# 2. ЛІСОЗНАВСТВО, ЛІСІВНИЦТВО ТА МИСЛИВСЬКЕ ГОСПОДАРСТВО

Forestry Academy of Sciences of Ukraine

Наукові праці Лісівничої академії наук України
Proceedings of the Forestry Academy of Sciences of Ukraine

http://fasu.nltu.edu.ua
https://doi.org/10.15421/412202
Article received 2022.14.09
Article accepted 2022.12.29

ISSN 1991-606X print
ISSN 2616-5015 online
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*УДК 630.165.6*

## Approbation of the method for assessing the invasive activity and selection value of *Robinia pseudoacacia* L. in Kirovohrad region conditions

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*The results of the analysis of Kirovohrad region forest evaluation database and field observations of Black Locust (Robinia pseudoacacia* L.*) forest stands at the State Enterprise "Oleksandrivsky Forestry" are presented aimed to develop a method for determining the invasive activity and selection value of Black Locust.*

*The observations of the forest stands were carried out according to a set of indicators by generally accepted methods of forest mensuration with additional estimation of qualitative indicators. A comprehensive assessment of the forest stands was carried out according to the sum of points determined by the average values of quantitative and qualitative indicators. To determine the invasive activity of Black Locust, a method based on the number of viable self-seeding in the study plot was proposed.*

*The high growth intensity, productivity and selection value of Black Locust, as well as the suitability of the species for the creation of forest plantations and protective stands in certain forest site conditions in the south of the Right Bank Forest-Steppe have been demonstrated.*

*Two stands that meet the requirements for the plus stands were selected. Possibility of plus trees selection and forest seed base creation is proved.*

*Low invasive activity of Black Locust was noted on the territory of the vast majority of the observed stands. At the same time, medium invasive activity was detected in 42.8% of the areas adjacent to the studied stands, low – in 28.6%, very high – in 28.6%. The proposed methodical approach can be used to determine the invasive activity and selection value of the Black Locust stands. Such comprehensive approach will provide an objective answer to the question of expediency of this species using for afforestation in a certain region.*

***Key words:*** *Black Locust; growth intensity; selection value; natural regeneration.*

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**Introduction.** *Robinia pseudoacacia* L., commonly known as Black Locust, is a hardwooded broadleaved tree species. The native range of the species includes two disjunctive areas in the eastern United States (Huntley, 1990). The extent boundary of black locust native range is not exactly known now because these species has been widely planted and has become distributed throughout North America (Neophytou, van Loo, & Klisz, 2018). Black Locust distributes in the subtropical and temperate belts of Asia, southern Africa, Australia, New Zealand, South America (Li, Xu, Guo, & Du, 2014). Currently, it occurs in forty-two European countries and is naturalized in thirty-two (Pyšek et al., 2009). In Europe this species extends over $2.3 \times 10^6$ ha. Now *Robinia pseudoacacia* L. rivaling hybrid poplars (*Populus* spp.) as the second most planted broadleaved tree species in the world after *Eucalyptus* spp. in terms of area (Nicolescu et al., 2020.).

The total area of Black Locust stands in Ukraine is 422,5 thousand hectares (Lavnyy, & Savchyn, 2016; Nicolescu et al., 2020). In the steppe part of the Dnieper River basin, Black Locust occupies one of the leading positions in the protective afforestation and forest reclamation of human-damaged landscapes on the dry rich soils (Ситник, 2021). In the Forest-Steppe it has been used for afforestation of ravine slopes and steep slopes with water-washed away soils (Гримальский, 1958). Black Locust is among nine dominated tree species on the Left-Bank Forest-Steppe territory (2% an area of forests) (Bondar et al., 2021). In the Polissia region, it acts as a transformer species, mainly in pine forests. On the Eastern Polissia, *Robinia pseudoacacia* is widely used for creation of shelterbelts on agricultural lands and on clear-cuts of oak-pine and deciduous forests (Протопопова, Шевера, 2019). In the view of both national and foreign scientists (Доценко та ін., 2021; Puchałka et al., 2021), in the conditions of the forecasted climate changes towards temperature increase and precipitation decrease, this species receives more and more advantages.

For the purpose of improvement of stem quality, Hungary, France and Germany have carried out the breeding programs as a result of which, especially in Hungary, a higher wood production has been achieved (Vítková et al., 2017; Rédei et al., 2018; Nicolescu et al., 2018; Nicolescu et al., 2020). Hungarian breeding programs are aimed at high growth rates, as well as obtaining a straight stem and a high nectar production. These programs started out with a selection of the plus trees and trees with high viability, also certain areas with good seed banks (Keserű, Rédei, Rásó, & Kiss, 2019; Tamás Ábri et al., 2021).

Breeding works with Robinia psevdoacacia in Ukraine were carried out in Kherson region in the 1970s. S.G. Kokhanyi selected the Black Locust plus trees of mast-shaped form at the Steppe branch of URIFFM (Коханий, 1979), which are successfully propagated and used for afforestation in the Steppe region. The elaboration of approaches to the complex study of forest stands with *Robinia pseudoacacia* L. participation in the climate change conditions in Ukraine is relevant. To date, no unified approaches have been developed to simultaneously determine the current state, growth intensity, breeding value of Black Locust stands. The analysis of the results obtained in one of the districts of Kirovohrad region should contribute to a better understanding of the current situation with the distribution of the species, its invasive activity, as well as finding approaches to managing *Robinia pseudoacacia* L., which would reflect the local context.

There is a need to develop the methodology due to the lack of unified approaches to determining the invasive activity of *Robinia pseudoacacia* L., the methodology which will provide analysis of results, formulation of recommendations and conclusions on the feasibility of creating forest stands of this species. The existing methods involve either only the assessment of the condition and productivity of stands (17) or only the distribution of the species (24). At the same time, only a comprehensive approach will provide an objective answer to the question of expediency of this species using for afforestation.

