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COMPLEX ASSESSMENT OF THE ADAPTATION POTENTIAL OF AMBROSIA ARTEMISIIFOLIA L. IN THE CONDITIONS OF THE RIGHT- BANK FOREST-STEPPE OF UKRAINE

Abstract. The corresponding literature on the peculiarities of further intensive distribution of *Ambrosia artemisiifolia* L. in Europe and directly in Ukraine have been studied. The botanical characteristics of this plant are given. On the basis of the conducted expeditionary researches, new locations of *A. artemisiifolia* in the conditions of the Right-Bank Forest-Steppe of Ukraine (RBFS) were revealed and the main stages of ontogenetic development were investigated. It was found out that before the winterset in these conditions, this invasive plant has time to produce viable seeds. Data on the ability of *A. artemisiifolia* to tolerate long periods of drought, accompanied by a sharp rise in temperature, have been confirmed. It is also noted that this herbaceous plant tolerates semi-shade conditions satisfactorily. High resistance of *A. artemisiifolia* to sharp fluctuations of air temperature in spring and autumn periods is revealed. The germination energy and seed germination of the studied species, collected in the conditions of the Right-Bank Forest-Steppe of Ukraine, were established by conducting experimental researches. The dynamics of shoot growth during the growing season was observed on the research areas. High regenerative capacity to restore lost organs (shoots) was noted. A method of complex assessment of the adaptation potential of *A. artemisiifolia* is proposed, based on indicators of temperature fluctuations, drought resistance, light requirement, relation to soil fertility, vegetative reproduction, seed reproduction, regeneration of shoots, using complex coefficient of the adaptation potential (CCAAPR). Based on this coefficient, which was calculated according to the formula $CCAAPR = FWR + DR + LR + RSF + VR + SR + RS$, the adaptation potential of *A. artemisiifolia* in the conditions of the Right-Bank Forest-Steppe of Ukraine was determined to be high.

Keywords: *Ambrosia artemisiifolia* L., complex assessment of adaptive potential, stages of ontogenetic development, regenerative capacity, drought resistance, seed reproduction.

Introduction. Due to the quick climate change on our planet, new areas are rapidly being inhabited by invasive herbaceous plants, which negatively affect the



growth of aboriginal species and harm human health. One of such herbaceous plants is a member of the family Compositae, genus *Ambrosia* L. - *Ambrosia artemisiifolia* L., which is rapidly "capturing" the territory of the Right-Bank Forest-Steppe of Ukraine. Currently, *A. artemisiifolia* is one of the most dangerous invasive plants in our country, which has spread to 24 regions (Palamarchuk et al. [9]; M. M. Neilyk, Ya. G. Tsytsiura [1]). The greatest threat is observed during flowering, when the pollen of this plant appears in the air, which causes an acute allergic disease, called "autumn fever" (S.E. Pruntsev [4]). Paying attention to the above said, the development of methods for complex assessment of the adaptation potential of *A. artemisiifolia*, which grows in the Right-Bank Forest-Steppe of Ukraine is quite relevant. Therefore, the aim of our research was to find out the peculiarities of plant growth and development at all stages of ontogenesis, to determine drought resistance, light requirement, relation to soil fertility, regenerative capacity and possible methods of reproduction.

Materials and Methods

Studies of the ontogeny periods of *A. artemisiifolia* were performed by observing their growth and development on the research areas during the growing season. Drought resistance and resistance of these plants to sharp temperature fluctuations during the growing season were performed by the method of visual observations of their leaf apparatus condition. The regenerative ability of shoots was studied during mowing, with intentional damage to the crown. Determination of seed germination energy was performed by germination in Petri dishes in the thermostat at constant temperature of $20 \pm 2^\circ \text{C}$. Seed germination was determined by sowing it into the soil to a depth of 2 cm. To assess each indicator of the adaptation potential of *A. artemisiifolia*, we propose to use the following tribal scales:

- *the scale of temperature fluctuations* was assessed in the following way - 1 point - unstable; 2 points - moderately stable; 3 points - stable;
- *drought resistance* - 1 point - not drought resistant; 2 points - moderately drought-resistant; 3 points - drought-resistant;
- *light requirement* - 1 point – light-requiring; 2 points - moderately light-requiring; 3 points – shade tolerant;
- *relation to soil fertility* - 1 point - related; 2 points - moderately related; 3 points – not related;
- *vegetative reproduction* - 1 point - weak; 2 points - moderate; 3 points - good;
- *seed reproduction* - 1 point - weak; 2 points - moderate; 3 points - good;
- *regeneration of shoots* - 1 point - weak; 2 points - moderate; 3 points - high.

