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Cyclachaena xanthiifolia (Nutt.) Fresen. spreading, abundance and occurrence in Ukraine

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Cyclachaena xanthiifolia is one of the expansive and dangerous weed plants in the Asteraceae family in Ukraine. We have identified *Cyclachaena xanthiifolia* in all ruderal, segetal, and natural plant communities, as well as in various growing areas, from overmoistened meadows and forests to xerophytic steppe lands. *Cyclachaena xanthiifolia* spreading in agrophytocenoses was reliably associated with twelve melons and gourds, vegetable, and tilled crops. Such connection was not discovered with winter and fodder crops.

Spacing of *Cyclachaena xanthiifolia* in ruderal phytocenoses was diffuse or clumped; spacing in agrophytocenoses was single or by separate spots; spacing in natural sites was sporadic or by individual plants at considerable distances from each other.

The highest frequency of *Cyclachaena xanthiifolia* occurrence was in ruderal areas: landfills, manure storage areas, along the roads, R=93-100%; a little less occurrence was on pastures, along the fields edges, along the embankments, streets, canals, shelterbelts, R=56-74%; insignificant occurrence was in plating of tilled, vegetable and spring grain crops, R=35-47%; and single plants occurrence was in plating of perennial grasses and winter crops.

The plants greatest density (80-120 pcs/m^2) was in the Northern and Southern steppe zones; the lesser density (20-30 pcs/m^2) was in the Forest steppe and Dry steppe zones; and the smallest density (4-8 pcs/m^2) was in Polesie and mountainous areas.

In landfills, wastelands, manure storage areas, and livestock farms, the number of *Cyclachaena xanthiifolia* plants in the seedling stage reached 420-480 pcs/m^2 and 60-110 pcs/m^2 in the stage of seed maturity. Along the field roads, forest shelter belts, canals, streets, and hedges, the plants density was 260-340 and 20-90 pcs/m^2, respectively.

The ability of *Cyclachaena xanthiifolia* to the ubiquitous intensive spreading, dissemination and naturalization was determined by the method of seed spreading. In Ukraine, it was characterized by both natural and anthropochorous ways of seeds spreading. The natural way (85%) was more pronounced on ruderal habitats, and the anthropochorous way (90%) was pronounced in the agrophytocenoses.

Keywords: *Cyclachaena xanthiifolia*; spreading; abundance; occurrence; agrophytocenoses; Ukraine

Introduction

In the last 20 years, the naturalization of new types of weeds in agricultural crops has become an extremely urgent problem. They are able to successfully compete with both existing weeds and cultivated plants (Protopopova, Shevera, Mosyakin, 2009; Tkach, Sherstoboeva, 2013; Follak, Dullinger, Kleinbauer I. et al. 2013; Konoplia, Kurdyukova, Zherdeva, 2014; Kurdyukova, Maslijov, Zherdeva, 2014; Kurdyukova, Zherdeva, 2014, 2015).

One of such expansive and dangerous species is *Cyclachaena xanthiifolia* in the Asteraceae family. It was introduced by Kiev Botanical Garden in 1840. In 1842, it became wild and was found on the streets of Kiev (Rogovich, 1869).

During the course of 60 years after the introduction, it spread only within the Kiev region. Over the next 40 years, it has significantly expanded its presence, but has not extended beyond the limits of the Forest steppe. Later, during 50 years, it was settling throughout the territory of Ukraine only in ruderal areas (Rogovich, 1869; Kotov, 1927, 1949; Protopopova, 1973).

It was referred to the weed plants group in 1925 after the finds in wastelands, pastures, and meadows (Protopopova, 1973). In the last 20 years, it began to be found in crops (Dranishhev, Malyhin, 2004; Kurdyukova, Konoplia, 2012, 2018; Kurdyukova, 2018).

Having a broad ecological lability, *Cyclachaena xanthiifolia* has shown significant resistance to adverse environmental factors in the recent years. It gives it a high intensity of spreading throughout Ukraine, while a high allelopathic activity as well as the absence of natural enemies provides it with a high competitive ability in both ruderal and segetal ecotopes (Kurdyukova, Konoplia, 2012; Tkach, Sherstoboeva, 2013; Konoplia, Kurdyukova, Zherdeva, 2014; Kurdyukova, Zherdeva, 2014).

Therefore, determining the time, ways and foci of occurrence, intensity of migrations, possibilities of penetration into various agrophytocenoses and *Cyclachaena xanthiifolia* fixing in them is extremely important for assessing the herbal status of territories and agrophytocenoses.

The aim of our work was establishing the habitats, abundance and characteristics of *Cyclachaena xanthiifolia* spreading in the natural and anthropogenically disturbed phytocenoses of Ukraine.

