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INCIDENCE OF ASH DIEBACK IN THE LEFT-BANK FOREST-STEPPE DEPENDING ON STAND CHARACTERISTICS

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The incidence of ash dieback in the forest-steppe part of Sumy and Kharkiv Regions was analysed taking into account the type of forest site conditions, the stand age, relative stocking density, site index class and the proportion of European ash in the stand composition. Ash dieback is quite widespread in inspected stands of the Left-Bank Forest-Steppe of Sumy and Kharkiv Regions. The disease spreads similarly in natural and artificial stands. It was more often revealed in the fresh fertile forest site conditions, however, such forest site conditions are the most spread and the most favourable for European ash. It was found that ash dieback incidence tends to grow with a stand aging and lasts up to the stand's age of 80. It can be explained by the development of stem and collar rots which occur later. Ash dieback incidence is the highest in the stands with 40–70 % of ash in their composition, at a relative density of stocking over 0.5 in the stands of different site index classes.

Key words: forest site conditions, stand age, relative stocking density, site index class, ash proportion.

Introduction. European ash (*Fraxinus excelsior* L.) is currently threatened across most of its distributional range by ash dieback caused by *Hymenoscyphus fraxineus* (Baral et al. 2014). In eastern Ukraine, the ash decline symptoms were observed for the first time in 2010 and the *H. fraxineus* was detected in symptomatic shoots in 2012 (Davydenko et al. 2013). Later it was reported for different regions of Ukraine (Matsiakh & Kramarets 2014, Davydenko & Meshkova 2017, Davydenko et al. 2019). The disease results in both a premature death of trees and stands, and deterioration of wood quality (Metzler et al. 2012, Langer 2017). The disease is characterized by a rapid gradual dieback of ash crowns during the growing season. The symptoms of the disease are necrotic spots on the bark of shoots, discoloration of wood and leaves, necrosis of leaves, a premature leaf fall, necrosis of the trunk, death of shoots and water shoots (Fig. 1).



Fig. 1 – Epicormic shoots of European ash affected by ash dieback

The pathogen spreads during the summer with spores that occur on the infected leaves in the litter in winter and are carried by the wind. These spores infect the leaves of healthy ash trees during the next summer, leading to leaf wilting, necrosis of shoots and stem.

Our previous research has showed that European ash susceptibility to different pathogens as well as the severity of tree damage increase with tree age (Meshkova et al. 2019). To predict the threat of ash damage, it was necessary to determine how its incidence depends on other characteristics of the stands.

The aim of this work was to reveal the features of ash dieback distribution in the different forest site conditions, age, the relative density of stocking, site index, and ash proportion in the stand composition in the Left-Bank Forest-Steppe of Ukraine.

Materials and Methods. Inspection of ash stands was carried out in 2016–2019 at 52 permanent sample plots and 125 temporary sample plots in the State Forest Enterprises located in the Left-Bank Forest-Steppe, particularly in four forestries (Neskuchanske, Lytovske, Makivske and Krasnianske forestries) of Trostyanets Forest Enterprise of Sumy Region (hereinafter referred to as Sumy Region) and in two forest enterprises of Kharkiv Region: Chuguyevo-Babchanske Forest Enterprise (Kochetokske Forestry) and Skrypaysivske Training and Experimental Forest Enterprise (Skrypaysivske and Mokhnachanske forestries) (hereinafter referred to as Kharkiv Region).

Presence or absence of visual signs of ash dieback were registered, particularly necrotic spots on the bark of shoots, discoloration of wood and foliage, necrosis of foliage and stems, dieback of twigs and epicormic shoots. All inspected subcompartments with European ash (*Fraxinus excelsior* L.) as the main forest-forming species and subcompartments with the ash dieback symptoms were grouped by the types of forest site conditions, age, the relative density of stocking, site index and proportion of European ash in the stand composition.

The distribution of ash stands with the ash dieback symptoms and without them was compared using the chi-square test (Atramentova & Utevskaia 2008) in MS Excel.

Results and Discussion. The analysis revealed the ash dieback symptoms in 47.9% of subcompartments of plantations and 52.1% in the natural stands in Sumy Region. All inspected ash stands in Kharkiv Region had natural origin. Therefore, in the further analysis, we considered the data sets regardless of the origin of a stand.

