Silver birch health condition in the parks of Kharkiv National Agrarian University named after V. V. Dokuchaev

V. L. Meshkova1, Y. V. Koshelyaeva2, M. S. Kolienkina3

Recently health condition of silver birch (Betula pendula Roth.) stands worsens in the forest and ornamental stands. It is important to know the probability of its improvement or deterioration in particular stands to take the necessary measures in time.

The aim of the research was to assess the trends in the health condition dynamics of silver birch stands depending on their age class and the initial health condition of the trees. The research was carried out in 2015-2019 in the Silver birch linear stands in two parks of Kharkiv National Agrarian University named after V. V. Dokuchaev (49°53’ N, 36°27’ E). Five sample plots of the 3rd age class are located in Veterans Park and the other 4 sample plots of the 5th age class – in Arboretum of this University. For each inspected tree diameter at breast height (DBH) was measured in 2015 and 2019. Crown defoliation and health condition class were visually assessed in July of each year. Health condition index (HCI) was calculated as mean weighted from trees number of each category of health condition, separately for all living and dead trees (HCI1–6) and for living trees only (HCI1–4). Tree mortality was expressed as a percentage of lost (dead) trees for research period out of the total trees in 2015.

It was shown that the silver birch stands of the 3rd age class didn’t change their health condition for 2015-2019 or improved it. The stands of the 5th age class worsened their health condition in three sample plots and improved it in one sample plot. Within each age class, the stands of lower diameter class had a worse health condition. Tree mortality was registered in two out of five sample plots in the stands of the 3rd age class and in three out of four sample plots in the stands of the 5th age class. In the stands of the 5th age class the trees from the stands of the smallest diameter class characterized by the highest mortality level (22.4%) and the worse health condition (HCI1–4 =2.8).

In pooled sample of plots, the death probability for silver birch trees, which 4 years ago had the 1st class of health condition is 3.5%, those of the 2nd class have the death probability of 10.7%, the trees of the 3rd class – 36.9%, those of the 4th class – 84.6%. As for an initially weakened stand, its trees which 4 years ago had the 1st, the 2nd, the 3rd or the 4th health condition class, have the death probability of 5%, 18.5%, 33.3%, and 100% respectively.

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Thus, the weakened silver birch stand which contains trees of 1\textsuperscript{st} – 3\textsuperscript{rd} classes of health condition is able to restore condition to a healthy one, and the deterioration may be expected only for severely weakened trees (having 3\textsuperscript{rd} class of health condition in 2015). The weakened silver birch stand which has the trees of 1\textsuperscript{st} – 4\textsuperscript{th} health condition classes is most likely to weaken even more severely over 4 years.

**Key words:** age class; diameter (DBH); defoliation; health condition index for living trees (HCI\textsubscript{1–4}); tree mortality; death probability.

**Introduction.** Silver birch (*Betula pendula* Roth.) is one of the most spread deciduous species in the forests, field protective forest belts and ornamental stands. Particularly in the forest fund of the State Agency of Forest Resources of Ukraine birch stands are only 5.7% from the forest-covered area (General characteristics, 2016). Birch timber is used for pulp and paper, plywood, sawmill, furniture, and also as firewood. Other parts of birch trees are used in the pharmaceutical and food industries (Ozolinčius et al., 2016).

Global warming promotes an increase in the birch proportion in boreal forests (Heimonen et al., 2015). At the same time, due to climate change and anthropogenic pressure, birch susceptibility to pests and pathogens increases (Nguyen et al., 2017, Shvidenko et al., 2017, Vinstad et al., 2019), particularly in the Forest-steppe zone (Parkhomenko et al., 2013, Skrylnik et al., 2019) and in Polissya (Goychuk et al., 2018).

The studies show the pathological birch mortality, particularly among trees with a diameter of over 20 cm (Meshkova et al., 2018). In the forest stands of the forest-steppe zone of Ukraine, the mean weighted age class of silver birch was estimated as IV.8 in vegetative stands and IV.6 in artificial seed stands. It was greater for the northern part of the forest-steppe zone (V.1) and less (IV.6) for the southern part of it (Meshkova & Koshelyaeva, 2019). Survival of pure and almost pure stands is the lowest (Hytonen et al., 2013).

