The issues of weed infestation with environmentally hazardous plants and methods of their control

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Abstract

The authors analyze expansion of segetal and ruderal vegetation on agricultural lands in Leningrad and Tomsk oblasts, typical for the European and Asian parts of Russia. The spreading conditions, composition of species, biological features and ecological requirements of the most aggressive species are identified. Some effective ways of weed control are suggested.

1. Introduction

Agricultural land areas in Russia and other countries of the former Soviet Union have reduced for recent years [1, 2], as well as the agricultural land use efficiency [3]. Soil fertility decline, water logging and weed infestation of the fields are conditioned by the shortage of funds, necessary for modern farming techniques, [4]. The relevance of research is determined by the urgent need for agricultural producers to develop strategic directions for weed control, based on long-term prognosis. The weeds include “wild plants growing on farmlands and reducing the size and quality of the products” [5]. They are classified into segetal (field weed, plow land weed), plants of natural lands, ruderal (weeds, coarse grasses, and wasteland plants) and plants of special areas [6, 7]. Weeds are the companions of cultural and compete with them for minerals and moisture, shading them, slowing growth and development. Species composition of weeds agrocoenosis includes: a) a complex of species naturally and steadily growing in the fields, b) species originating from ruderal habitats due to lower levels of agricultural technology, c) adventitious species classified as harmful in other regions. Weed dispersal speed depends on the biological characteristics: plasticity, competitiveness, productivity, etc.

The objectives of the study were to analyze the species composition, identify the most aggressive weeds in European and Asian parts of Russia using Leningrad and Tomsk oblasts as an example, and test effective ways of weed control.

2. Objects and methods of research

The objects of the study were weeds common to the European and Asian parts of Russia. Long-term data were used for analysis, with minimum period of five years. Statistical, analytical and cartographic methods were used in the research.

3. Results and discussions

298 weed species from 38 families are currently growing in Leningrad oblast; 25 representatives of Asteraceae, Leguminosae, Buckwheat, Brassicaceae, Poaceae families dominate [8]. More than 50 years of observations reveals the stability of the floristic structure of the spectrum. The fields of Tomsk oblast are the habitat for 22 species of weeds. Many of them are cosmopolitans and common to the crops all over Russia, including Leningrad oblast (quinoa, field sow thistle, couch grass and mayweed, etc.) (figure 1). The most aggressive are field sow thistle and pink, couch grass, quinoa and duck wheat (representatives of Asteraceae,

Chenopodiaceae and Polygonaceae families) [9]. Their leadership is conditioned by high seed productivity, long-term organic rest of seeds and several life forms. The roots of the field sow thistle, sow-thistle pink and quinoa are able to penetrate the soil to the depth of four to five meters and reach moistened layers. Thlaspi arvense, Fumaria officinalis, Pinweed and Hemp nettle are probably the least typical for the region (figure 1). High moisture in Tomsk region (hydrothermal coefficient is 1.4-1.2 [10]) facilitates aggressive spread of segetal and ruderal vegetation. Studies of spring and winter crops fields, which were carried out in 2010-2015, revealed their 100% infestation [11] (figure 2).