Materials and methods

The studies were carried out by the expeditionary method during 2014-2018. Own gatherings and herbarium collections from Ukraine and Russia were taken as the materials for the studies. Frequency of occurrence (R%) was defined as the ratio of the number of registration plots, whereon the species was recorded, to the total number of plots surveyed. Plants spacing was represented by four indicators: single spacing (individual plants at a great distance from each other); spots or clumps (individual clusters or groups in small areas or territories); sporadic spacing (dispersed location or by groups in ecologically defined areas or flora complexes); diffuse spacing (even location throughout the site or territory at a short distance from each other). Plants abundance or density was determined by direct counting per 1 m^2 in 6-12 replicates.

Results and discussion

Inside the territory of Ukraine, we have found *Cyclachaena xanthiifolia* in all ruderal, segetal, and natural plant communities, as well as in various growing areas, from overmoistened meadows and forests to xerophytic steppe lands (Figure 1).

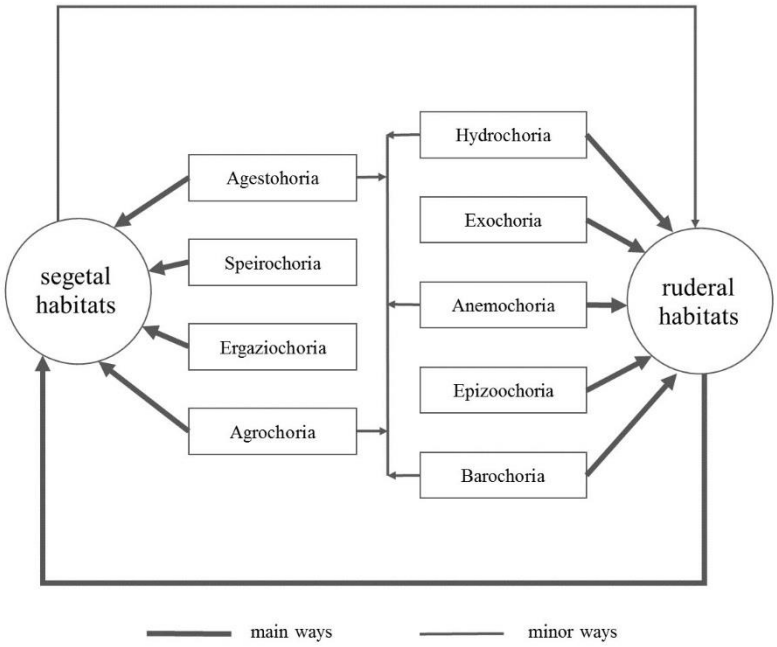

Figure 1. Spreading and number of *Cyclachaena xanthiifolia* populations in natural phytocenoses, agrophytocenoses and uncultivated lands of Ukraine, 2014-2018.

Agrophytocenoses: 1. Tomato, pepper, eggplant; 2. Watermelon, melon, pumpkin; 3. Sunflower, corn, sorghum; 4. Barley, oats, spring crops; 5. Perennial herbs; 6. Wheat, rye, barley, winter crops.

Uncultivated lands: 7. Landfills; 8. Along the streets; 9. Industrial sites; 10. Along the roads; 11. Along the railways; 12. Territories of livestock farms; 13. Gardens, squares, parks.

Natural phytocenoses: 14. Edges of floodplain forest; 15. Steppe pastures; 16. Lowland meadows; 17. Flood meadows; 18. Preserved steppes.

Cyclachaena xanthiifolia spacing on uncultivated lands was diffuse or clumped with uniform single or cluster plants location in coenopopulations, whereas in agrophytocenoses its spacing was by single individuals or separate spots within the field and crop rotation, and in natural sites the spacing was sporadic (by groups in defined flora complexes) or single, i.e. by individual plants at considerable distances from one plant to another.

The nature of *Cyclachaena xanthiifolia* positional application in phytocenoses was the same in both tolerant and regressive populations.

Frequency of occurrence and density of plants in coenopopulations were determined by both natural and anthropogenic factors.

The highest frequency of *Cyclachaena xanthiifolia* occurrence was in ruderal areas: landfills, manure storage areas, along the roads, R=93-100%; a little less occurrence was on pastures, along the fields edges, along the embankments, streets, canals, shelterbelts, R=56-74%; insignificant occurrence was in plating of tilled, vegetable and spring grain crops, R=35-47%; and single plants occurrence was in plating of perennial grasses and winter crops (Figure 2).

