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Weed activity in arable plant communities in the Central Urals (Sverdlovsk oblast)

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Abstract

Weed activity is an integral criterion based on the abundance and frequency of weeds occurrence in crops. Identifying the aggressive, underactive and nonactive weed species is essential for effective agriculture management. In arable plant communities of the Central Urals there are four activity groups of weeds. The group of the most active (aggressive) weeds includes 40 species or 16% of weed species present in the Central Urals. Within this group, weeds most common in crops form a group of highly active species with a high abundance (7% of the total weed species composition). The remaining 9% comprise a group of moderately active weeds which can also be considered as the most adapted to arable plant communities. Underactive and nonactive weeds make up most of the area's weed species composition (84%). Underactive weeds (82 species or 32%) were found in arable plant communities of many crops, but mainly in small numbers. The group of nonactive weeds was the most diverse and included about half of the weed species present in the Central Urals (52%).

Keywords: alien species, arable plant communities, cereal, crops, root crop, weeds

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Introduction

In Russia there is a large number of long-term studies of weed species composition (in the northwest and middle zone of the European part of Russia (Mirkin et al. 1985; Ulyanova 1985; Terekhina 2000; Ulyanova 2005; Khasanova et al. 2014; Palkina 2015; Tuganayev et al. 2015; Khasanova et al. 2016; Tretyakova and Kondratkov 2018a, 2018b; Kondratkov and Tretyakova 2019a, 2019b). It was shown that the regional weed species diversity varies from 200 to 350 species and the level of weed species richness was positively related to the area under crops (Tretyakova et al. 2020).

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We suggest that the study of weed species composition should be amplified by their activity in arable land by which we mean the selection a group of aggressive and competitive weeds, random weeds, and a transitional group in which weeds can change their status under various circumstances. Unfortunately there are no generally accepted classifications of weeds by activity in arable land as well as there are no fixed terms for the weed groups, however, some researchers distinguish different groups of weeds calling them noxious weeds, aggressive, competitive, obligate or facultative, economically significant or not significant (e.g. Holzner 1982; Gbèhounou 2013; Galon et al. 2015; Palkina 2015; Rana and Rana 2016).

The assessment of weed activity will allow to develop a phytosanitary zoning scheme of Sverdlovsk oblast. It is necessary for predicting the weed contamination of crops and developing the protective measures. All this will contribute to the optimization of regional farming systems.

Materials and methods

The study was carried out in Sverdlovsk oblast, the Central Urals. The area of the region is 194.8 thousand km²; its length from north to south is 660 km and from west to east is 560 km. The northern border of Russian agriculture passes through the region; therefore, the arable areas are located mainly in the southeastern and south western parts of the region (the southern taiga and northern forest-steppe). The extreme northern areas under crops are in Alapaevsk district (the middle taiga). In the southern part of the region gray forest soils are prevalent, and in the extreme southwest and southeast there are leached and podzolized chernozems and meadow-chernozem soils.

The climate of the studied area is continental. The annual amount of precipitation decreases from north (450–650 mm) to south (350–320 mm). The average temperature in July (the warmest month) is +18°C. The average temperature in January (the coldest month) is –16°C. The duration of the snow cover lasts 150–160 days in the western and southern parts and 170–180 days in the northern part. The thickness of the snow cover is up to 70 cm. The duration of the growing season varies from 160–170 days in the west and south and 110–120 days in the northern part. Late spring and early autumn frosts are common, which markedly shorten the frost-free period. The positive temperatures sum varies from 1 800°C (in the north) to 2 300°C (in the south). The hydrothermal coefficient varies along here from 0.85–1.8.

According to the Russian Federal State Statistics Service, the areas under crops in Sverdlovsk oblast reached 835.9 thousand ha, which is 4.3% of the total region area. Among agriculture forage crops (51.4%), grain and leguminous crops (39.5%) are most prevalent. The proportion of industrial crops and open ground vegetables is 2.5% and 6.6% respectively.

The study of the weed species composition was carried out in 2015–2019 by the method of route counts (Baranova 2002; Scherbakov and Maiorov 2006) in all the arable areas in the region. One route covered one cultivated crops field and came to no less than 400 m per each field. The study of weed communities of industrial, row crops and perennial grasses began with the stage of stemming and branching, for grain crops began with the stage of tillering and ended before harvesting. For perennial grasses the 1st year planting were examined. For biennial row-crop and winter crops both 1st and 2d year plantings were examined. The peculiarities of agrotechnical methods, as well as the use of fertilizers, were not taken into account. Weeds referred to any plants in crops that did not serve the crop purpose including other cultivated plants. Weeds were taken

into account in any age state (seedlings, juvenile, immature, generative, excluding seeds), in any phenological state (vegetation, budding, flowering, fruiting) and in any vital state (normally developed and depressed). The crops of spring cereals, industrial and forage crops (oats, wheat, barley, corn, sunflower, flax, rapeseed, white mustard), winter crops (rye, wheat), row crops (potatoes, carrots, beets, cabbage, radish, turnip), and perennial grasses (crops of clover and alfalfa) were investigated. A total of 120 fields were examined.

