of the resulting wood. It has been established that of the many species of dendrophilous phytophages, the most dangerous are leaf-eaters, among which the predominant gypsy moth (Porthetria dispar L.), green oak budworm (Tortrix viridana L.), lacewing (Euproctis chrysorroea L.), and ringed cocoon moth (Malacosoma neustria) are the most dangerous. L.), winter moth (Operophthora brumata L.).

Keywords: dendrophilous insects; defoliation; growth; plantings; damage

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АГРОНОМИЯ

4.1.3. Агрохимия, агропочвоведение, защита и карантин растений

Научная статья

Оценка ущерба, наносимого листогрызущими насекомыми насаждениям Нижнего Поволжья

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Аннотация. В лесных насаждениях, расположенных в насаждениях Нижнего Поволжья, часто возникают вспышки массового размножения многих лесных насекомых, вызывающих ослабление и усыхание древесных растений на больших площадях. Выявлено, что фитофаги способны своими повреждениями причинять ощутимый экологический и экономический ущерб, снижать средозащитные и средообразующие свойства насаждений. Дефолиация крон ведет за собой потерю прироста деревьев, что, в конечном счете, сказывается на качестве и количестве полученной древесины. Установлено, что из множества видов дендрофильных фитофагов наибольшую опасность представляют листогрызущие, среди которых преобладают непарный шелкопряд (Porthetria dispar L.), зеленая дубовая листовертка (Tortrix viridana L.), златогузка (Euproctis chrysorroea L.), кольчатый коконопряд (Malacosoma neustria L.), зимняя пяденица (Operophthora brumata L).

Ключевые слова: дендрофильные насекомые; дефолиация; прирост; насаждения; ущерб

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Introduction. Dendrophilous insects, during the period of their development and reproduction, cause great damage to forest plantations [1, 2, 5, 12, 16]. One of the most harmful insects are massive needle- and leaf-eating insects. By eating needles and foliage, these pests lead to a sharp decrease in wood growth and cause drying out of plantings. Studying the influence of insects on the condition of plantings will make it possible to foresee various reasons for their weakening and outline protective measures.

Materials and methods. The research methodology was developed in accordance with the goals and objectives of the research. The place and time of work were chosen in order to give a comparative assessment of the research results.

To establish connections between the influence of leaf-eating insects on the condition of woody plants, appropriate studies have been carried out. At the same time, trial plots were laid out that were susceptible to being eaten. Trees damaged and not damaged by the listed insects were analyzed, taking into account their growth.

The trial plots were laid out in accordance with the generally accepted methodology, with an area of 0.1 hectares, with the number of trees of the tree species being studied at least 100. The location and collection of trial units was random and systematic according to the existing statistical methodology [6, 15].

The condition of trees was also studied according to the scale of their physiological weakness. At the same time, areas with the same forest and vegetation conditions and pest infestation were selected.

The degree of weakening of trees from being eaten by leaf-eating insects was assessed on various tree species: English oak, common elm, Norway maple, green ash. A plot of plantings with a similar species composition, but without the presence of insects, served as a control. The degree of damage caused by insects was determined according to a scale of physiological weakness (categories I-VI) [15]:

category I - conditionally healthy (without external signs of weakening);

category II - weakened (with an openwork crown, with drying branches of no more than 1/2 of the crown, which have begun to dry up);

category III - severely weakened (with a very lacy crown, with drying branches of more than 1/2 of the crown, with an abundance of water shoots);

category IV - dying (with obvious signs of drying out and infestation by stem pests, with pale green leaves);

category V - fresh dead wood – shriveled trees this year;

category VI - old dead wood - trees that have withered away in previous years.

Data on the population of trees by leaf-eating insects were converted to a unified accounting unit using formula (1) [11, 12].

$$y = 38,9d + 7,2d^2 \quad (1)$$

where y is a density of growth shoots (growth points on the tree); d is an average diameter of the counting tree.

Caterpillars were counted using the method of selecting terminal branches along the tiers of model trees.

The census was carried out layer by layer from the upper, middle and lower parts of the model trees.