To conduct a complex assessment of the adaptation potential of *A. artemisiifolia*, we propose to use the following formula:

$$\text{CCAAPR} = \text{FWR} + \text{DR} + \text{LR} + \text{RSF} + \text{VR} + \text{SR} + \text{RS}, \text{ where}$$

CCAAPR - coefficient of complex assessment of the adaptation potential of ragweed;

FWR - frost - and winter resistance;

DR - drought resistance;

LR - light requirement;

RSF - relation to soil fertility;

VR - vegetative reproduction;

SR - seed reproduction;

RS – regeneration of shoots.

If the sum of points according to this formula is from 1 to 10 points, the adaptation potential is low; from 11 to 16 points – the adaptation potential is average; from 17 to 21 points - the adaptation potential is high.

Results and Analysis

Stationary studies were conducted in several districts of Cherkasy and Kirovohrad regions adjoining to the railway tracks. Expeditionary researches covered various areas of the Right-Bank Forest-Steppe of Ukraine. Detection of ragweed was performed by expedition-route method.

That according to the expeditionary research, the locations of *A. artemisiifolia* were noted by us in the area around the following settlements: Kyiv; Vinnytsia; Cherkasy; Mohyliv-Podilskii; Berdychiv; Balta; Boryspil; Uman; Kalynivka; Illintsi; Derezhnia; Tetiiv; urban village Novoarkhangelsk; urban village Popilnia; urban village Olexandrivka; the village of Moshny.

A. artemisiifolia is an annual weed from 20 to 250 cm tall that is dangerous to humans and the environment. Externally, this plant resembles *A. absinthium* L., which is widespread in Ukraine.

This annual plant has a strong taproot system, which is able to settle in the soil to a depth of several meters, depleting it. The stem is erect, branched. Leaves are dissected, up to 4-15 cm long, pinnately dissected. The upper side of the leaf blade is dark green, the lower - gray-green, pubescent. Leaves of *A. artemisiifolia* are characterized by the phenomenon of heterophyllia.

Male flowers (collected in baskets) are yellow and form spike-shaped inflorescences. Fruiting of *A. artemisiifolia* takes place only in the conditions of short light period (less than 12 hours). Flowers are unisexual, collected in heterosexual baskets. Female flowers can be located in the axils of leaves and near male inflorescences, several flowers together. They are characterized by pollination - anemophilia. Ragweed pollen is the source of a number of allergic diseases called "pollinosis". On the territory of the Right-Bank Forest-Steppe of Ukraine, the flowering period of *A. artemisiifolia* is observed during the second or third decade of August, and therefore it is during this period that it is the most dangerous. The fruit is an achene.



The homeland of *A. artemisiifolia* is North America. This herbaceous plant came to Europe in the late nineteenth century, and the first memories of its discovery in Ukraine date back to 1914. In the future, with the decrease of forest cover and intensive plowing of areas free from forests, the rapid spread of this dangerous invasive plant is observed (M.M. Neilyk, Ia. G. Tsytsiura [1]).

Ontogenesis is the individual development of a plant from its inception to death. Each of the new periods of ontogenesis has unique physiological properties and morphological features and includes the formation and growth of new structures, as well as physiological changes that prepare the emergence of these structures. The main criteria for the transition of plants from one period of ontogenesis to another in most cases are the emergence of embryonic structures for each period, recognizing that the physiological changes that prepare the emergence of these structures occur at the end of the previous period.

A. artemisiifolia has the following stages of ontogenesis: sm - seeds; p - seedling, which lasts from the beginning of seed germination until the appearance of the first true leaves; j - juvenile (the period in which the intensive growth of the plant takes place); im - immature (the period in which vegetative organs develop and generative ones are not formed); v - virginal (the period in which the most intensive development of vegetative parts of the plant takes place); g - generative (generative organs are developing). It should be noted that there is another period - aging (senile), which begins with the processes of complete cessation of growth and ends with the complete extinction of the plant organism. In the conditions of the Right-Bank Forest-Steppe of Ukraine *A. artemisiifolia* completes its full cycle of ontogenesis by the end of the vegetation.

V. YA. Mariushkina [2] emphasizes that the main reasons for the rapid spread of *A. artemisiifolia* in our country are its bioecological features, namely high seed productivity; strong root system; high regenerative capacity; high ecological plasticity of the species.