In Sumy Region, most of the inspected ash stands (98.1 %) and dieback symptomatic ash stands are in the fresh fertile forest site conditions. Only 1.5% of subcompartments are in fresh relatively fertile forest site conditions and 0.5% in wet fertile forest site conditions. Therefore, the distribution of ash dieback by ash proportion in the stands composition, age, relative density of stocking and site index class in Sumy Region was analysed in the fresh fertile forest site conditions.

In inspected ash stands in Kharkiv Region, the types of forest site conditions were presented somewhat more widely, although fresh fertile forest site conditions also dominated (Fig. 2). Statistical analysis has showed that the differences in the distribution of all stands and dieback infected stands in Kharkiv region are significant ($\chi^2_{\text{fact.}} = 23.1$; $\chi^2_{0.05} = 9.49$).

The distribution of ash stands by three age groups was analysed: up to 40 years old, 41–80 years old, and over 80. In the inspected stands in Sumy Region, the tendency of ash stands over 80 to predominate is clearly expressed (Fig. 3).

The proportion of subcompartments with the stands aged 41–80 years is 2.3 times larger than the proportion of those under 40 years old, and the proportion of stands over 80 years old is 1.9 times larger than that of the stands aged 41–80 (see Fig. 3). Among the stands affected by ash dieback, almost half (47.9%) was aged 41–80 and slightly more than a third (37.5%) were over 80 years old. At the same time, the proportion of subcompartments with ash dieback symptoms at the age of 41–80 is significantly higher than the available stands of such age, and it is significantly lower at the age of over 80. This may be due to the fact that the stands over 80 years old are often affected by the stem and root rot (Davydenko et al. 2019). Statistical analysis has showed that the differences in the distribution of all stands and dieback infected stands in Sumy Region by age are significant ($\chi^2_{\text{fact.}} = 8.4$; $\chi^2_{0.05} = 5.99$).

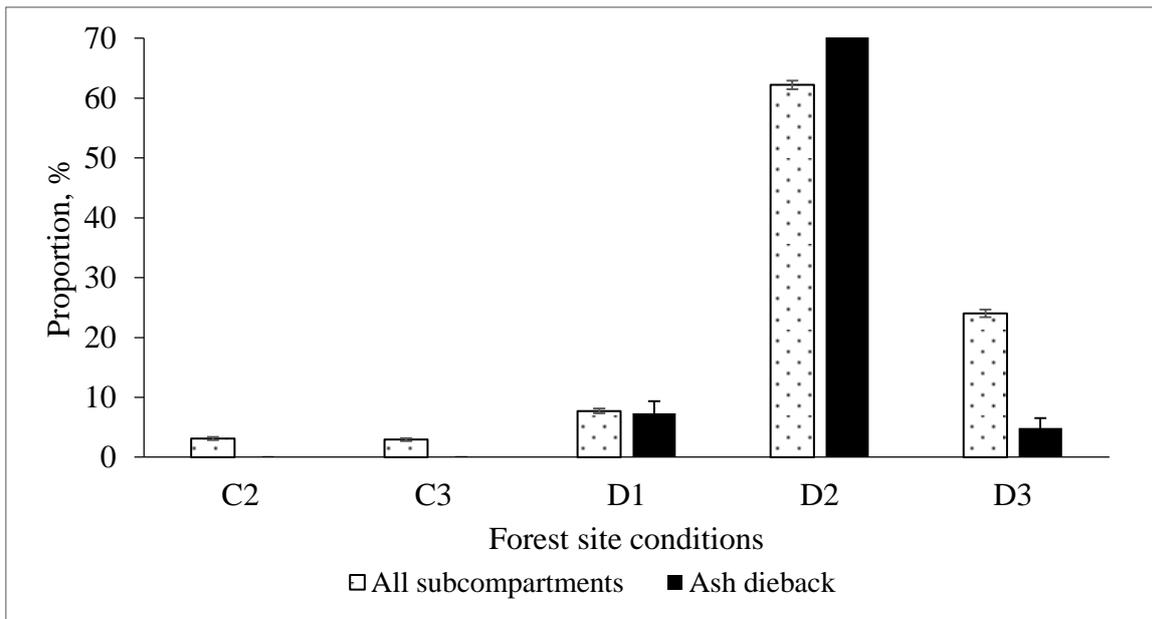


Fig. 2 – Distribution of all stands with European ash and the stands with the ash dieback symptoms by forest site conditions (Kharkiv Region)