To determine the weighted average number of caterpillars per counting unit, their average estimates in the upper, middle and lower parts of the crown were multiplied by factors of 0.38, 0.42, 0.20, respectively. These coefficients were obtained earlier based on the distribution patterns of insects in the crowns of model trees [9].

The counted number of caterpillars was summed up. After completing the census, the total number of caterpillars found in each part of the crown was divided by the total number of growth points in this part of the crown and multiplied by 100. This determined the population of caterpillars per 100 growth points or ecological density.

Calculated values of crown defoliation were obtained depending on the number of wintering stock of leaf-eating insects per 100 growth shoots.

Mass quantitative surveys of pests with simultaneous assessment of the degree of eating of plant crowns made it possible to identify statistical dependencies between these indicators.

Statistical analysis of the obtained data was carried out according to the method of B.A. Dospehov using the Statistika program [6].

Results. According to the data obtained during the research, it was revealed that with the predominance of English oak, the greatest harmfulness of insects was noted, and trees with signs of severe drying out predominated, average damage (3.42) was caused by green oak budworm, maximum damage (4.06) was applied by a gypsy moth. When it ate the plantings, the greatest degree of drying out was observed.

In turn, the activity of the ringed cocoon moth was expressed in 3.07 degrees of oak damage. From the winter moth the degree of drying out was 3.64, from the lacewing – 3.52.

During the control, the weighted average degree of forest damage ranged from 2.06 to 2.34, which indicates its relatively favorable condition. In the plantation with a predominance of small-leaved elm, the greatest damage was caused by the winter moth (damage degree - 3.30). Goldentail caused the forest to weaken to category 3.04.

In plantations with a predominance of common elm (control), the degree of tree weakening did not exceed 2.40, i.e. their slight weakening was noted.

Plantations dominated by Norway maple were practically not exposed to the harmful effects of insects, and therefore the degree of damage in these areas varied from 1.00 to 1.98.

The winter moth caused the greatest damage to stands dominated by green ash. The attenuation category was 3.48 (Table 1).

The mortality process was especially intense in the outbreaks of the gypsy moth, green oak budworm, and lacewing.

Table 1 – The condition of deciduous plantings depending on their eating by insects

Таблица 1 – Состояние лиственных насаждений в зависимости от объедания их насекомыми

Wood species	Total trees in sample (pcs./%)	Weighted average tree weakness category				
		Insect species				
		Green oak budworm	Gypsy moth	Ringed cocoon moth	Winter moth	Goldilocks
English oak	50/100	3.42	4.06	3.07	3.64	3.52
Control	50/100	2.28	2.14	2.34	2.06	2.24
Small-leaved elm	50/100	2.92	2.66	2.38	3.30	3.04
Control	50/100	2.18	2.40	2.14	2.02	1.54
Norway maple	50/100	1.38	1.98	1.04	1.60	1.90
Control	50/100	1.18	1.34	1.04	1.00	1.08
Ash green	50/100	1.00	1.46	1.08	3.48	1.42
Control	50/100	1.18	1.14	1.06	1.12	1.17

The study of the relationship between the influence of leaf-eating insects on the condition of plantings made it possible to obtain mathematical models characterizing the degree of their expected weakening and drying out.

At the same time, an assessment and counting of trees was made with the number of phytophages causing the degree of weakening and drying out in categories II-V. In the calculations, category I was excluded due to the absence of insects of the studied group in it. The calculations included tree species where these pests developed. The average age of the tree stand is 50 yearsю

The resulting models look like this:

green oak budworm:

$$y = 3{,}482 + 0{,}028x_1 + 0{,}042x_2 + 0{,}030x_3 + 0{,}0069x_4, \quad (2)$$
$$R^2 = 0{,}81;$$

gypsy moth:

$$y = 2{,}671 + 3{,}29x_1 - 0{,}225x_2 + 0{,}201x_3 + 0{,}126x_4, \quad (3)$$
$$R^2 = 0{,}76;$$

goldilocks:

$$y = 1{,}123 + 0{,}224x_1 - 0{,}193x_2 + 0{,}675x_3 + 0{,}082x_4, \quad (4)$$
$$R^2 = 0{,}78;$$

ringed cocoon moth:

$$y = 1{,}920 + 0{,}176x_1 + 0{,}092x_2 + 0{,}314x_3 + 0{,}189x_4, \quad (5)$$
$$R^2 = 0{,}81;$$

winter moth:

$$y = 0{,}802 + 0{,}087x_1 - 0{,}0104x_2 + 0{,}009x_3 + 0{,}007x_4, \quad (6)$$
$$R^2 = 0{,}71,$$

where y – the expected degree of weakening and drying out of the forest stand; x – values of the average number of caterpillars per 100 growth points of a particular species of leaf-eating insects in the studied plantings.