Tree health assessment and prediction is important for forest management strategy in forest and urban stands (Boeck et al., 2014, Bircher et al., 2015). Particularly in urban stands, silver birch is under the greater anthropogenic influence than in the forest due to a higher temperature and traffic pollution (Tubby & Webber, 2010, Hilbert et al., 2019, Klein et al., 2019).

Different approaches have been developed for early detection of the first symptoms and signs of tree weakening as well as for prediction tree mortality for different tree species (Cailleret et al., 2016, Maleki & Kiviste, 2016, Hülsmann et al., 2017). For example, on the base of seven years monitoring, the probability of health condition change and mortality of Scots pine (*Pinus sylvestris* L.) trees was evaluated with considering forest site conditions, age and initial health condition of the stands (Meshkova & Kolienkina, 2016). Our current research is based on five-year monitoring data on the health condition of 450 birch trees in urban stands.

**Objects and methods.** Object of research – the trends in health condition dynamics for silver birch stands. Subject of research – the trends in the health condition dynamics of silver birch stands depending on their age class and the initial health condition of the trees.

The aim of research was to assess the trends in the health condition dynamics of silver birch stands depending on their age class and the initial health condition of the trees.

Research was carried out in 2015–2019 in the Silver birch linear stands in two parks of Kharkiv National Agrarian University named after V. V. Dokuchaev (49º53’ N, 36º27’ E). Five sample plots (SP 1 – SP 5) of the 3\textsuperscript{rd} age class are located in Veterans Park and the other 4 sample plots (SP 6 – SP 9) of the 5\textsuperscript{th} age class in Arboretum of this University (Tab. 1).

In each sample plot, from 15 to 156 trees were represented.

For each inspected tree diameter at breast height (DBH) was measured in 2015 and 2019. Crown defoliation and health condition class were visually assessed in July of each year.

Defoliation was assessed in percents and converted into ranges according to ICP monitoring score (Manual, 2010): 0 – 0–10% (defoliation is absent); 1 – 11–25% (slight defoliation); 2 – 26–60% – moderate defoliation; 3 – 61–99% – severe defoliation; 4 – 100% – dead trees.

Category (class) of health condition for each tree was evaluated on a range of visual characteristics according to “Sanitary rules in the forests of Ukraine” (Anonymous, 1995) by the following classes: 1\textsuperscript{st} – healthy; 2\textsuperscript{nd} – weakened; 3\textsuperscript{rd} – severely weakened; 4\textsuperscript{th} – drying up; 5\textsuperscript{th} – recently died; 6\textsuperscript{th} – died over year ago. Health condition index (HCI) was calculated as mean weighted from trees number of each category of health condition, separately for all living and dead trees (HCI\textsubscript{1–6}) and for living trees only (HCI\textsubscript{1–5}).

Tree mortality was expressed as a percentage of lost (dead) trees for the research period out of the total trees in 2015.

Normality tests, summary statistics, one-way analysis of variance (ANOVA) with Mann–Whitney U test with a significance level of p<0.05 (Atramentova & Utevskaya, 2008) were performed using Microsoft Excel applications and statistical software package PAST: Paleontological Statistics Software Package for Education and Data Analysis (Hammer et al., 2001).

**Results and discussion.** For four years, DBH increased significantly at the sample plots SP 1 – SP 3 and SP 5, and insignificantly at SP 4 and SP6-SP 9 (see Tab. 1). An average DBH of the 3\textsuperscript{rd} age class trees varied from 12.4 cm to 21.3 cm in 2015 and from 14.9 to 24.9 cm in 2019, and in both cases was the smallest at SP 2 and the largest at SP 3. An average DBH of the 3\textsuperscript{rd} age class trees varied from 20.7 to 30.2 in 2015 and from 21.9 to 30.9 in 2019, and in both cases was the smallest at SP 9 and the largest at SP 7. An average DBH of the 3\textsuperscript{rd} age class trees at SP 3, SP 4 and SP 5...
(the 3rd age class) did not significantly differ from that at SP 9 (the 5th age class). Despite the significant difference in age, the average DBH only at SP 1 and SP 2 (age class 3) was significantly lower than that in the remaining sample plots, and at SP 6 and SP 7 (age class 5), it significantly exceeded the remaining sample plots. This is due to the fact that the growth of trees in diameter decreases with age, and most of all in stands under adverse conditions or in weakened trees.

The trees in each sample plot are represented in a rather wide range. This is due to the heterogeneity of the growth conditions of the trees, as well as the fact that sometimes after the dying of the main stem there was a renewal of growth.