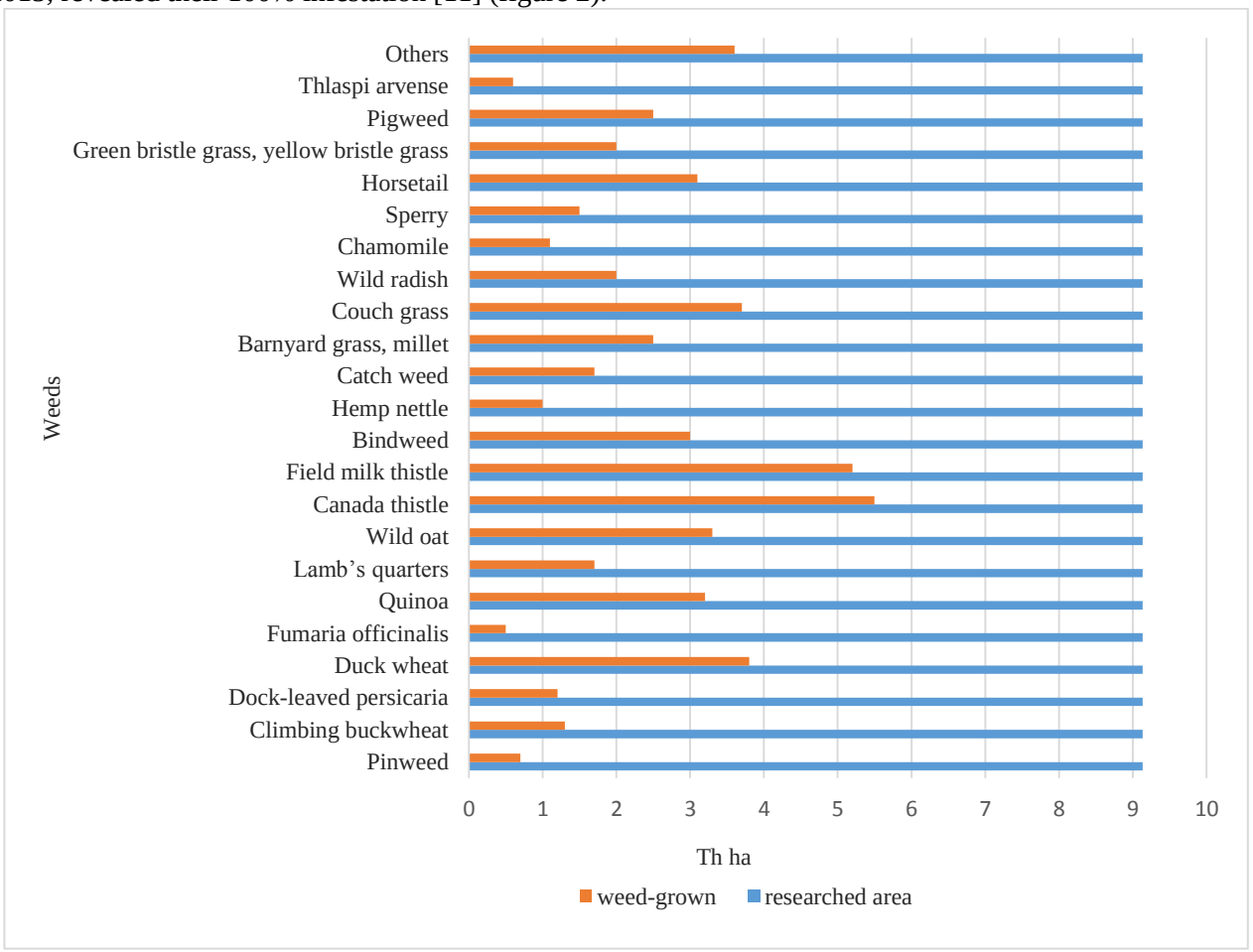
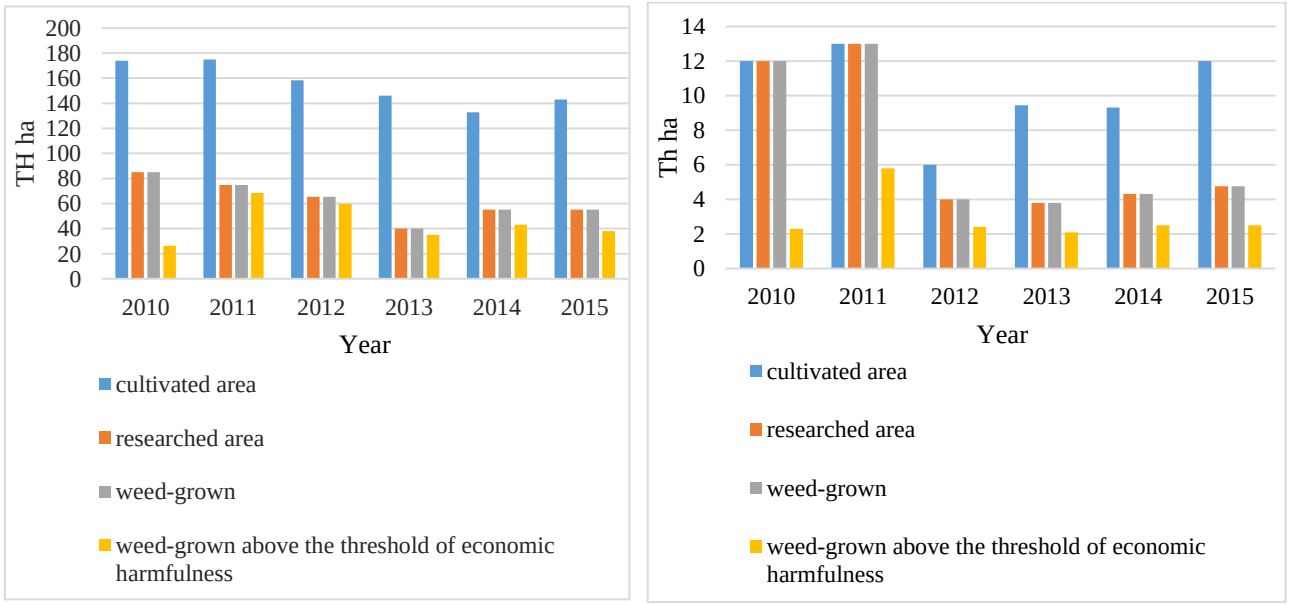


Figure 1. Correlation between weeds in spring wheat culture of Tomsk oblast in 2015 [data 8]



A B

Figure 2. Dynamics of weediness in Tomsk oblast for 2010-2015
A - Spring crops, B – winter crops [data 10]

There are some ways of weed infestation: abandoned and infested areas, sowing of untreated seeds, and fresh manure application. High level of weed infestation in Tomsk region results from the lack of agro-technical works, lack of mineral nutrition for crops and favorable agro-climatic conditions for regional mass distribution of cosmopolitan weeds.