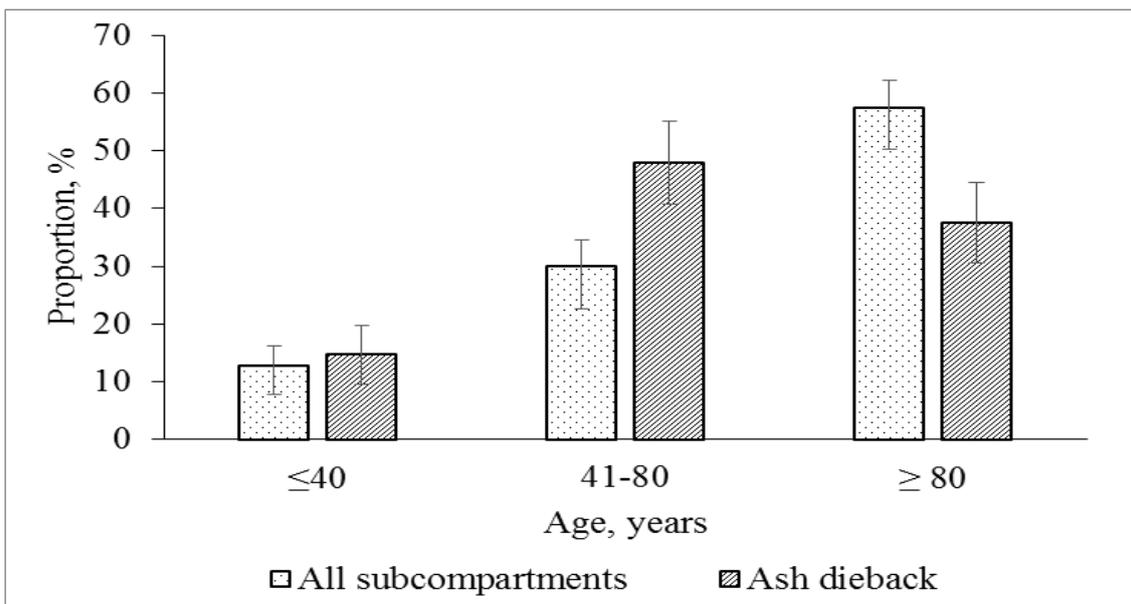


Fig. 3 – Distribution of all stands with European ash and the stands with the ash dieback symptoms by age (Sumy Region)

Among the inspected ash stands in Kharkiv Region, more than half (54.2%) were aged 41–80 years old, a slightly smaller share (32.4%) were up to 40 years old, and only 13.4% – over 80 (Fig.4). The ash dieback symptoms were found among the largest number of stands aged 41–80 years (75.6%). The differences in the distribution of all stands and dieback infected stands in Kharkiv Region by age are significant ($\chi^2_{\text{fact.}} = 10.8$; $\chi^2_{0.05} = 5.99$).

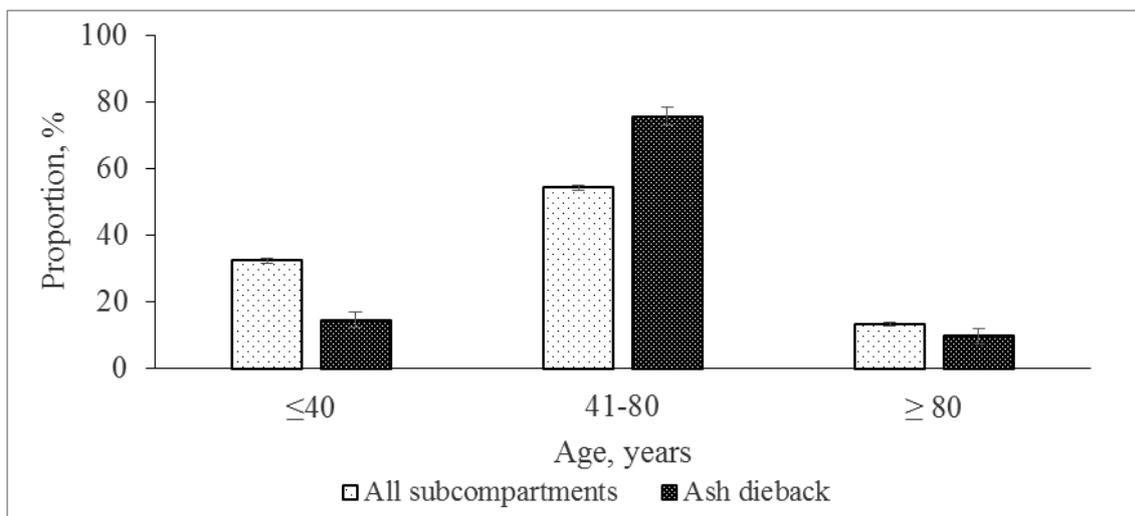


Fig. 4 – Distribution of all stands with European ash and the stands with the ash dieback symptoms by age (Kharkiv Region)

In most of the inspected stands of Sumy Region (60.3%), the proportion of ash in the composition did not exceed 30%. The plots with 40–70% of ash made 38.5%, while with over 80% – about 1% only (Fig. 5).