Table 1

| Sample plot (age class) | Year of assessment | Number of trees | Mean DBH*±SE, cm** | Range of DBH, cm |
|------------------------|--------------------|-----------------|--------------------|----------------|
| SP 1 (3)               | 2015               | 25              | 16.9±1.08a         | 7.0–27.4       |
|                        | 2019               | 23              | 20.3±1.26b         | 7.2–32.1       |
| SP 2 (3)               | 2015               | 15              | 12.4±0.75a         | 8.0–17.8       |
|                        | 2019               | 15              | 14.9±0.83a         | 9.5–21.0       |
| SP 3 (3)               | 2015               | 19              | 21.3±0.91bc        | 10.5–28.3      |
|                        | 2019               | 18              | 24.9±1.04c         | 13.1–33.1      |
| SP 4 (3)               | 2015               | 16              | 19.2±1.11bc        | 12.7–28.3      |
|                        | 2019               | 16              | 21.7±1.19bc        | 14.3–30.9      |
| SP 5 (3)               | 2015               | 35              | 19.6±0.80bc        | 9.9–29.9       |
|                        | 2019               | 35              | 22.4±0.86bc        | 13.1–34.7      |
| SP 6 (5)               | 2015               | 57              | 26.8±0.56d         | 20.1–34.9      |
|                        | 2019               | 57              | 28.4±0.61d         | 21.3–36.8      |
| SP 7 (5)               | 2015               | 60              | 30.2±0.70e         | 16.9–45.5      |
|                        | 2019               | 58              | 30.9±0.70e         | 17.2–45.8      |
| SP 8 (5)               | 2015               | 156             | 22.9±0.46bc        | 8.8–38.2       |
|                        | 2019               | 127             | 24.2±0.51c         | 8.9–39.5       |
| SP 9 (5)               | 2015               | 67              | 20.7±0.74b         | 3.0–31.2       |
|                        | 2019               | 52              | 21.9±0.86bc        | 4.5–32.1       |

Notes: * DBH – diameter at breast height; **Means followed by different letters in each column are significantly different at the 95 % confidence level.

In the region of our research, no noticeable direct defoliation of silver birch as a result of insect damage was registered. Defoliation was mainly manifested as increased transparency of the crown of weakened trees.

In sample plots in the stands of the 3rd age class, defoliation rarely exceeded 1 point (at SP 1 in 2017 and 2018 it was 1.1 points), and the differences in this parameter in 2015 and 2019 were insignificant (Tab. 2). At SP 6, rather high defoliation was registered in 2015 (1.9 points) and a significant decrease in this parameter to 0.5 points in 2019. For the remaining sample plots in the stands of the 5th age class over the years of research, the defoliation score significantly increased (to 1.5, 2.2 and 2.4 points for SP 7, SP 8 and SP 9, respectively). An average health condition index HCI1-6 is calculated for both living and dead trees. Therefore, at the high proportion of trees, which died over a year ago, the impression is that the stands are in poor health condition. In 2015 the health condition index show, that the stands at SP 3-SP 5 were healthy (HCI1-6<1.5), and at other sample plots they were weakened. The highest HCI1-6 was evaluated at SP 9 (2.1).

Table 2

| Sample plot | Defoliation score ±SE | Defoliation score change for 2015–2019 |
|-------------|------------------------|---------------------------------------|
|             | 2015   | 2016   | 2017   | 2018   | 2019   | 2015–2019 |
| SP 1        | 0.7±0.14bc | 1.0±0.19b | 1.1±0.14b | 1.0±0.19bc | 0.8±0.23a | insignificant |
| SP 2        | 0.9±0.21c  | 0.6±0.19b | 0.6±0.19a | 0.5±0.13a  | 0.8±0.22a | insignificant |
| SP 3        | 0.4±0.11ab | 0.9±0.22b | 1.0±0.21b | 0.9±0.21b  | 0.7±0.23a | insignificant |
| SP 4        | 0.3±0.11ab | 0.3±0.17a | 0.3±0.06a | 0.2±0.10a  | 0.3±0.12a | insignificant |
| SP 5        | 0.4±0.08b  | 0.6±0.14b | 0.7±0.15a | 0.7±0.11ab | 0.4±0.10a | insignificant |
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During our studies (2015-2019) at SP 1 and SP 6, the index of the health condition of silver birch stands significantly decreased (from 1.8 to 1.4 and from 1.8 to 1.3 respectively) (Tab. 3).