A giant Sosnovskyi cow parsnip plant (Heracleum Sosnovskyi Manden) (hereinafter cow parsnip) is the major environmental threat for the European part of Russia. It was brought from the Caucasus to the northern regions of Russia in the mid 40-ies of the last century. A type of cow parsnip resistant to harsh climatic conditions was fancied as a forage crop. It allowed obtaining about 500-600 kg / ha of green mass over a growing season [12, 13]. With the dramatic decline in agriculture, it stopped being mowed. The plant began to spread on derelict lands, garden plots, slopes of drainage canals, roadsides, forming arrays ranging from a few square meters to several hectares. The plant is 1.5-3.0 m high, the thickness of the base is 4-6 cm. Root system is strong, well developed, penetrates the soil to 70 cm and deeper. Having high reproductive capacity, one plant produces 5 - 20 thousand seeds per year, which are able to germinate for 5-6 years and are spread by wind, surface water, birds, and vehicles. The average life of the plant is 8 years, with the reproductive stage starting in the 2nd year [14].

There are no natural enemies of cow parsnip due to the presence of furocoumarins, so it is little damaged by herbivores. The plant is hazardous for human health, since skin-to-furocoumarins contact under the influence of ultraviolet sunlight causes burn-like dermatitis (the1st, 2nd and 3rd degree - depending on contact time). There are cases of toxicological poisoning, accompanied by disorder of the nervous system and the heart muscle work [15].

Strong competitiveness in the ecosystem and sustainability to the adverse factors of environment allow Sosnovskyi cow parsnip to be more aggressive and impervious compared to related species. [16] It captures the sunniest and most fertile areas, displaces natural vegetation, and forms a new monospecific successional system. According to our estimates, cow parsnip is able to capture about 5-7% of new territories annually, which will cause significant economic losses due to infestation and non-use of lands.

The area, covered with cow parsnip, and the rate of its spread are so great, that it is almost impossible to make an up-to-date map of cow parsnip infestation. We made an attempt to analyze and visualize the open access information in the issue for the European part of Russia. The administrative region was taken as an information unit. The areas “damaged” by uncontrolled spread of the species are marked on the map (figure 3).