**Objects and methods.** *The objects of research* were Black Locust stands of artificial origin in Kirovohrad region. The *subject of research* was the invasive activity of *Robinia pseudoacacia* L. *The aim of study was* to propose a method for determining the invasive activity and the selection value of Black Locust.

The forest evaluation database of Kirovograd region and the SE "Oleksandrivsky Forestry" was analyzed. At the SE "Oleksandrivsky Forestry" the Black Locust stands had an age from 5 to 71 years. The study plots were laid out in Black Locust forest stands aged from 16 to 71 years of seed and vegetative origin in the SE "Oleksandrivsky Forestry". A total of 17 study plots (SP) have been observed. The stands with an area of more than one hectare and with a share of Black Locust in the growing stock of more than 50 % in the stand composition were selected for a detailed observation. The SPs were laid out in $B_1$, $B_2$, $C_1$, $C_2$, $D_1$ and $D_2$ forest site conditions (Table 1), in particular, four of them in stands under 30 years old ($B_2$, $C_1$, $D_1$, $D_2$), two – in stands aged from 31 to 60 years ($B_2$, $C_2$) and nine – over 60 years old ($B_1$, $B_2$, $C_2$, and $D_2$).

Attention to older stands was paid due to the importance of determining the durability of Black Locust in the Right-Bank Steppe and ability of tree improvement work.

During the observation of the stands in the autumn of 2021, damage and disturbance of the forest stands growing conditions, the presence of clutter and natural regeneration, disturbance of the litter, and also the turf in young forest stands on lands that have come out of agricultural use were taken into account. The observations of the stands were carried out according to indicators set with the laying out of the study plots according to generally accepted forest mensuration methods (Швиденко та ін., 1987; Інструкція…, 2006), with additional estimation of quality indicators (selection category, stem straightness, presence of defects and damages, reproduction, etc.) (Лось та ін., 2018). Mainly linear SP were laid along the transects by measuring tape along the diagonal of the subcompartment or along the accounting rows (Лось та ін., 2017).

*Table 1.* **The short description of observed Black locust stands**

| #SP | Forestry subunit | Compartment / sub compartment | Forest site conditions | Age, years | Species composition* |
|---|---|---|---|---|---|
| SP1 | Oleksandrivsky | 30/17 | $B_2$ | 16 | 10 Bl |
| SP2 | Oleksandrivsky | 30/22 | $B_1$ | 70 | 9Bl1Sp |
| SP3 | Oleksandrivsky | 30/21 | $C_2$ | 71 | 10Bl |
| SP4 | Oleksandrivsky | 30/39 | $C_2$ | 71 | 7Bl3 Ga |
| SP5 | Oleksandrivsky | 30/38 | $C_2$ | 71 | 10Bl |
| SP6 | Oleksandrivsky | 32/27 (1) | $D_2$ | 65 | 10Bl |
| SP7 | Oleksandrivsky | 32/27 (2) | $D_2$ | 65 | 10Bl |
| SP8 | Oleksandrivsky | 32/27 (3) | $D_2$ | ~25 | 8Bl1Ga1Alm |
| SP9 | Oleksandrivsky | 23/11 | $C_1$ | 68 | 8Bl2 Ga |
| SP10 | Oleksandrivsky | 50/22 | $C_1$ | 27 | 10Bl |
| SP11 | Oleksandrivsky | 41/3 | $B_2$ | 15 | 8Bl2Bc |
| SP12 | Oleksandrivsky | 39/1 | $C_2$ | 56 | 9Bl1Sll |
| SP13 | Oleksandrivsky | 39/2 | $C_2$ | 36 | 8Bl2Sll |
| SP14 | Birkovsky | 68/4 | $C_2$ | 62 | 10Bl |
| SP15 | Birkovsky | 71/8 | $D_1$ | 22 | 10Bl |
| SP16 | Birkovsky | 19/3 | $B_2$ | 71 | 9Bl1Sp |
| SP17 | Oleksandrivsky | 41/11 | $B_2$ | 59 | 10Bl |
| Control | Oleksandrivsky | 41/8 | $B_2$ | 70 | 10Sp |

* Bl – Black locust; Ps – Scots pine; Ga – Green ash; Alm – Ash-leafed maple; Sll – small-leaved lime; Bc – black cherry

The tree-to-tree measurement of the stem diameter at a breast height (DBH) and estimation of selection category (SC), straightness of the stem, condition, presence of defects and damage, as well as, if possible, the presence of reproduction, were carried out at the SPs. In addition, the proportion of multi-stem trees per SP was noted.

The values of the average DBH and height of Black Locust, measured on of the SPs, were compared with the control. Forest mensuration indicators of Scots pine stands (for $B_1 – B_2$ and $C_1 – C_2$ forest site conditions) and English oak stands (for $D_2$ conditions) of the appropriate age on the territory of the corresponding forestry subunit (or Forest Enterprise) were used as the control.

Qualitative assessment of Black Locust stands was based on the proportion of trees of I and II selection categories according to the modified M. M. Veresin's scale (Молотков та ін., 1982; Волосянчук та ін., 2003).

Complex assessment of forest stands was carried out on the basis of the points sum, determined by the average values of quantitative and qualitative indicators for the SP according to the following scale suitability for stands creating: 1) unpromising (5.0-11.5 points); 2) relatively promising (11.6-18.5 points); 3) promising (18.6-25 points). The stands of the last category can be integrated to the permanent forest seed base (PFSB). They can be given the status of plus or seed stands. In these stands, it is advisable to select the plus trees.

To determine the Black Locust invasive activity (Table 2), the method based on the number of viable undergrowth and self-sowing according to the "Recommendations for reproduction of natural stands in lowland forests and forests of the Mountainous Crimea" (Кобець та ін., 2017) was used. Good regeneration on the SPs indicated about very high invasive activity, satisfactory – high, insufficient – medium, unsatisfactory – low and absent – absence.