Studies of the peculiarities of growth and development of *A. artemisiifolia*, which we conducted in the Right-Bank Forest-Steppe of Ukraine, also noted its high regenerative potential, when the stem was damaged, there was a rapid regrowth of lost organs during mowing around roads and railways.

According to (S.M. Koniakina, I.A. Chemerysa [3]), the high regenerative potential of *A. artemisiifolia* allows to form additional roots and to deepen them successfully even when the shoots are covered with soil, and to form new shoots damaged by mowing the area where it grows. Our research also confirms the high regenerative capacity of *A. artemisiifolia* to restore lost shoots and to allow their rapid settlement. When the shoots are damaged in June - July and early August, the plant has time to restore lost organs and to complete the generative phase (seeds have the property to germinate even in the stage of wax ripeness).

In the conditions of the Right-Bank Forest-Steppe of Ukraine *A. artemisiifolia* shows high plasticity in relation to sharp temperature fluctuations that allows to pass successfully a full cycle of the development and formation of viable seeds annually. During the research period (2021-2022) there were fluctuations (up to 5-10 days) in the phase of the beginning of seed germination, the formation of the first pair of true leaves and the formation of generative organs. Short-term spring and early autumn frosts on the soil surface (several hours of temperature decrease to 2-3 °C did not significantly affect the condition of plants. The effect of different temperature fluctuations on seed germination of *A. artemisiifolia* should be studied separately. Brandes D., Nitzsche J.[5], report that the seeds of this invasive species can germinate at a temperature of 40-45° C. Guillemain J.P. [7]; Leiblein-Wild M.C.[8], observed seed germination in the range from 3.6 to 5.0° C. Therefore, in relation to temperature fluctuations, *A. artemisiifolia* can be referred to the stable group.

Researching the ability of the studied species to withstand high temperatures during the summer, gives reason to attribute it to highly drought-resistant plants. Despite significant fluctuations in temperature, this plant did not show visible signs of deterioration of the external condition of plants. The hottest summer period in the studied years fell on 2021, when the main signs of high temperatures and insufficient soil moisture were low growth rates of the above-ground part of *A. artemisiifolia*. The plant also felt satisfactorily during the long water-logging of the soil in the growth zone of the root system (May - mid June 2021). During the summer period of 2021-2022, in the conditions of the Right-Bank Forest-Steppe of Ukraine, the air temperature was abnormally high (during the day it sometimes reached 38-40°C), at night it dropped to 10-12°C, and the soil moisture was minimal. In terms of drought resistance, these herbaceous plants should be classified as drought tolerant.

A number of researchers (Friedman, Barrett [6]) claim that *A. artemisiifolia* is undemanding to soil fertility, and it can grow satisfactorily on different types of soils, and the most favorable for it are clay and loamy sand, which give it an advantage over other plant species. Pajević S. [10], informs that this species has effective mechanisms of nitrogen use and a high level of photosynthesis / respiration during flowering (Pajević S. [10]). Sang W.G. et al [11] indicates the successful germination of *A. artemisiifolia* seeds in solutions with pH values in the range between 4-12, with a maximum pH of 5-7 in the distilled water. Thus, it can be stated that in relation to fertility and soil pH, the studied plant is unpretentious.

A. artemisiifolia belongs to the group of light-loving plants, but can grow satisfactorily in the conditions of moderate shading. This plant loves sunny places next to the roads, fields, railways. Under these conditions, it produces the largest number of viable seeds.

A. artemisiifolia does not reproduce vegetatively.



In the natural environment and in the areas of its modern distribution, these plants are reproduced well by seed. For several years (2021-2022) we conducted researches to establish the germination energy and soil germination of seeds.

Particular attention during the research of the adaptation potential of the studied species was paid to the impact of the following indicators: temperature fluctuations during the growing season, drought resistance, soil fertility, light and reproductive characteristics.

Analyzing the obtained data, we note that the germination energy of *A. artemisiifolia* seeds collected on the research areas of the Right-Bank Forest-Steppe of Ukraine averaged from 55 to 60%, and soil germination was at the level of 65-73%. Different indicators of germination energy and seed germination are explained by differences in weather conditions of separate years.

For several years, we also observed the dynamics of the increasing number of *A. artemisiifolia* in the research areas. The control variant (№ 1) was the area that was not covered with gravel and was located near the railway track of the urban village Novoarkhangelsk, Golovanivskii district, Kirovohrad region. Other research areas were located near the railway stations, along the tracks, in the city of Uman, Cherkasy region (№ 2); the city of Balta, Odessa region (№ 3); urban village Novoarkhangelsk (№ 4). The parameter of each research area was 100 m².