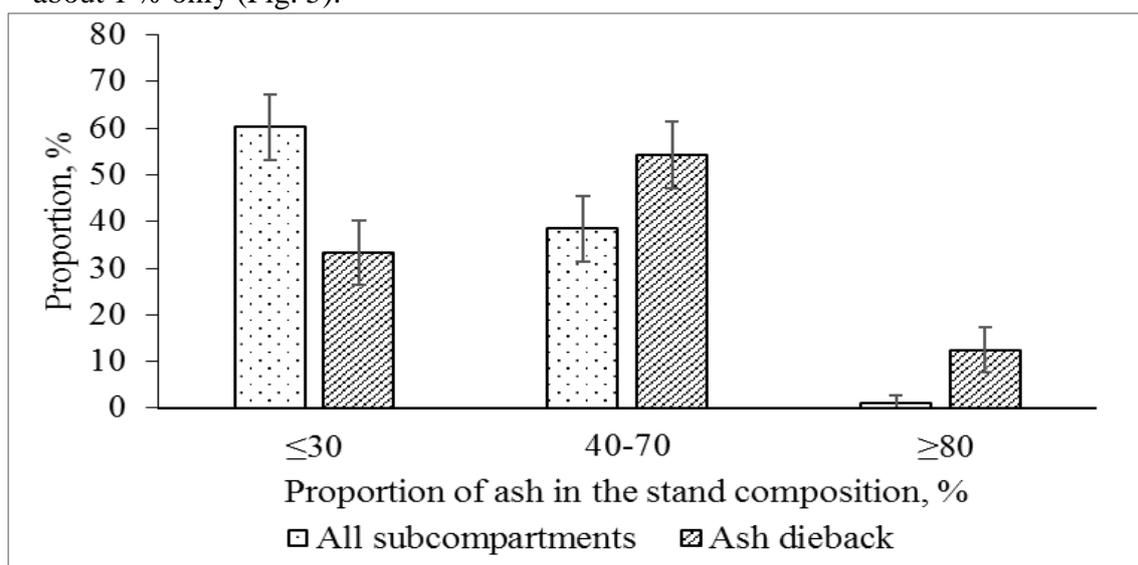


Fig. 5 – Distribution of all stands and the stands with the ash dieback symptoms by ash proportion in their composition (Sumy Region)

Among the stands with 10–30% of common ash in the composition, the proportion of plots with symptoms of the disease was lower than the proportion of available plots with such composition, and in the remaining plots – higher. Most often, the ash dieback symptoms were found in the stands with 40–70% of ash in the composition (54.2%) (see Fig. 5). The data obtained are explained by the fact that the disease is characteristic of ash. The differences in the distribution by ash proportion in all stands and dieback infected stands in Sumy Region are significant ($\chi^2_{\text{fact.}}=19.8$; $\chi^2_{0.05}=5.99$).

In the inspected stands in Kharkiv Region, the proportion of ash in the stand composition ranged from 10% to 70%, and the representation of stands with 10–30% and 40–70% of ash was quite close – 44.8% and 55.2%, respectively (Fig. 6). The frequency of subcompartments with the ash dieback symptoms in the stands with 40–70% of ash was almost three times higher than in the stands with 10–30% of ash in their composition. The differences in the distribution by ash

proportion in all stands and dieback infected stands in Kharkiv Region are significant ($\chi^2_{\text{fact.}} = 8.1$; $\chi^2_{0.05} = 3.84$).