The Black Locust invasive activity indicators on the Enterprise territory were determined on the basis of the generalization of indicators for each examined subcompartment, in particular, the share of stands with a certain invasive activity. A comparison of indicators of invasive activity in the observed stands and outside these boundaries was carried out, taking into consideration the growth conditions, disturbed turf and litter.

The obtained data were calculated by the statistical methods using the MC Excel software package. The share of trees with certain characteristics for each stand was also analyzed.

**Results.** The share of Black Locust stands areas ranges from 0.5 to 8.1% in the region and from 1.7 to 8.3% at the Enterprise, depending on the age (Fig. 1). In both cases, stands aged from 31 to 60 years prevail. The shares of the stand areas with a high share of marketable trees (25% and above) in all age groups are similar. It proves the representativeness of the stands of

the Enterprise for assessing the distribution and selection value of these species in the region.

The majority of robinia's stands in the region is located in $D_1$ forest site conditions, slightly less is in $C_2$ and $D_2$, and half as much is in $C_1$ (Fig. 2). The stands areas in $A_1$, $A_2$, $B_1$, $B_2$ and $D_3$ conditions are insignificant. In the SE "Olexandrivsky Forestry" the majority of stands are in $C_2$, slightly less in $D_2$ and $D_1$ and half as much are in $C_1$ forest site conditions. There are small areas of stands in $A_2$, $B_1$ and $B_2$ conditions. So, the distribution of forest areas by forest site conditions of the SE "Oleksandrivsky Forestry" is typical for the region.

The results of observations in the Black Locust stands of the SE "Oleksandrivsky Forestry" indicate its high growth intensity. The average height of stands was inferior to the average height of the control only in four cases out of 17 the average (Table 3). Half of the stands were characterized by the diameter at the control level, and the rest exceeded it.

*Table 2.* **The scale of Black Locust invasive activity**

| Category of regeneration success | Category of potential forest efficiency using natural regeneration | Number of viable undergrowth and self-sowing, th. plants. • ha$^{-1}$, years | | | Invasive activity | |
|---|---|---|---|---|---|---|
| | | 1-3 years | 4-8 years | 9-15 years | Category | Point |
| Good | 1 | 12 | more of 6.0 | more of 4.0 | Very high | 1 |
| Satisfactory | 2 | 7.1-12.0 | 3.1-6.0 | 2.1-4.0 | High | 2 |
| Insufficient | 3 | 3.1-7.0 | 1.1-3.0 | 0.5-2.0 | Medium | 3 |
| Unsatisfactory | 4 | до 3.0 | до 1.0 | до 0.5 | Low | 4 |
| Absent | 5 | 0 | 0 | 0 | Absent | 5 |

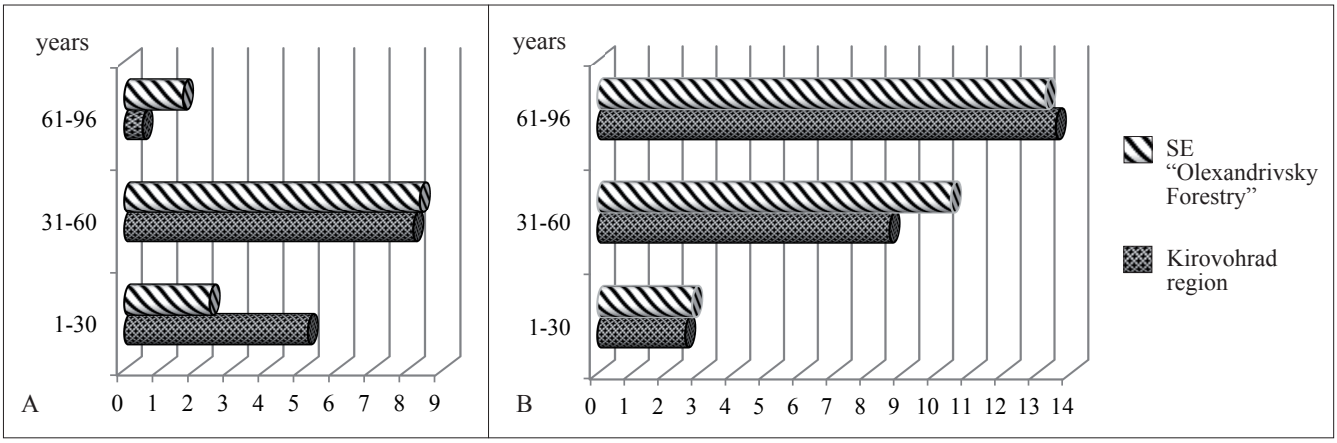


Fig. 1. A. Black Locust stands areas. B. Share of stands with high portion of marketable timber in Kirovohrad region and in the SE "Oleksandrivsky Forestry"