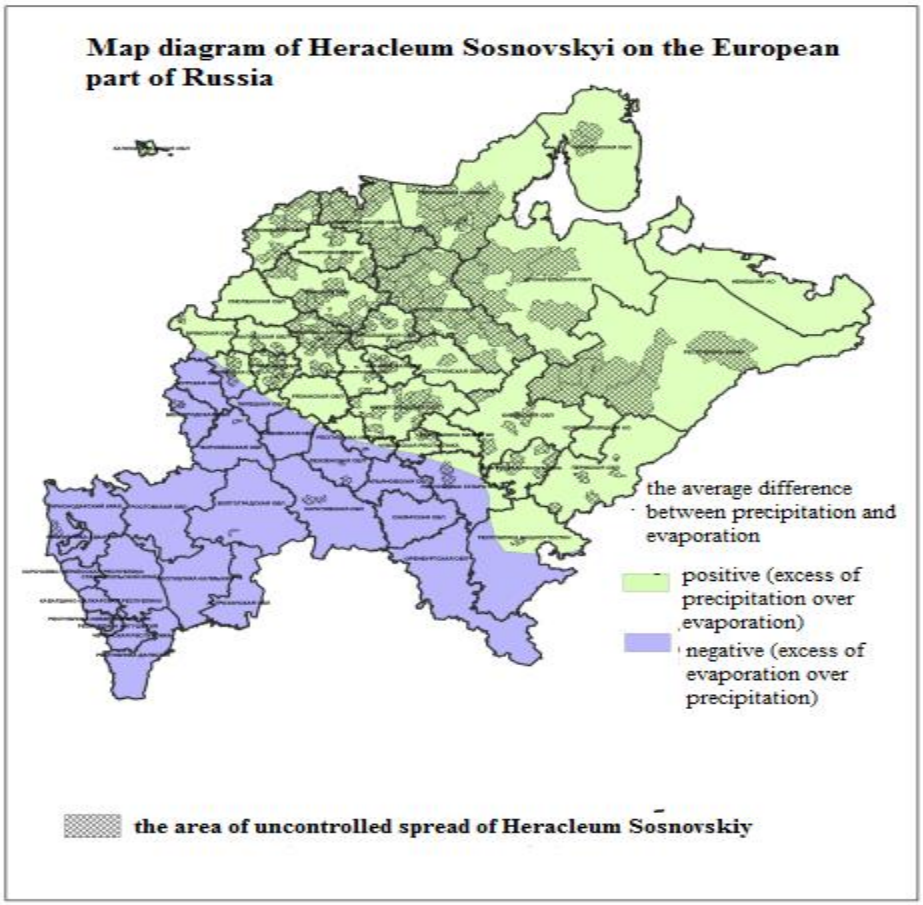


Figure 3. Map diagram of Heracleum Sosnovskyi spread on the European part Russia

The secondary area of cow parsnip distribution in the European part of Russia is almost identical to the zones of excessive (Northwestern Federal District) and adequate (the major part of Central Federal District) moistening [17]. It can be obvious from the map (figure 3), where the areas with positive and negative values of the difference between the average annual precipitation and evaporation, which characterizes moisture content of the area, are shown in different colors. The only factor impeding further spread of cow parsnip southward is insufficient humidity of climate, which previously prevented its cultivation. However, the cow parsnip has recently appeared in the areas associated with unstable and insufficient moisture (Belgorod, Voronezh, Penza, Saratov, Ulyanovsk regions). The obtained data are incomplete; nevertheless, it allows evaluating the scale of the disaster and can help to forecast the areas of further spread of the species. The most infested areas are Leningrad, Moscow, Ivanovo, Kirov, Novgorod, Pskov, Vologda, Arkhangelsk, Tula, Yaroslavl regions. The southern part of the Komi Republic is threatened by cow parsnip infestation: the plant communities intensively spread the agricultural lands and settlements of the region.

In 2013, more than 83 thousand hectares of land in Leningrad oblast were reported to be cow parsnip infested. The analysis of current situation and the forecast showed that unless the problem is taken under control, 25-30% of the land in natural landscapes and up to 15-20% of agricultural lands may be infested in 10 years. In this regard, the studies related to developing effective low-cost measures to control this dangerous type of weed and restoration of natural ecosystems become extremely important. Environmental conditions in Leningrad oblast are favorable for cow parsnip [17], which allows it to spread on the whole territory.

A field experiment was used to study the effect of agricultural activities on the growth of cow parsnip. We carried out plowing, disking, harrowing of soil infested with cow parsnip, followed by planting of vegetable crops, as well as burning of old vegetation. Before agronomic tillage, the abundance of cow parsnip in phytocenosis was 5 - 12 plants per 10 m2. Next autumn plowing was followed by disking. In

spring only individual plants of cow parsnip were observed on the plowed field. At the end of May the farming techniques were repeated and dill was planted. In September, cow parsnip was reported to occur very rare and grow in single specimens. Thus, we assume that the agricultural techniques ensure effective elimination of cow parsnip. It should be noted that the agricultural methods are to be carried out regularly for several years, since large supply of seeds in the soil allows the plant to restore the population quickly. The burning of old vegetation in ecosystem of old-growth reclaimed meadows did not have negative impact on the spread of cow parsnip.

In order to study the effect of herbicides on the reproductive capacity and destruction of cow parsnip was field experiment was conducted in Vyborg district, Leningrad oblast. The mixture of herbicides (glyphosate, banvel) at doses of 1 - 8 l / m2 of the soil surface was tested. The plants were treated in the stem extension stage, on June 9. The most effective dose for the destruction of cow parsnip was reported to be a mixture of glyphosate and banvel BP 8 l / m2 in the ratio 3: 1 respectively. Three weeks after the treatment the stems and leaves of the cow parsnip wilted, and the roots of the 1st, 2nd and 3rd order blackened. However, the seeds, that were present in the soil, were not damaged and after a while they gave shoots. The ecosystem started to restore gradually one month after the chemical treatment. Barbarea vulgaris, galeopsis common, pigweed white, and foal foot were the first herbs that occurred in the area.

One more field experiment was conducted to study the impact of mulching with black film on the growth and development of the cow parsnip. The field experiment took place in Vyborg district, Leningrad oblast. In early May the meadow land infested with cow parsnip (on the average 2 plants per 1 m2; rosette phase) was covered with black film, which was removed after 3.5 months. 100% of cow parsnip plants died, moreover, the seeds taken from the soil surface after mulching, did not germinate.

Thus, we assume that the method of cow parsnip mulching on the early stages of its development is a highly efficient way to control it. Further soil cultivation and sowing of perennial grasses allowed restoring the aboriginal ecosystem.

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