In four plots (SP 2 – SP 5) the health condition index changed slightly, and in three plots (SP 7 – SP 9) increased significantly. In accordance with “Sanitary rules in the forests of Ukraine” (Anonimous, 1995), in 2019 the stands at SP 1, and SP 3 – SP 6 should be considered as healthy, at SP 2 and SP 7 as weakened, at SP 8 as severely weakened, and at SP 9 as drying out.

If the health condition index is calculated only taking into account living trees (HCI_{1-4}), a real estimate of the viability of the stands can be obtained. In 2015 by health condition index for living trees the stands at SP 3 – SP 5 and SP 7 were healthy (HCI_{1-4} < 1.5), and at other sample plots they were weakened. The highest HCI_{1-4} was evaluated at SP 9 (2.1) (Tab. 4).

### Table 3

| Sample plot | Health condition index (HCI_{1-6}) ±SE * | HCI_{1-6} change for 2015–2019 |
|-------------|----------------------------------------|----------------------------------|
| SP 1        | 1.8±0.18bc 1.5±0.18b 1.3±0.21a 1.5±0.25ab 1.4±0.28a | decreased (p<0.05) |
| SP 2        | 1.7±0.23b 1.9±0.27bc 1.3±0.19ab 1.5±0.19ab 1.7±0.21b | insignificant |
| SP 3        | 1.4±0.14ab 1.7±0.19b 1.3±0.21a 1.4±0.27ab 1.3±0.26a | insignificant |
| SP 4        | 1.1±0.06a 1.1±0.09a 1.1±0.09a 1.1±0.09a 1.1±0.06a | insignificant |
| SP 5        | 1.2±0.07a 1.4±0.11b 1.1±0.06a 1.1±0.07a 1.2±0.08a | insignificant |
| SP 6        | 1.8±0.09c 1.5±0.08b 1.4±0.07b 1.6±0.11b 1.3±0.10a | decreased (p<0.05) |
| SP 7        | 1.5±0.13ab 2.1±0.15c 1.7±0.16b 2.2±0.18c 2.3±0.18b | increased (p<0.01) |
| SP 8        | 1.8±0.07c 2.3±0.09c 2.2±0.11c 2.5±0.11d 2.8±0.12c | increased (p<0.01) |
| SP 9        | 2.1±0.11d 2.6±0.13d 2.5±0.16c 2.7±0.16d 3.5±0.17d | increased (p<0.01) |

* Health condition index (HCI_{1-6}) considers all living and dead trees

**Means followed by different letters in each column are significantly different at the 95% confidence level (Mann-Whitney test)

### Table 4

| Sample plot | Health condition index (HCI_{1-4}) ±SE * | HCI_{1-4} change for 2015–2019 |
|-------------|----------------------------------------|----------------------------------|
| SP 1        | 1.8±0.18bc 1.4±0.12ab 1.1±0.08a 1.2±0.08a 1.0±0.04a | decreased (p<0.05) |
| SP 2        | 1.7±0.23b 1.9±0.27bc 1.3±0.19ab 1.5±0.19a 1.7±0.21b | insignificant |
| SP 3        | 1.4±0.14ab 1.7±0.19bc 1.1±0.06a 1.2±0.09a 1.0±0.00a | decreased (p<0.05) |
| SP 4        | 1.1±0.06a 1.1±0.09a 1.1±0.09a 1.1±0.09a 1.1±0.06a | insignificant |
| SP 5        | 1.2±0.07a 1.4±0.11ab 1.1±0.06a 1.1±0.07a 1.2±0.08a | insignificant |
| SP 6        | 1.8±0.09c 1.5±0.08b 1.4±0.07ab 1.6±0.11ab 1.3±0.10a | decreased (p<0.05) |
Over the years of research, HCI1–4 significantly decreased by sP 1, sP 3, sP 6, slightly changed by sP 2, sP 4 and sP 5, and significantly increased by sP 7 – sP 9 (see Tab. 4). In accordance with HCI1–4, in 2019 the stands at sP 1, and sP 3 – sP 5 should be considered as healthy, at sP 2, sP 7 and sP 8 as weakened, and at sP 9 as severely weakened.

The final analysis of the health condition of silver birch in the sample plots shows that the stands at sP 1 and sP 6 have different age and diameter class (Tab. 5). In both sample plots, the health condition of trees has improved for the research period; however, low mortality was registered in the youngest stand. Therefore, the dynamics of HCI1–4 was almost similar, and HCI1–4 increased at sP 1 after removing the dead trees.