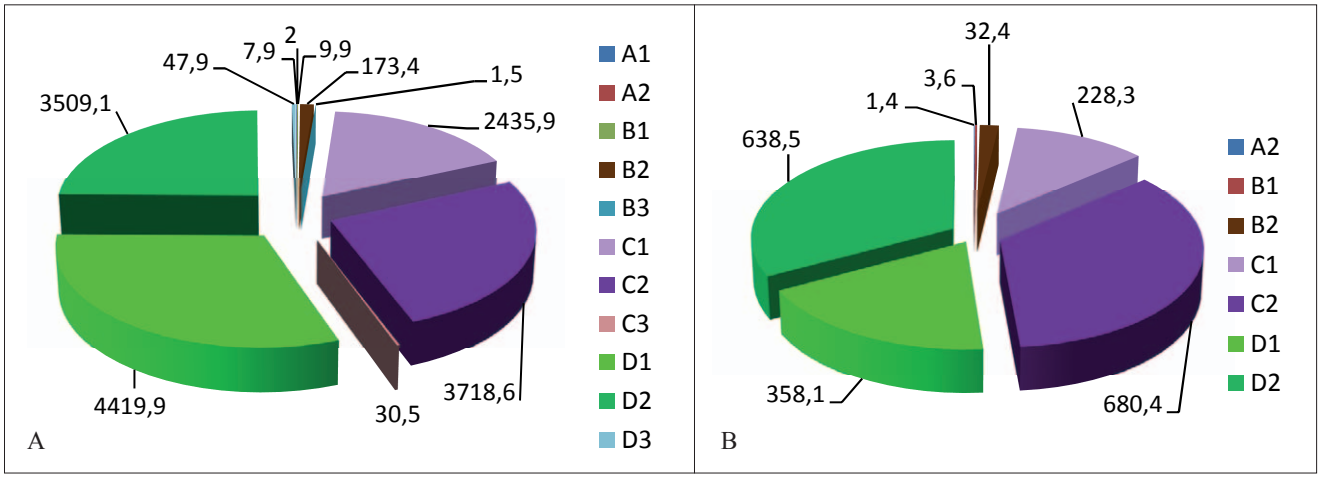


Fig. 2. Areas of Black Locust stands in different forest site conditions: A – Kirovohrad region, B – The SE "Oleksandrivsky Forestry"

*Table 3.* **The growth intensity, condition and quality indicators of observed Black Locust stands**

| Forestry subunit | Compartment / sub compartment | Comparatively control, % | | Trees of I i II SK, % | Condition index, point | Proportion of multi-stem trees, % |
|---|---|---|---|---|---|---|
| | | H, m | DBH, cm | | | |
| Oleksandrivsky | 30/17 | 31.8 | 20 | 8.5 | 3.7 | 20.0 |
| Oleksandrivsky | 30/22 | -16.6 | 20 | 12.1 | 3.2 | 20.0 |
| Oleksandrivsky | 30/21 | 2.3 | 3.3 | 5.6 | 4.0 | 3.3 |
| Oleksandrivsky | 30/39 | 9.5 | 15.4 | 8.3 | 3.4 | 15.4 |
| Oleksandrivsky | 30/38 | 15.9 | 0 | 3.3 | 3.8 | 0 |
| Oleksandrivsky | 32/27 (1) | -17.5 | 0 | 9.1 | 3.6 | 0 |
| Oleksandrivsky | 32/27 (2) | -6.3 | 3.6 | 20.0 | 3.3 | 3.6 |
| Oleksandrivsky | 32/27 (3) | 90.1 | 0 | 6.3 | 2.8 | 0 |
| Oleksandrivsky | 23/11 | 26.2 | 11.1 | 11.1 | 3.4 | 11.1 |
| Oleksandrivsky | 50/22 | 10 | 9.2 | 20.4 | 3.6 | 9.2 |
| Oleksandrivsky | 41/3 | 60 | 16.9 | 2.0 | 3.8 | 16.9 |
| Oleksandrivsky | 39/1 | 4.8 | 0 | 25.0 | 4.3 | 0 |
| Oleksandrivsky | 39/2 | 15.7 | 0 | 31.8 | 2.7 | 0 |
| Birkovsky | 68/4 | -19 | 0 | 14.3 | 3.9 | 0 |
| Birkovsky | 71/8 | 46.9 | 0 | 28.3 | 3.0 | 0 |
| Birkovsky | 19/3 | 22.1 | 0 | 4.7 | 3.5 | 0 |
| Oleksandrivsky | 41/11 | 20 | 0 | 2.6 | 4.4 | 0 |
| Oleksandrivsky | 41/8 | 5.4 | 6.2 | 55.6 | 2.3 | 6.2 |

The Black Locust stands were characterized by high productivity. The site index of the vast majority of them is I and above. The growing stock of Black Locust at the age of 59-71 years in some cases exceeds 400 $m^3$/ha, which is at the level of Scotch pine indicators (Fig. 3).

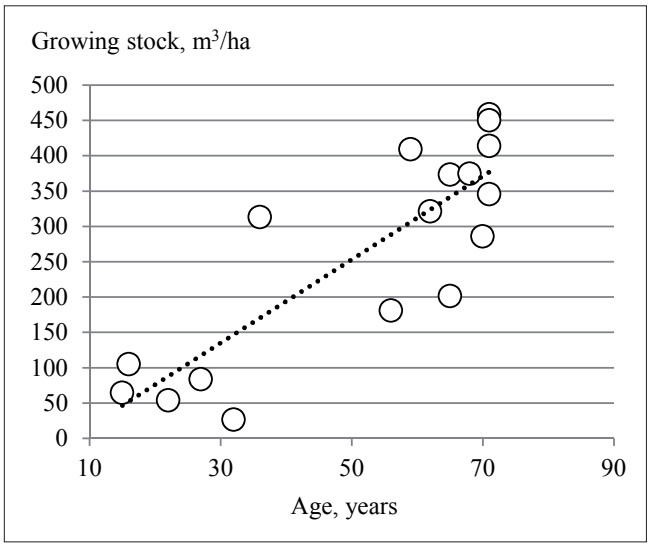


Fig. 3. Growing stock of observed stands depending on the age

The analysis of the selection structure of the observed Black Locust stands in the SE "Oleksandrivsky Forestry" (see Table 3) indicates different quality of the trunks in different forest site conditions. Most stands have normal selection structure and only two stands comply with plus stands (comp. 39, subcomp. 2 and subcomp. 2. in Olexandrivsky and subcomp. 71 in Birkyvsky forestry subunit).