The practical value of the proposed models lies in the fact that, having the average number of caterpillars per 100 growth points of the species of leaf-eating insects of interest to us, it is possible to determine how much this population will cause the weakening and drying out of plantings in categories II–V.

Many scientists recommend determining the loss of growth due to defoliation by selecting a specific area of plantings that is illogical in all respects to the experimental one, the foliage of which has not been damaged by insects [15]. In this case, according to the authors of the studies, the difference in the experimental and control plots can be attributed to defoliation and further loss of growth.

In our case, to determine the damage caused by leaf-eating insects, we partially used the methodology for calculating the consequences of the destruction of the assimilation apparatus [9, 10], as well as the data obtained from our own research on the amount of this damage.

Calculated growth values were obtained depending on the number of leaf-eating insects per 100 growth shoots.

$$\Pi_{pq} = LX/100, \qquad (7)$$

where Π_{pq} is a loss of volume growth in fractions of a unit or percentage; L is a coefficient depending on the phenological group of leaf-eating insects (spring – 0.4, spring-summer – 0.42, summer-autumn – 0.38), X is a degree of damage to tree crowns, %.

Generalized calculated data are given in Table 2.

Table 2 – The amount of growth loss in oak stands depending on the population of leaf-eating insects

Таблица 2 – Величина потерь прироста насаждений дуба в зависимости от заселенности листогрызущими насекомыми

Insect species	Phenogroup coefficient	Number of eggs per 100 growth points									
		growth loss, %									
gypsy moth	0,42	1,1 / 4	4,3 / 8	10 / 11	18 / 15	28 / 19	40 / 23	55 / 27	72 / 30	90 / 34	103 / 38
Green oak budworm	0,4	10 / 4	39 / 8	90 / 13	158 / 17	248 / 21	356 / 25	450 / 29	635 / 34	804 / 38	900 / 42
Goldilocks	0,42	3 / 4	13 / 8	23 / 11	33 / 15	43 / 19	53 / 23	63 / 27	73 / 30	83 / 34	93 / 38
winter moth	0,4	20 / 4	56 / 8	104 / 13	162 / 17	230 / 21	305 / 25	385 / 29	476 / 34	592 / 38	675 / 42
ringed cocoon moth	0,42	8 / 4	17 / 8	28 / 11	35 / 15	48 / 19	57 / 23	71 / 27	87 / 30	92 / 34	103 / 38

According to this table, the amount of oak damage from the listed group of phytophages on average reached 20%. Its maximum value ranged from 38 to 42 %. Defoliation in different phenological periods has different effects on the amount of growth.

According to the research results, the largest number of insects developed on pedunculate oak. In the best growing conditions, where the oak growth period is longer, the greatest losses are caused by insects that eat foliage in the first half or mid-summer, such as the gypsy moth, the ringed cocoon moth, and the lacewing.

In the worst growth conditions, where oak growth begins and ends much earlier, large losses are caused by early spring insect species (winter moth, green oak budworm).

Large losses are apparently due to the fact that trees lose their leaves during the most important period for the formation of the overall annual growth of oak trees.

Conclusion. Studies have shown that in our case the reason for the weakening and drying out of plantings is the activity of insect pests.

The amount of growth loss depends primarily on leaf-eating insects and ranges from 38 to 42 %, depending on the degree of damage. Based on the research results obtained, it should be taken into account that the developing entomocomplex of dendrophilous insects has a negative impact on the condition, stability and biological productivity of plantings. Therefore, in the practice of creating and caring for them, systematic work should be carried out to identify harmful insects and timely implementation of protective measures.

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