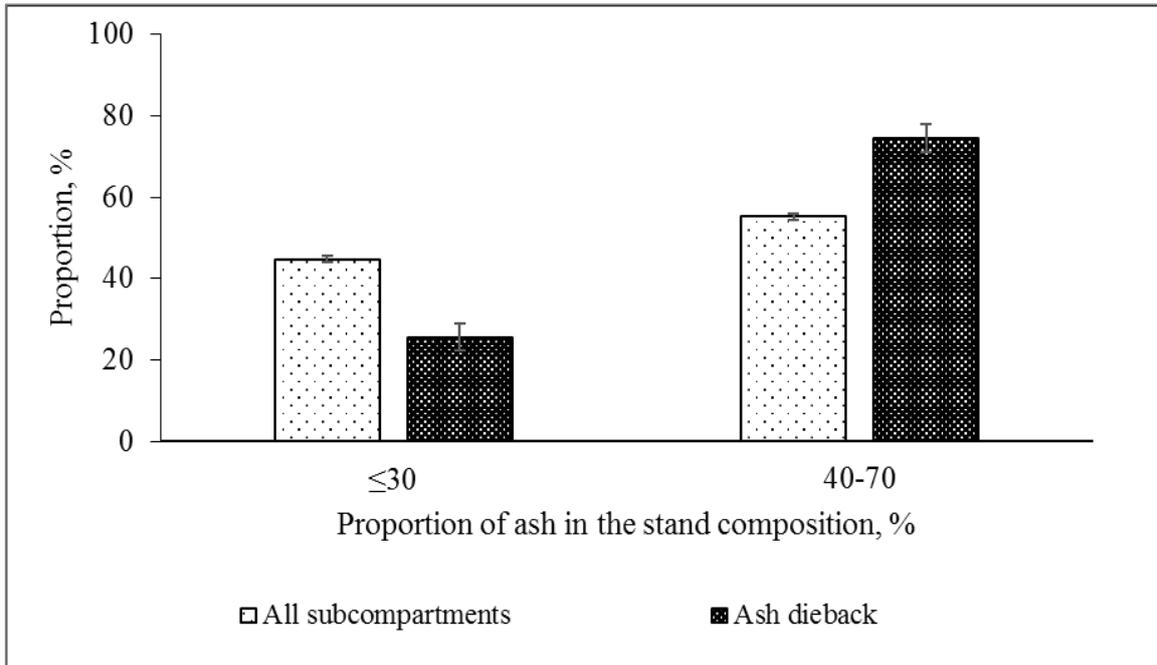


Fig. 6 – Distribution of all stands and the stands with the ash dieback symptoms by ash proportion in the composition (Kharkiv Region)

Among the inspected stands of Sumy Region with common ash in their composition, the proportion of stands with a low density of stocking (≤ 0.6) is only 11.5% (Fig. 7).

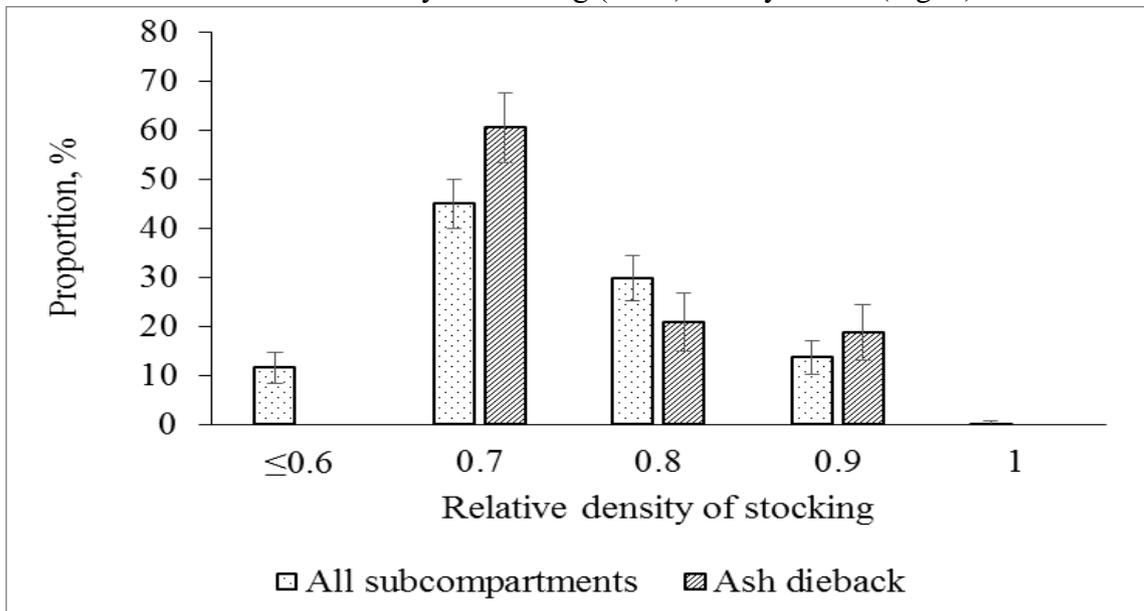


Fig. 7 – Distribution of all ash stands and the stands with the ash dieback symptoms by relative stocking density (Sumy Region)