The condition of the Black Locust tree in the SE "Oleksandrivsky Forestry" was satisfactory in the vast majority of cases. The condition index ranged from 2.7 to 4.4 points (see Table 3). The proportion of dead trees ranged from 0 to 64.1% and did not depend on the age of the stand. At the same time, the average correlation between the age of stands and the share of unsatisfactory conditions trees were revealed. The proportion of such trees increases with age and in most stands over 60 years of age exceeds 40%.

According to the results of the point complex assessment by the productivity, quality and condition of Black Locust at the SE "Oleksandrivsky Forestry", the stands scored from 13 to 21 points (Fig. 4). Such results confirm the suitability of the species for the creation of forest crops and protective stands in the south of the Right-Bank Forest-Steppe of Ukraine. The stands, that have scored 19 and more points can be included in a permanent forest seed base as seed stands and plus stands.

For studying the Black Locust natural regeneration at the SE "Oleksandrivsky Forestry", the sample plots were laid out: 1) on arable land, beyond the boundary of the black locust stand (4 pcs.); 2) on the forest lawn; 3) on broken lands (3 stands); 4) in forest plantations

of 16-27 years old (4 stands) and 56-71 years old (11 stands), as well as in pine forest plantations (2 stands) near the black locust stand. The results of the natural regeneration accounting are given in Fig. 5.

It was definite that in the arable land, the appearance of self-seedling of black locust is due to the circulation of air masses during seeds dispersal. In particular, the number of seedlings on the leeward side of the forest plantations was five times more as on the windward side. The distance of black locust self-seeding from the stand boundary on the field was more than 30 m. On the lawn near to the 70-year-old black locust stand in $C_2$ growing conditions, the number of viable undergrowth and black locust self-seeding is insufficient to form a forest stand.

Three study plots were laid out on the disturbed lands: SP10 – in a stand formed on the site of a former cowshed, SP17 – a stand formed on the site disturbed of Black Locust stand due to conduct of high-voltage power line constructed with the involvement of bulldozers and other machinery, SP18 – former vegetable gardens on the plot bordering the Black Locust stand. The vast majority of plants in these areas are of coppice origin. At the same time, there are also self-seeding individuals, mostly up to 3 years old (Fig. 5).

The surveyed the youngest 5-year-old Black Locust forest crops (SP11, Oleksandrivske subunit, c. 23. s.13), created on a hill (slope 10-15°) were classified as anti-erosion forests. In $C_2$ forest site conditions, plant survival was 45%, the average height was 2.1 m. The height of individual trees ranged from 0.6 to 4 m. The last year's increment for most trees (67%) exceeded 1 m. Up to 7% of trees showed signs of fruiting. Condition index of forest crops was 2.1 points. The share of single-stemmed trees was 76%. There were no self-seeded plants.

In a 16-year-old stand of mixed origin (natural regeneration + artificial forest crops) (SP1), a small number of viable undergrowth and self-seeded of Black Locust up to 8 years of age was recorded.

Among the 16-27-year-old Black Locust forest stands (SP13, 14, 20), a significant occurrence of 1-year-old self-seeding was recorded at SP20. In 22-year-old stands, its number was equal to 9.7 thousand trees per ha, they are placed in groups, the number of plants of other age groups is much smaller (up to 0.6 thousand trees per ha). The appearance of such a number of seedlings can be due to a sufficiently wet spring, insufficient density of stands (row spacing of 3 m), as well as soil richness (forest site conditions $D_1$).