In 2021, 20 plants grew on the research area № 1 (control), and in 2022 their number increased to 35. It is noted that the tendency in increasing the number of plants for the next year in comparison with the previous year, was observed in other areas too : № 2 - 8 plants in 2021 and 15 - in 2022; № 3 - 3 plants - in 2021 and 7 - in 2022; № 4 - respectively 12 and 19 plants. It should also be noted that the plants of the studied species grew in the well-lighted conditions.

Researched investigating the peculiarities of seed germination on the research areas, the dynamics of shoot growth was studied as well. Analyzing the obtained data, the highest growth of *A. artemisiifolia* shoots was observed in May - mid-June from 20 to 71 cm. A sharp decrease in growth was observed during the end of June - August - from 5 to 37 cm.

Due to the great harmfulness of *A. artemisiifolia*, which grows in the Right-Bank Forest-Steppe conditions, there is a need for a complex assessment of the adaptation potential. To do this, we propose to use the following indicators (Table 1):

Table 1.

| Indicators of the adaptation potential of <i>A. artemisiifolia</i> | | | |
|--|------------------------------|---------------|---------------------------------------|
| No | Indicators | Score, points | Note |
| 1 | temperature fluctuations | 3 | |
| 2 | drought resistance | 3 | can grow evenly in water-logging soil |
| 3 | light-requiring | 2 | |
| 4 | relation to soil fertility | 3 | |
| 5 | vegetative reproduction | – | vegetative |
| | reproduction is not detected | | |
| 6 | seed reproduction | 3 | |
| 7 | regeneration of shoots | 3 | a rapid recovery of lost shoots |

Source: developed by the authors

The obtained points (Table 1) for each individual factor were inserted into the formula for a complex assessment of the adaptation potential of *A. artemisiifolia* - $CCAAPR = 3 + 3 + 2 + 3 + 3 + 3 = 17$ points. Based on the score, it can be concluded that in the conditions of the Right-Bank Forest-Steppe of Ukraine, this plant shows a high adaptive potential.

Conclusions. Based on the research on the adaptation potential of *A. artemisiifolia* in the Right-Bank Forest-Steppe of Ukraine, the following conclusions can be made:

- Ontogenesis of *A. artemisiifolia* in the conditions of the Right-Bank Forest-Steppe of Ukraine was studied and it was found out that by the end of the vegetation period it has time to pass all the stages of its development.
- High regenerative potential is noted, which is manifested in the rapid restoration of the above-ground part and the formation of generative organs and the subsequent formation of viable seeds.
- High ecological plasticity of *A. artemisiifolia* to sharp temperature fluctuations in the phase of the beginning of seed germination, the formation of the first pair of true leaves and formation of generative organs was revealed. It is noted that short-term spring and early autumn frosts on the soil surface do not significantly affect the development of these plants.
- It has been confirmed that *A. artemisiifolia* is a drought-resistant plant that is able to withstand long periods of drought and sharp fluctuations in temperature



with minimal soil moisture, when during the day the temperature sometimes reached 38-40 °C and at night dropped to 10-12° C.

– It is noted that in the conditions of stationary researches (research areas № 1-4) *A. artemisiifolia* successfully grows on soils of different pH levels and is undemanding to their fertility.

– High indicators of germination energy (55-60%) and seed germination of *A. artemisiifolia* (65-73%) growing in the conditions of the Right-Bank Forest-Steppe of Ukraine were established.

– There is a clear tendency in increasing the number of *A. artemisiifolia* plants on the research areas - 20 plants grew on the research area № 1 (control) in 2021, and 35 - in 2022; № 2 - 8 plants in 2021 and 15 - in 2022; № 3 - 3 plants - in 2021 and 7 - in 2022; № 4 - respectively 12 and 19 plants.

– A study of the growth dynamics of *A. artemisiifolia* seedlings on the research areas was done and it was found out that the largest increase in shoots occurs in May - mid June (from 20 to 71 cm), and a sharp decrease in growth occurs in late June - August (from 5 to 37 cm).

– The technique of complex assessment of the adaptation potential of *A. artemisiifolia*, on the basis of point indicators of temperature fluctuation is offered to use; drought resistance; light requirement; vegetative and seed reproduction; regeneration of shoots and the coefficient of integrated assessment of the adaptation potential. According to this method, the adaptation potential of this plant in the conditions of the Right-Bank Forest-Steppe of Ukraine is high.

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