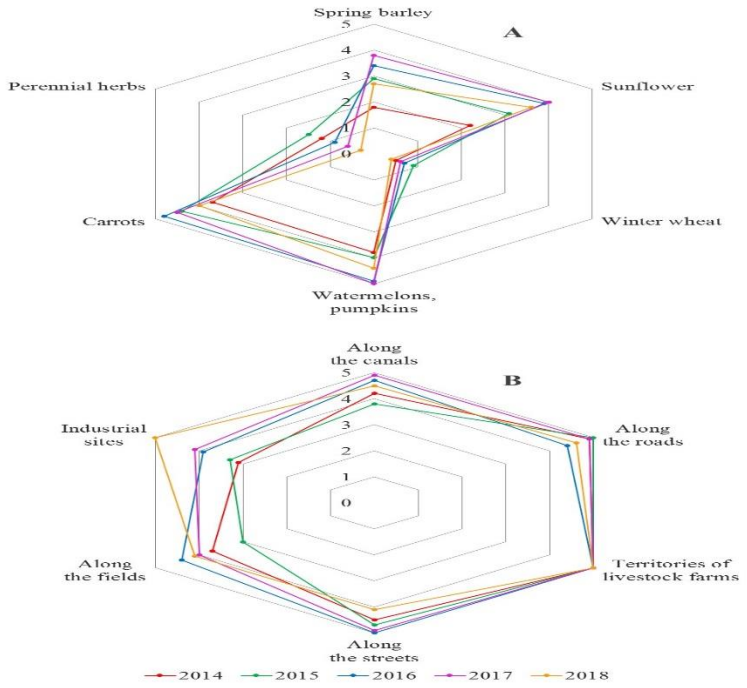

Figure 2. Classes of Cyclachaena xanthiifolia occurrence in agrophytocenoses (A) and uncultivated lands (B).

The highest density of plants (80-120 pieces/m^2) was in coenopopulations of the Northern and Southern steppe zones; the lesser density (20-30 pieces/m^2) was in Forest steppe and Dry steppe zones; and the smallest density (4-8 pieces/m^2) was in Polesie and mountainous areas.

The number of seedlings reached 420-480 pieces/m^2 in landfills, wastelands, manure storage areas, and livestock farms, where *Cyclachaena xanthiifolia* formed monodominant communities; and 60-110 pieces/m^2 in the stage of seed maturity. Along the field roads, forest shelter belts, canals, streets, and hedges, the plants density was 260-340 and 20-90 pieces/m^2, respectively (Table 1).

Table 1. Density of *Cyclachaena xanthiifolia* plants (pcs/m2) in agrophytocenoses and uncultivated lands, 2014-2018.

Vegetation	**Natural zones of Ukraine**					
	Northern steppe	**Southern steppe**	**Forest steppe**	**Polesie**	**Dry steppe**	**Foothills**
Melons and gourds	48/27*	26/21	33/25	16/20	21/20	24/19
Sunflower	43726	43602	43658	43532	43656	43752
Barley, spring crops	15/-	9/-	8/-	4/-	7/-	10/-
Vegetable crops	43721	43784	43656	43498	43528	43688
Pastures	45/31	43/26	47/34	24/21	29/25	38/36
Landfills	480/109	466/97	472/110	420/68	443/71	468/84
Wastelands	429/84	441/90	470/62	437/75	440/60	422/81
Along the field roads	321/20	340/31	298/48	284/56	255/61	260/78
Along the forest shelter belts	293/36	303/64	277/33	265/49	250/60	271/69
Along the canals	260/82	276/77	268/66	261/89	276/80	289/90
Along the fields	316/70	339/75	316/62	327/88	320/78	311/80

***Note:** The seedling stage is in the numerator; the stage of seed maturity is in the denominator.

When introduced into the new ruderal plant communities, *Cyclachaena xanthiifolia* quickly squeezed other types of weeds out of them and became dominant with a participation share from 44% to 100%. It was not affected by any disease, was not damaged by pests, and was not eaten by animals; it formed continuous thickets with plants average height of 201-244 cm and biomass of 3,0-7,0 kg/m^2.

Cyclachaena xanthiifolia spread to agrophytocenoses from the ruderal growing areas. Its seeds were distributed to crops by wind and water, with the help of animals, with dung, by agricultural machines and implements. In spring time, in 0-30 cm soil layer on the edges of fields littered with *Cyclachaena xanthiifolia*, 32,4 thousand pieces/m^2 of its seeds were found; 23,0 thousand pieces/m^2 were found at a distance of 20 m from the edge of the field; 16,1 thousand pieces/m^2 at a distance of 50 m; 6,9 thousand pieces/m^2 at a distance of 100 m, and 1,5 thousand pieces/m^2 at a distance of 200 m.