The health condition of silver birch trees at sP 2 was the worse among the sample plots with an insignificant change of health condition (sP 3 – sP 5) for the whole research period. It can be connected with the smallest diameter class of silver birch trees at sP 2 comparing to the other sample plots of the same age class.

Among these four sample plots with an insignificant change of health condition, both health condition indices (HCI1–6 and HCI1–4) stayed unchanged for the whole research period at sP 2. These indices for silver birch in other sample plots of this group had an increase in 2016 and a decrease in 2017 with a subsequent slight increase.

Silver birch trees at the sample plots sP 7 – sP 9 had the worse health condition among all sampling plots. Both health condition indices (HCI1–6 and HCI1–4) increased for 2015-2019. In this group of sample plots, the trees of the smallest diameter class (sP 9 – 20 cm) characterized by the highest mortality level (22.4 %) and HCI1–4 (2.8), that is, were considered severely weakened. As the diameter increases in this group of sample plots, the values of both health condition indices and mortality of trees decrease. However, when comparing two sample plots with almost similar diameter class (sP 6 and sP 7) we see large differences in health condition indices (1.3 and 1.8 respectively), health status (healthy and weakened respectively), mortality level (absent and low respectively), as well as in the trend of changes in health condition. The health condition of silver birch at sP 6 trends to improve (HCI decreases), and at sP 7 it trends to worsen (HCI increases).

The data obtained show that when predicting changes in the health condition of silver birch stands, it is necessary to take into account the trend to improvement or worsening the health condition of individual trees in a certain group of stands.

so among all trees (sP 1 – sP 9), the healthy ones were a little more than half (50.6 %) in 2015 and 39.9 % in 2019 (Tab. 6).
Table 6

Distribution of silver birch trees by health condition classes in 2019 depending on their health condition in 2015

| In 2015* | In 2019 ** |
|----------|------------|
|          | Distribution by health condition classes: | I_1–6 | I_1–4 |
|          | 1  2   3  4   5  6 |      |      |
| All sample plots (SP1 — SP9) | 100.0 | 39.9 | 23.3 | 18.6 | 5.1 | 3.1 | 10.0 | 1.9 | 2.4 |
| 1  | 50.6 52.6 30.7 12.3 0.9 0.9 2.6 1.6 1.7 |
| 2  | 33.3 33.3 20.0 28.7 7.3 4.0 6.7 2.1 2.5 |
| 3  | 12.6 17.5 8.8 22.8 14.0 8.8 28.1 2.5 3.7 |
| 4  | 2.9 0.0 0.0 0.0 15.4 7.7 76.9 4.0 5.6 |
| 5  | 0.7 0.0 0.0 0.0 0.0 0.0 100.0 – 6.0 |

SP6 – decrease of health condition index for 2015–2019

| 1 | 36.8 81.0 14.3 4.8 0.0 0.0 0.0 1.2 1.2 |
| 2 | 49.1 85.7 7.1 7.1 0.0 0.0 0.0 1.2 1.2 |
| 3 | 14.0 62.5 12.5 0.0 25.0 0.0 0.0 1.9 1.9 |
| 4 | – – – – – – – – – |

Total 100.0 80.7 10.5 5.3 3.5 0.0 0.0 1.3 1.3 |

SP9 – increase of health condition index for 2015–2019

| 1 | 29.9 5.0 35.0 55.0 0.0 5.0 0.0 2.5 2.7 |
| 2 | 40.3 3.8 30.8 30.8 19.2 14.8 3.7 2.8 3.2 |
| 3 | 22.4 0.0 0.0 40.0 26.7 13.3 20.0 3.4 4.1 |
| 4 | 7.5 0.0 0.0 0.0 0.0 0.0 100.0 – – |

Total 100.0 3.0 22.7 37.9 13.6 10.4 13.4 2.8 3.5 |

Note: * – proportion of trees from total amount in 2015; ** – proportion of trees from total amount in 2019.

From trees of the 1st class of health condition in 2015, for 4 years 52.6% didn’t change health condition class, 43% changed it to 2nd–3rd class and 4.4% changed it to 4th–6th health condition class. From trees of the 2nd health condition class in 2015, 33.3% improved their health condition to the 1st class, 20% didn’t change it, and the rest worsened. Among the trees of the 3rd class of health condition in 2015, 26.3% improved their health condition, 22.8% stayed without changes, and 50.9% worsened.