The ash dieback symptoms were only found in the stands with a density of stocking of 0.7–0.9. At a relative density of stocking of 0.7, the proportion of stands with ash dieback is significantly higher than that of all stands, while these proportions at a higher relative density of stocking differ insignificantly. The data obtained may be due to the fact that the relative density of stocking has decreased due to the disease development in previous years. The differences in the distribution by

the relative density of stocking of all stands and dieback infected stands in Sumy Region are not significant ($\chi^2_{\text{fact.}} = 2.5$; $\chi^2_{0.05} = 5.99$).

Inspected stands in the Forest-Steppe part of Kharkiv Region were represented by the relative density of stocking from 0.3 to 0.8 (Fig. 8).

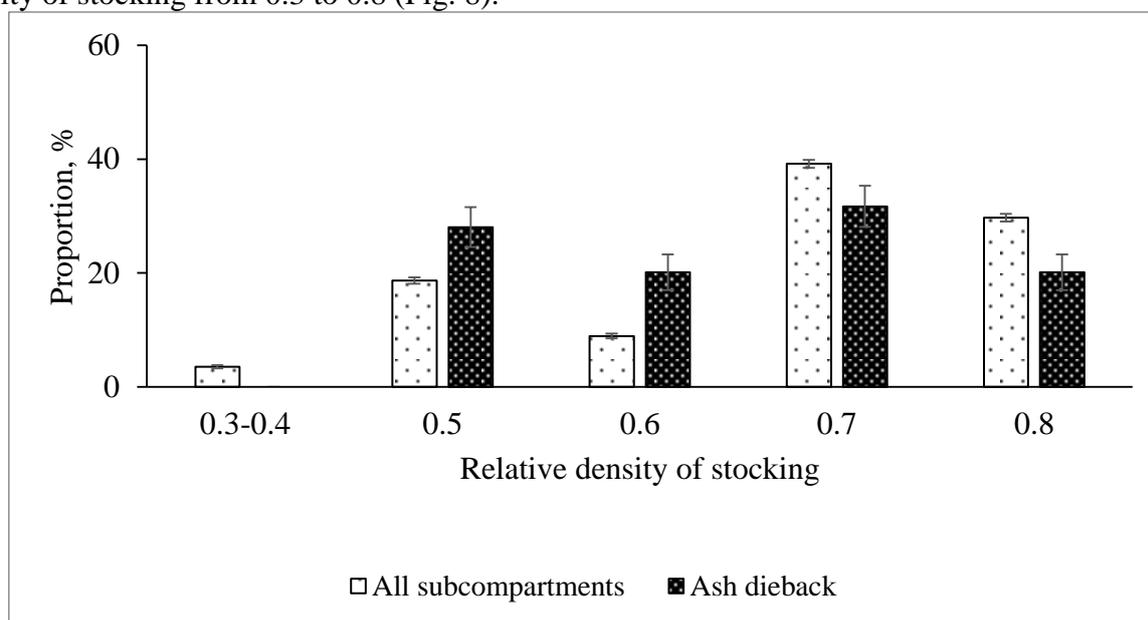


Fig. 8 – Distribution of all ash stands and the stands with the symptoms of ash dieback by relative stocking density (Kharkiv region)

No ash dieback signs were found in the stands with a relative density of stocking of 0.3–0.4. The proportion of subcompartments with ash dieback symptoms at a relative stocking density of 0.5 and 0.6 is significantly higher than that of all ash stands, and at a relative stocking density of 0.7 and 0.8 it is lower (see Fig. 9). The differences in the distribution by the relative density of stocking of all stands and dieback infected stands in Kharkiv Region are significant ($\chi^2_{\text{fact.}} = 12.3$; $\chi^2_{0.05} = 9.49$).

The absolute majority (95.8%) of the inspected ash stands in Sumy Region grow according to the I and higher site index classes (Fig. 9).