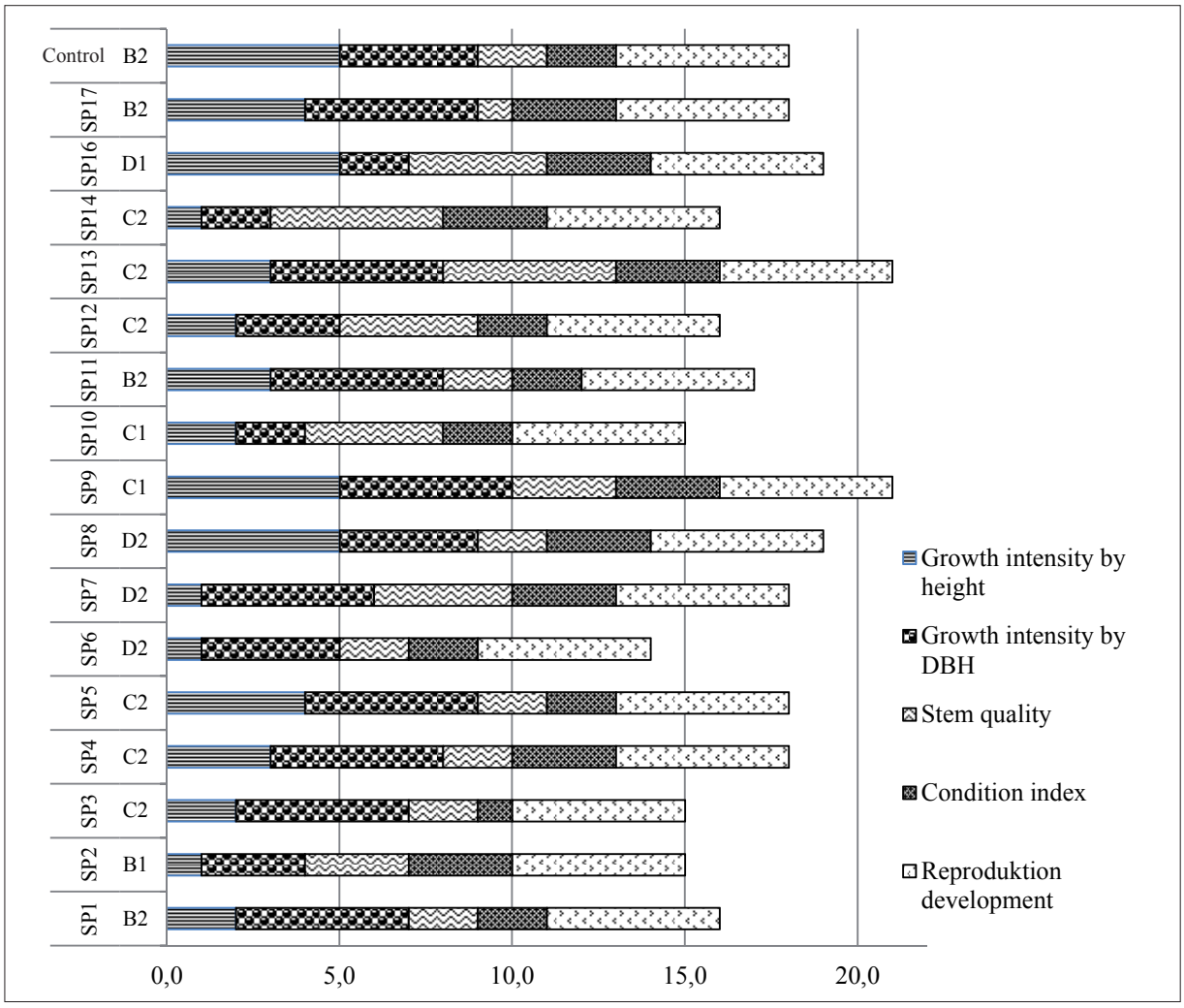


Fig. 4. Complex assessment of Black Locust stands by productivity, quality and condition characteristics

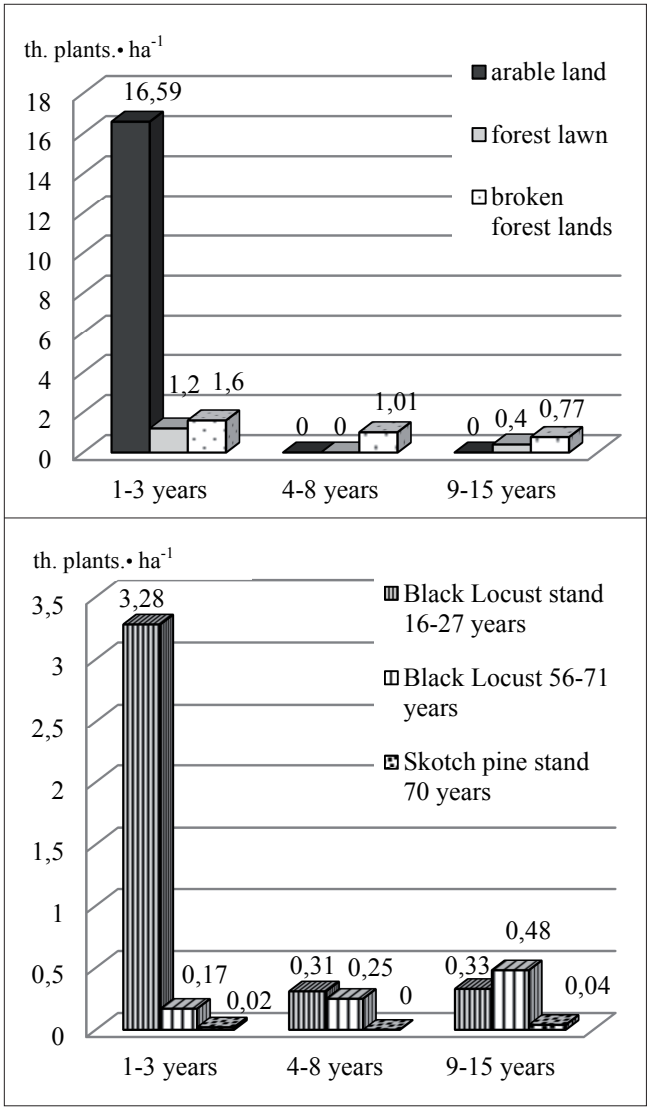


Fig. 5. Natural regeneration of Black Locust in different lands

According to the data of 11 Black Locust study plots in stands aged 56-71 years (SP2, 3, 6-8, 9, 12, 16, 19-22), there was a low amount of natural regeneration in them. The sufficiently high amount of regeneration both of coppice and seed origin was noted only in the stand damaged by the wildfire in 2000 (SP19). At the same time some trees of coppice origin became dead.

In the 70-year-old pine stand (forest site conditions – $B_2$), which borders the Black Locust stand (SP23), specimens of Black Locust trees of various ages were noted. Most of the last year's self-seeding was concentrated around Scots pine stumps and in moss curtains. Black Locust plants of the older age group (9-15 years) concentrated in the pine forest gaps, and their coppice regeneration was recorded. In another pine stand of the same compartment in $B_2$ forest site conditions, 55-year-old Black Locust trees are located on the border of the subcompartment, along the forest road. On a biomeadow the regeneration of Black Locust is located in groups. In such a group aged from 1 to 7 years, where this year's self-seeding prevails, up to 15 seedlings with a height of up to 7 m were counted.

High Black Locust invasive activity was noted on the disturbed lands. It is very high in the case of the location of arable land on the windy side of the Black Locust stand and it is lower in the case of the location of arable land on the windward side of the stand.

On the disturbed forest lands, the invasive activity of the species ranges from low to medium. In the case of Black Locust location on both sides of such an area, its regeneration occurs mainly by coppice and there is little amount of self-seeding (SP10). If there are shrubs along the border of the disturbed area, in particular black elderberry (SP17), the proportion of self-seeded plants is higher. However, it is less than that in the case of the conversion of former agricultural lands.

In young Black Locust stands (5 years old), there is no invasive activity due to the small number of trees with reproduction and strong soil compaction. In the mixed stand (SP1), the self-seeding occurs due to the reproduction of trees of coppice origin and the presence of gaps in the canopy. In the vast majority of cases, the Black Locust invasive activity in forest stands is low. However, it can be medium in a stand in the presence of non-grassy meadows (SP16) and where the density of stocking of the stand is less than 0.6 (SP2). Under favorable weather conditions, invasive activity can be high on richer soils in insufficiently stocked stands (SP20). Seed regeneration of Black Locust is absent in the presence in the composition of other tree and bush species, and the density of stocking being 0.7 and above.