In general, within the range of 1-3 classes of health condition in 2015 this parameter in 2019 varied only within these classes. Trees of the 4th class did not change health condition (7.7%) or died. The probability of death for the tree in each successive class tends to increase.

The dependence of tree mortality in 2019 on the health condition index in 2015 is described by quadratic equation (Fig.).

However, it is difficult to clearly predict changes in health condition for all silver birch stands. For example, silver birch stands at SP 6 and SP 7 have a close diameter class (28 and 30 cm at SP 6 and SP 7, respectively) and are of the fifth age class, which is known to be the age of significant deterioration of silver birch in the forest stands of the region (Meshkova & Koshelyaeva, 2019). In 2015-2019 the health condition of silver birch improves at SP 6 and worsens at SP 7 (see Tab. 5).

Another pair of stands has the same age and different diameter classes (28 and 20 cm at SP 6 and SP 9, respectively). For 2015-2019 the health condition of silver birch stand has improved at SP6 and worsened at SP9.

Figure. Probability of silver birch dying depending on the initial tree condition (General sample of 451 trees: \( Y = 10.15x^2 - 23.82X + 17.3 \), where \( Y \) – probability of dying; \( X \) – health condition class; \( R^2 = 0.99 \)
Conclusions. Silver birch stands of the 3rd age class didn’t change their health condition for 2015-2019 or improved it. The stands of the 5th age class worsened their health condition in three sample plots and improved it in one sample plot.

Within each age class, the stands of lower diameter class had a worse health condition. Tree mortality was registered in two out of five sample plots in the stands of the 3rd age class and in three out of four sample plots in the stands of the 5th age class. In the stands of the 5th age class the trees from the stands of the smallest diameter class characterized by the highest mortality level (22.4%) and the worse health condition (HCl_{1-4}=2.8).

In pooled sample of plots, the death probability for silver birch trees, which 4 years ago had the 1st class of health condition was 3.5%, those of the 2nd class have the death probability of 10.7%, the trees of the 3rd class – 36.9%, those of the 4th class – 84.6%. As for an initially weakened stand, its trees which 4 years ago had the 1st, the 2nd, the 3rd or the 4th health condition class, have the death probability of 5%, 18.5%, 33.3%, and 100% respectively.

Thus, the weakened silver birch stand which contains trees of 1st – 3rd classes of health condition is able to restore condition to a healthy one, and the deterioration may be expected only for severely weakened trees (having initially the 3rd class of health condition). The weakened silver birch stand which has the trees of 1st – 4th health condition classes is most likely to weaken even more severely over 4 years.

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Санітарний стан берези повислої у дендропарку Харківського національного аграрного університету ім. В. В. Докучаєва

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Останнім часом санітарний стан берези повислої (Betula pendula Roth.) погіршується у лісових і декоративних насадженнях. Важливо знати ймовірність погіршення або покращення стану окремих насаджень, щоб вчасно вжити необхідні заходи.

Мета досліджень полягала в оціненні тенденцій зміни санітарного стану насаджень берези повислої залишок від класу віку та початкового санітарного стану дерев. Дослідження здійснені впродовж 2015-2019 рр. у лінійних насадженнях берези повислої у двох парках Харківського національного аграрного університету ім. В. В. Докучаєва (49º53’ пн.ш., 36º27’ сх.д.). П’ять пробних площ розташовані у парку Ветеранів, а чотири пробні площі з насадженнями III класу віку розташовані у парку Ветеранів.

Встановлено, що насадження берези повислої III класу віку не змінили санітарний стан впродовж 2015-2019 рр., або поліпшили його. Насадження V класу віку погіршили санітарний стан на трьох пробних площах і поліпшили – на одній. У межах кожного класу віку насадження меншої середньої пробних площ мамої гірший санітарний стан. Відпад дерев зареєстровано на двох із трьох пробних площ у насадженнях III класу віку і на трьох із чотирьох пробних площ у насадженнях V класу віку.

У насадженнях V класу віку дерев найменшою діаметра характеризувались найбільшим рівнем відпала (22,4%) та найгіршим санітарним станом (H<sub>1</sub> = 2,8).