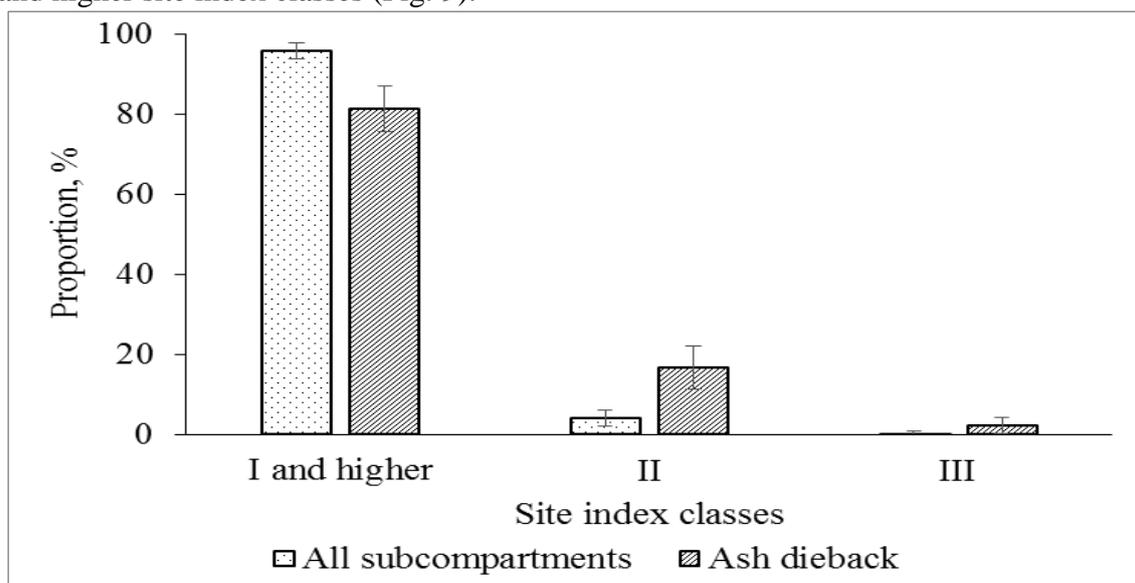


Fig. 9 – Distribution of all ash stands and ash stands with dieback by site index classes (Sumy Region)

Among the stands with the ash dieback symptoms, 81.3% of plots are characterized by I and higher site index classes, i.e. the disease covers significantly fewer plots than those available with

such site index. The proportion of ash stands of II site index class, on the contrary, is significantly lower in the forest fund than among those affected by ash dieback. Indirectly, this may indicate that less productive stands are more susceptible to the disease. The differences in the distribution of all stands and dieback infected stands in Sumy Region are significant ($\chi^2_{\text{fact.}} = 50.2$; $\chi^2_{0.05} = 5.99$).

In comparison with the inspected stands in Sumy Region (see Fig. 9), in Kharkiv the stands of I and higher site index classes make only 21.6%, the stands of II site index class make 54.3%, and even III and IV site index classes are presented (15.5 and 8.6% respectively) (Fig. 10).