**Discussion.** Recently, the research for obtaining an answer to the question whether it is worth growing introduced species of woody plants into forest crops has become particularly relevant. There is a lot of controversial information about Black Locust. In some countries, for example in Great Britain, Germany, France, Japan and New Zealand, Black Locust is considered a harmful invasive species (Podrázský, & Prknová, 2019). In others, it is actively used to create plantation forest crops to obtain wood, medicinal raw materials, and as a honey plant (Rédei et al., 2018; Vítková et al., 2017; Nicolescu et al., 2018; Nicolescu et al., 2020).

The reasons why Black Locust has been planted globally are numerous and varied: durable and rot-resistant wood, high calorific value of wood, a nitrogen fixer, soil erosion control, reforestation, forage for livestock, nectar and honey source, edible flowers, an ornamental tree species in parks and alleys (Kraszkiewicz, 2021; Sabo, 2000; Halasz et al., 2021; Farkas, & Zajácz, 2007; Papadopoulou et al. 2018; Podrázský, & Prknová, 2019; Moser, Rötzer, Pauleit, & Pretzsch, 2016). In some characteristics, such as wood strength and hardness, Black Locust exceeds English oak, also its wood has much higher durability and resistance to weathering and biotic agents (Podrázský, & Prknová, 2019). In previous years, Black Locust was included in the European subsidizing programme of tree species cultivation, aiming at the creation of new forest stands in many European countries (Vasiliki, & Ioannis, 2017).

Hungarian breeding programs are aimed at high growth rates as well as a straight stem and a high nectar production. These breeding programs started out with a selection of the plus trees and vital trees, also certain areas with good seed banks (Keserű et al., 2019; Tamás Ábri et al., 2021). The selected trees were used as the base for vegetative propagation; seed orchards have been founded. The goals of such programs are better wood quality, more production of biomass, higher nectar production and frost hardiness. In Hungary, Bulgaria, Romania, Germany, Italy, Belgium, Czech Republic, Slovakia, Croatia, Bosnia and Herzegovina, and Poland the reproductive material collected in certified/selected seed stands and seed orchards are used. For example, in Hungary the offspring of selected plus trees were vegetatively propagated and grouped together into cultivars, which are composed of one or several clones, 7 cultivars are approved by the competent country national office (Rédei et al., 2017b). In Poland, 2 selected seed stands have been registered, as well as 34 plus trees and 2 seed orchards (Wojda et al., 2015).

Despite the significant number of works devoted to the study of the invasiveness of plants, there is no consensus on the criteria for assessing the invasiveness of woody species when creating classification schemes (Протопопова, Шевера, 2019). In most cases, when it comes to invasive activity, the conclusions are not supported by numeric indicators that could precisely "estimate" the degree of this "activity". So, in work (Nicolescu et al., 2020) the "invasive potential" of Black Locust was estimated, but this indicator is considered in general as the ability to spread. In other cases, the assessment of invasive activity is overloaded with a large number of indicators. For example (Morse et al., 2004), the answers to 20 questions in points make up the main part of the assessment. At the same time, the field studies on the quantitative assessment of Black Locust regeneration are important. Unfortunately, such researches are fragmentary. Thus, in assessing the distribution of *Robinia pseudoacacia* L. in Mediterranean ecosystems, Italian researchers (Crosti et al., 2016) accounted the number of trees (adults: individuals > 1 m tall; seedlings: individuals ≤ 1 m tall) on strip transects from the edge of each of the four sides of stands. The diameter at breast height (DBH) and height were also measured for Black Locust. The obtained data were grouped based on the distance from the edge of the stand.

The method for assessing invasive activity proposed in this paper is based on quantitative assessment of Black Locust regeneration by vegetative and seed origin in the territory of sub-compartment and beyond, given that the main characteristic of invasiveness is the ability of the species to uncontrolled spread. This approach makes it possible to provide a quantitative description of the invasive activity of the species both in the territory of the sub-compartment and in forestry subunit and the enterprise as a whole.

The obtained results confirm the conclusions of other authors (Crosti et al., 2016) regarding the ability of Black Locust to spread to a distance of up to 30 m from the edge of the stand and regarding its most active spread in disturbed plots.

It has also been confirmed that Black Locust does not regenerate in dense forests or thickets of bushes with closed crowns: because the seedlings do not tolerate shade (Crosti et al., 2016; Vítková et al., 2017).

The application of complex approach also allowed for determining the selection value of both certain stands and the species for the region as a whole.

Determination of the selection value of Black Locust is usually carried out on the basis of the analysis of indicators of growth intensity and trunk quality. The following trees of Black Locust were considered valuable: with narrow, full, and symmetrical crowns that occupy about a third of the height, a straight trunk of high quality with a strong central leader, rapid growth in height, and good health (Nicolescu et al., 2018). Both Romanian and Hungarian scientists (Rédei et al., 2017a, 2018; Tamás et al., 2021) compared the average height and diameter of the best clones with those of the control. Along with these indicators, the shape of the trunk was determined. In Hungary, the following classification is used for the evaluation of the stem form: 1 – straight, 2 – more or less straight, 3 – crooked, 4 – strongly crooked (Tamás at al., 2021). German cientists, parallel to growth measurements, assessed the stem shape and crown formation: the number of trees with multiple stems, and forks as well as trees with stem and bark injuries, and branch and crown fractures (Lange at al., 2022).