Загалом на всіх пробних площах ймовірність відпаду дерев берези повислої, що мали у 2015 р. I категорію санітарного стану, становить 3,5%, II категорію – 10,7%, III категорію – 36,9%, а IV категорію – 84,6%. У насадженнях, ослаблених у 2015 р., ймовірність відпаду дерев, що мали чотири роки тому I, II, III і IV категорії санітарного стану, становить 5; 18,5; 33,3 та 100% відповідно.

Таким чином, ослаблені березові насадження, які містять дерев I-III категорій санітарного стану, спроможні відновитись до стану «здорових». Покращення стану очікується для сильно ослаблених дерев (III категорії стану у 2015 р.). Ослаблене бере зове насадження, яке мало у 2015 р. дерев I-IV категорії санітарного стану, останній ще більше через чотири роки.

Ключові слова: клас віку, діаметр (ДВН); дефоліація; індекс санітарного стану, визначений для життєздатних дерев (HI<sub>1</sub>-4); відпад дерев; ймовірність відпаду.

Санітарне состояние березы повислой в дендропарке Харьковского национального аграрного университета им. В. В. Докучаева

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В последнее время санитарное состояние березы повислой (Betula pendula Roth.) ухудшается в лесных и декоративных насаждениях. Важно знать вероятность ухудшения или улучшения состояния отдельных насаждений, чтобы вовремя принять необходимые меры.

Целью исследований была оценка тенденций изменения санитарного состояния насаждений березы повислой в зависимости от класса возраста и начального санитарного состояния деревьев. Ис-
следования проведены в 2015-2019 гг. в линейных
насаждениях березы повислой в двух парках Харь-
ковского национального аграрного университета
им. В. В. Докучаева (49°53’ с.ш., 36°27’ в.д.). Пять
пробных площадей в насаждениях III класса воз-
раста расположены в парке Ветеранов, а четыре
пробные площади в насаждениях V класса возрас-
та – в Дендропарке этого же университета.
Измеряли диаметр каждого дерева на высоте
1,3 м в 2015 и 2019 гг. Дефолиацию крон и катего-
рию санитарного состояния оценивали визуально в
июле каждого года. Индекс санитарного состояния
каждого насаждения рассчитывали как средневзве-
щенное от количества деревьев каждой категории
санитарного состояния, отдельно с учетом всех
живых и мертвых деревьев (НС1–6) и лишь живых
derевьев (НС1–4). Отпад деревьев выражали в про-
центах утраченных (погибших) особей за период
исследований от общего количества деревьев в
2015 году.
Показано, что насаждения березы повислой III
class emphasis не изменили санитарного состоя-
ния в период 2015-2019 гг. или улучшили его. На-
sаждения V класса возраста ухудшили санитарное
содержание на трех пробных площадях и улучшили
на одной. В пределах каждого класса возраста на-
sаждения меньше средней степени толщины име-
ли лучшее санитарное состояние. Отпад деревьев
зарегистрирован на двух из пяти пробных площадей
в насаждениях III класса возраста и на трех из
четырех пробных площадей в насаждениях V класса
возраста. В насаждениях V класса возраста деревья
наименьшего диаметра в насаждениях характери-
зировались наибольшим уровнем отпада (22,4%) и
наихудшим санитарным состоянием (НС1–4 = 2,8).
В совокупности всех деревьев на всех пробных
площадях вероятность отпада деревьев березы
повислой, имевших в 2015 г. I категорию сани-
тарного состояния, составляет 3,5%, имевших II
категорию, – 10,7%, III категорию – 36,9%, а IV
категорию – 84,6%. В насаждениях, ослабленных
в 2015 году, вероятность отпада деревьев, имевших
четыре года назад I, II, III и IV категорию санитар-
ного состояния, составляет 5, 18,5, 33,3 и 100% со-
ответственно.
Таким образом, ослабленные березовые насаж-
dения, содержащие деревья I-III категорий сани-
tарного состояния, способны восстановиться до
состояния «здоровых». Ухудшение состояния ожи-
dается для сильно ослабленных деревьев (имевших
III категорию состояния в 2015 г.). Освобожденное бе-
резовое насаждение, содержащее в 2015 г. деревья
I-IV категорий санитарного состояния, ослабится
еще больше через 4 года.
Ключевые слова: класс возраст, диаметр
(dbh); дефолиация; индекс санитарного состоя-
ния, определенный для жизнеспособных деревьев
(НС1–4); отпад деревьев; вероятность отпада.