At an average for 2014-2018, in the phase of two pairs of true leaves in sunflower crops, the number of *Cyclachaena xanthiifolia* plants was 65 pieces/m2 at a distance of 20 m from the edge of the field; 37 pieces/m^2 at a distance of 50 m, 22

pieces/m^2 at a distance of 100 m, and 14 pieces/m^2 at a distance of 200 m. In crops of spring barley on an area of 80-100 hectares, 16 to 28 clumps of *Cyclachaena xanthiifolia* with a size of 9-610 m^2 were found with the same plant density of 24-47 pieces/m2. In vegetable crops, its distribution was uniformly scattered with a density not exceeding 1-5 pieces/m^2.

Cyclachaena xanthiifolia spreading in agrophytocenoses was reliably associated with twelve melons and gourds, vegetable, and tilled crops. Such connection was not discovered with winter and fodder crops (Table 2).

Table 2. The results of analysis of variance of *Cyclachaena xanthiifolia* distribution condition by type of crops, 2012-2018.

Agriculture	**Fisher index, F**	**Statistical Significance, P**	**Renewal Index, I**
Watermelon, melon, pumpkin	2,56	0.05	0.95
Cucumber, zucchini	2,11	0.02	0.93
Carrots, beetroot	3,27	0.16	0.94
Tomato	2,95	0.18	0.93
Sunflower	1,88	0.01	0.86
Corn, sorghum	2,69	0.09	0.86
Wheat, rye, barley, winter crops	2,30	2.7	0.65
Barley, oats, spring crops	2,52	0.23	0.7
Alfalfa for green fodder	1,73	2.1	0.21
Pea-oat mixture for fodder	2,44	3.03	0.32

The ability of *Cyclachaena xanthiifolia* to the ubiquitous intensive spreading, dissemination and naturalization was determined by the method of seed spreading. In Ukraine, it was characterized by both natural and anthropochorous ways of seeds spreading. The natural way (85%) was more pronounced on ruderal habitats, and the anthropochorous way (90%) was pronounced in the agrophytocenoses. In both cases, complex combinations of spreading ways with 2 to 4 dominants were identified (Figure 3).

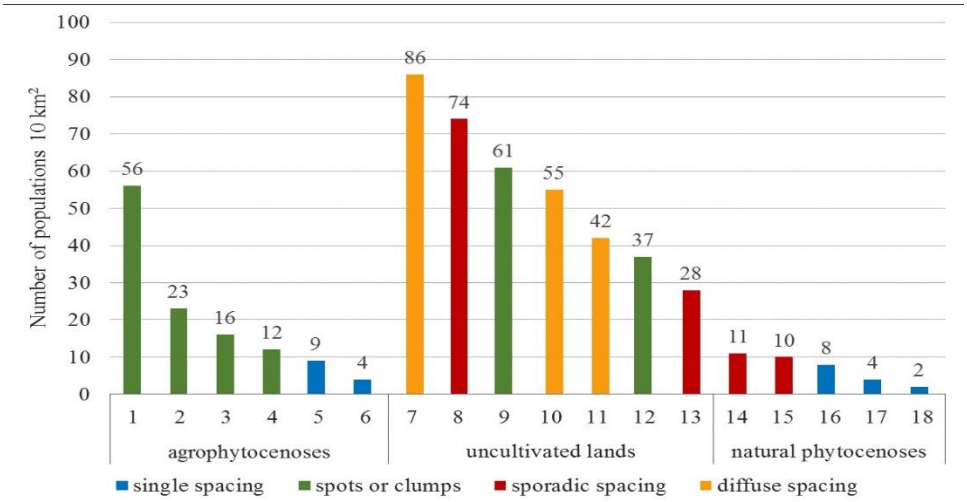

Figure 3. Ways of *Cyclachaena xanthiifolia* seeds spreading in ruderal and segetal growing areas.

Cyclachaena xanthiifolia renewal indices were mainly determined by the edaphic conditions of the growing areas and increased with improved feeding conditions from 0.50-0.60 at industrial sites and residential areas to 0.93-0.96 at landfills, manure storage areas, and farm areas. In agrophytocenoses, *Cyclachaena xanthiifolia* maximum renewal indices (0.93-0.95) were typical of melon and vegetable crops.

Conclusion

Cyclachaena xanthiifolia spreading in agrophytocenoses occurs from the edge of the field to the center. The main sources of *Cyclachaena xanthiifolia* occurrence in the fields are uncultivated lands. Its distribution, spreading and naturalization in agrophytocenoses occurs according to the following scheme: natural or anthropogenic distribution of single or several plants in the field; seed formation and fall; further dissemination in the places of distribution; naturalization and dissemination in the places of distribution; formation of micro and macrofoci in the places of distribution; growth of populations and diasporas radial distribution beyond the distribution location. This scheme is the basis for the development of a system for preventing the occurrence and distribution of *Cyclachaena xanthiifolia* in agrophytocenoses.

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