This paper presents the results of the approval of the method of a comprehensive evaluation of breeding material of Black Locust, which we usually use for other species (Лось та ін., 2018, 2020; Терещенко, Дишко, 2019). We also used a comprehensive approach, which involved evaluating the intensity of growth and the quality of the trunks, but in addition, we introduced indicators of the condition and the proportion of multi-stemmed trees. The first indicator is an indicator of stability, especially in harsh growing conditions. While the indicator of the share of multi-stemmed trees is considered on the one hand as a characteristic of the stem quality, and on the other hand as an indicator of the adaptation of the species, given that the formation of several trunks is characteristic of trees on the borders of the range and in unfavorable growth conditions (Лось, Самодай, Терещенко, Бірченко, 2020).

The conducted studies are pilot and cover only a small area. At the same time, the expansion of similar works covering different regions and forest site conditions using an identic methodology can become the basis for developing recommendations not only regarding the expediency of using Black Locust, but also measures to control and prevent its spread. The development of such recommendations, in turn, requires experiments that would include both the creation of experimental plantations of Black Locust and testing of various measures and approaches to limiting the

spread of the species. It is to develop a tree improvement program for Black Locust in Ukraine, given its multi-purpose use and resistance to harsh conditions. It is necessary to provide for the search for the best stands, the selection of plus trees and the creation of promising varieties based on them for different conditions and regions.

**Conclusions.** The Black Locust stands occupy from 0.5 to 8.1% of the total area of the forest land in Kirovohrad region and from 1.7 to 8.3% at the SE "Oleksandrivsky Forestry". The stands aged from 31 to 60 years predominate.

Summarizing the results of our research at the SE "Oleksandrivsky Forestry", it should be noted that in the vast majority of stands, low invasive activity of Black Locust is noted, in a small number of stands it is absent, or is medium or high. Areas of artificial forests with very high invasive activity were not detected. At the same time, medium invasive activity was detected in 43% of adjacent areas, low – in 29%, very high – in 29%.

The high intensity of Black Locust growth, productivity and selection value in the studied stands at the SE "Oleksandrivsky Forestry" were proven. The complex assessment confirmed the suitability of the species use for the artificial forest and protective stands creation in the south of the Right Bank Forest-Steppe conditions provided that its spread beyond the boundaries of tree stands is controled and, if necessary, its spread is limited.

Two stands that meet the requirements for the plus stands were selected. Possibility of plus trees selection and forest seed base creation is proved.

The proposed methodical approach can be used to determine the invasive activity and selection value of Black Locust. Such comprehensive approach will provide an objective answer to the question of expediency of the species using for afforestation and plantation forestry in a certain region.

**Acknowledgment** The authors would like to thank the employees of the SE "Oleksandrivsky Forestry" for assistance in conducting field work, Tetiana Pyvovar for editing the English text and the anonymous reviewers for their valuable pieces of advice during the preparation of this manuscript.

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# Апробація методики оцінювання інвазійної активності та селекційної цінності *Robinia pseudoacacia* L. в умовах Кіровоградщини

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Проаналізовано таксаційну базу лісостанів Кіровоградської області та здійснено польові дослідження насаджень робінії звичайної віком від 6 до 90 років насінного і вегетативного походження.

Мета досліджень полягала в опрацюванні методики визначення інвазійної активності та селекційної цінності робінії звичайної на прикладі насаджень ДП «Олександрівський лісгосп».

Обстеження деревостанів здійснювали за комплексом показників відповідно до загальноприйнятих таксаційних методик. Комплексне оцінювання насаджень здійснювали на основі суми балів, визначених за середніми значеннями кількісних та якісних показників. Для визначення інвазійної активності робінії звичайної запропоновано методику, яка базується на обліках кількості життєздатного підросту та самосіву. Показники інвазійної активності робінії звичайної на території господарства визначали узагальненням показників по кожному обстеженому виділу, зокрема – частки деревостанів з певною інвазійною активністю робінії. Здійснювали порівняння показників *інвазійної активності* у межах обстежених деревостанах та поза їхніми межами, з урахуванням типу лісорослинних умов, ступеня порушення дернини і підстилки.

Насадження робінії звичайної на території Кіровоградської обл. за групами віку займають від 0,5 до 8,1% від загальної площі лісових земель. Переважають деревостани віком від 31 до 60 років. Більшість робінієвих деревостанів в області ростуть в умовах $D_1$, трохи менше – в умовах $C_2$, $D_2$ і вдвічі менше – в умовах $C_1$. Площі деревостанів робінії в умовах $A_1$, $A_2$, $B_1$, $B_2$ і $D_3$ незначні.

Засвідчено високі інтенсивність росту, продуктивність та визначено селекційну цінність насаджень робінії звичайної. Бонітет переважної більшості з них характеризується I і вище класом. Запас насаджень робінії у віці 59-71 років на окремих ділянках перевищує 400 $м^3 \cdot га^{-1}$. Комплексне оцінювання засвідчило придатність деревного виду для створення лісових культур і захисних насаджень у певних лісорослинних умовах на півдні Правобережного Лісостепу.

Відібрано два деревостани, які відповідають вимогам щодо плюсових. Підтверджено можливість відбору плюсових дерев та створення лісонасінної бази.

На території переважної більшості деревостанів зафіксовано низьку інвазійну активність робінії, для решти насаджень вона відсутня, середня або висока. Ділянок лісових культур з дуже високою інвазійною активністю не виявлено. Водночас на 42,8% прилеглих до деревостанів ділянках виявлена середня інвазійна активність робінії, низька – на 28,6%, дуже висока – на 28,6%.

Запропонований методичний підхід може бути використано для визначення інвазійної активності та селекційної цінності насаджень робінії звичайної. Такий комплексний підхід дасть об'єктивну відповідь на питання щодо доцільності використання деревного виду для лісорозведення та плантаційного лісовирощування у конкретному регіоні.

**Ключові слова**: робінія звичайна; інтенсивність росту; селекційна цінність; природне поновлення.

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