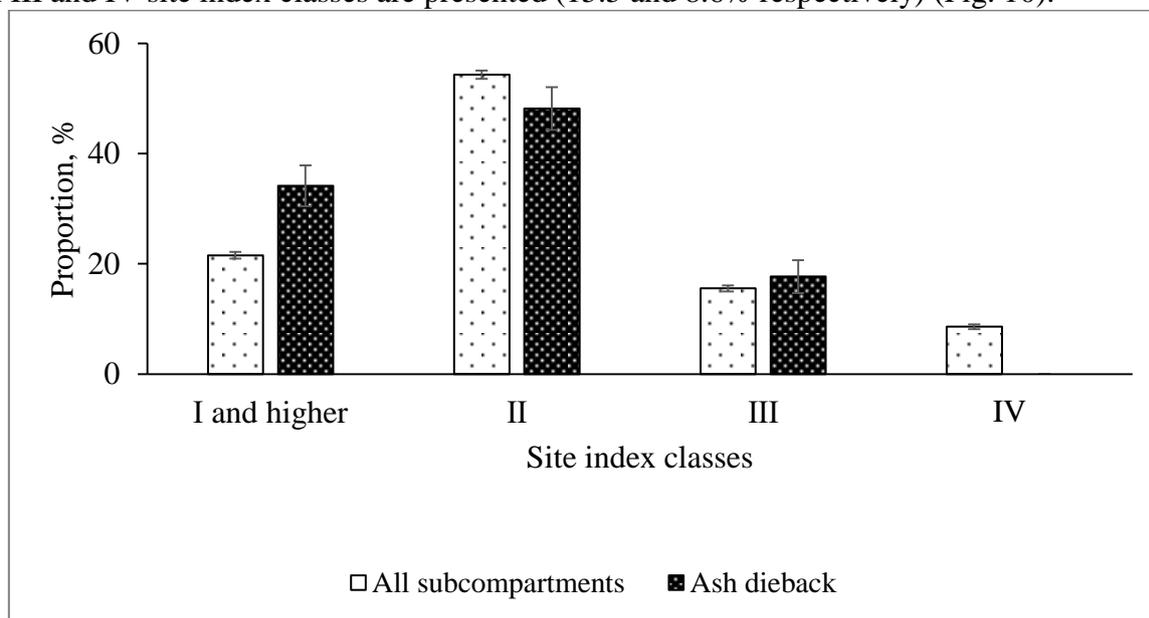


Fig. 10 – Distribution of all ash stands and ash stands with dieback by site index classes (Kharkiv Region)

The ash necrosis symptoms were found on trees of all site index classes except IV class. The differences in the distribution of all stands and dieback infected stands in Kharkiv Region are significant ($\chi^2_{\text{fact.}} = 10.5$; $\chi^2_{0.05} = 7.81$).

Conclusions.

1. Ash dieback is quite widespread in the inspected stands of the Left-Bank Forest-Steppe in Sumy and Kharkiv Regions.
2. The spread of the disease occurs similarly in natural and artificial stands.
3. The disease was detected more often in the fresh fertile forest site conditions; however, such forest site conditions are most spread and most favourable for European ash.
4. The ash dieback incidence tends to grow with a stand aging up to 80 years old which can be explained by the development of stem and collar rots later.
5. Ash dieback incidence is the highest at 40–70% of ash in the stand composition, at a relative density of stocking over 0.5 and in the stands of different site index classes.

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ПОШИРЕНІСТЬ ХАЛАРОВОГО НЕКРОЗУ ЯСЕНА В ЛІВОБЕРЕЖНОМУ ЛІСОСТЕПУ УКРАЇНИ ЗАЛЕЖНО ВІД ХАРАКТЕРИСТИК НАСАДЖЕНЬ

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Проаналізовано поширення халарового некрозу ясеня в лісостеповій частині Сумської та Харківської областей із урахуванням типу лісорослинних умов, віку, повноти, бонітету насаджень та участі ясеня у складі. Поширеність хвороби є однаковою у природних і штучних насадженнях. Хворобу частіше виявляють в умовах свіжого грудя, але такі умови є найбільш поширеними та сприятливими для ясеня звичайного. Тенденція збільшення поширення халарового некрозу з віком насаджень виявляється до 80 років, що можливо пояснити розвитком пізніше стовбурових і окоренкових гнилей. Поширеність халарового некрозу є найбільшою в насадженнях із 40–70 % ясеня у складі, за відносної повноти понад 0,5 у насадженнях різних класів бонітету.

Ключові слова: лісорослинні умови, вік насадження, повнота, бонітет, участь ясеня у складі насаджень.

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РАСПРОСТРАНЕННОСТЬ ХАЛАРОВОГО НЕКРОЗА ЯСЕНЯ В ЛЕВОБЕРЕЖНОЙ ЛЕСОСТЕПИ УКРАИНЫ В ЗАВИСИМОСТИ ОТ ХАРАКТЕРИСТИК НАСАЖДЕНИЙ

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Проанализирована встречаемость халарового некроза ясеня в лесостепной части Сумской и Харьковской области с учетом типа лесорастительных условий, возраста, полноты, бонитета насаждений и участия ясеня в составе. Распространение заболевания одинаково в естественных и искусственных насаждениях. Болезнь чаще обнаруживалась в условиях свежего грудя, однако такие условия наиболее распространены и наиболее благоприятны для ясеня обыкновенного. Тенденция к увеличению распространения халарового некроза с возрастом насаждений проявляется до 80 лет, что может быть объяснено развитием позже стволовых и комлевых гнилей. Распространение халарового некроза наиболее высоко в насаждениях с 40–70 % ясеня в составе, при относительной полноте более 0,5 в насаждениях различных классов бонитета.

Ключевые слова: лесорастительные условия, возраст насаждения, полнота, бонитет, участие ясеня в составе насаждений.

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