The weed activity in arable plant communities was determined based on the abundance and frequency of their occurrence. The abundance was determined by A.I. Maltsev's eye scale (1962) from score 1 (low infestation degree) to score 4 (high infestation degree). The frequency of occurrence was determined by (1) the number of crops in which the weed species was found and (2) the constancy class: IV class (high occurrence), in which the weed species occurs in 61–100% of the surveyed arable plant communities; III (moderate occurrence), in which the species occurs in 41–60% of surveyed communities; II (low occurrence), in which the species occurs in 21–40% of surveyed communities; and I (very low occurrence), in which the species occurs in less than 20% of surveyed communities (Markov 1972; Palkina 2015). Four activity groups of weeds were identified (Table 1).

Table 1. Weed activity criteria.

Activity groups	Abundance	Frequency of occurrence	
		Constancy class	Occurrence in arable plant communities
Highly active	3–2	IV	high occurrence, registered in arable plant communities of all the examined crops
Moderately active	2	III	moderate occurrence, registered in most arable plant communities of the examined crops or, less often, all the crops
Underactive	2–1	II	low occurrence, registered in arable plant communities of half of the examined crops
Nonactive	1	I	very low occurrence, registered in arable plant communities of a single examined crop

Results and discussion

The weed species composition in the Central Urals included 258 vascular plant species belonging to 165 genera and 41 families. The most species-rich families were *Asteraceae*, *Poaceae*, *Brassicaceae*, *Caryophyllaceae*, and *Fabaceae*. The most species-rich genera were *Vicia* and *Potentilla* (which included 7 species each), *Trifolium* (6 species), *Persicaria* and *Rumex* (5 species each), and *Artemisia*, *Brassica*, *Medicago*, *Poa*, *Ranunculus*, and *Galium* (4 species each). Monocarpic (50.8% or 131 species) and polycarpic (49.2% or 127 species) herbaceous plants were in equal proportions in the life forms spectrum. In the weed flora most monocarpic plants were represented by annual grasses. More than half of polycarpic species (52%) were plants with intensive vegetative propagation, including species with long and short rhizome, stolon-forming, rootsucker, creeping, and tuber-forming. Native plants were dominant (148 species), while alien plants included 108 species (42 %).

The use of herbicides drastically decreased the weed infestation of crops. It was shown the score abundance of weeds in arable plant communities was 1–2 points and the weed cover was 20–30%. High plant cover was most often observed for *Cirsium*

arvense (L.) Scop., *Erodium cicutarium* (L.) L'Hér., *Convolvulus arvensis* L., *Sonchus arvensis* L., *Echinochloa crus-galli* (L.) P. Beauv., *Avena fatua* L., *Setaria viridis* (L.) P. Beauv. etc.

The weed constancy class analysis showed: 15 species (6%) had a constancy class of IV, 20 species (8%) a class of III, and 36 species (14%) a class of II. The vast majority of weeds (187 species or 72%) had a constancy class of I, being found in a small number of examined arable plant communities.

The weed occurrence analysis revealed that most of the weeds (184 species or 71%) had a moderate occurrence in the examined arable plant communities.

Twenty-two weed species (9%) had a high occurrence. These species were not selective and were found in arable plant communities of all crops. These species included, for example, *Cirsium arvense*, *Erodium cicutarium*, *Galium spurium* L., *Fumaria officinalis* L., *Fallopia convolvulus* (L.) A. Löve, *Convolvulus arvensis*, *Viola arvensis* Murray, *Galeopsis bifida* Boenn., *G. speciosa* Mill., *Avena fatua* etc.

Fifty-two weed species (20%) had low occurrence. Thirty-three weed species were unique to arable plant communities of spring crops. There were 28 native species (*Agrostis stolonifera* L., *Arabis pendula* L., *Hypericum perforatum* L., *Persicaria minor* (Huds.) Opiz, *Solanum kitagawae* Schonb.-Tem. etc.) and 5 alien species (*Artemisia sieversiana* Ehrh., *Echinocystis lobata* (Michx.) Torr. & A. Gray, *Echium vulgare* L., *Scleranthus annuus* L. and *Vicia villosa* Roth). Thirteen weed species were unique to arable plant communities of perennial grasses: 6 alien species (*Atriplex patula* L., *Cirsium vulgare* (Savi) Ten., *Lepidium densiflorum* Schrad., *Senecio vulgaris* L. etc.) and 7 native species (*Beckmannia syzigachne* (Steud.) Fernald, *Plantago lanceolata* L., *Verbascum nigrum* L. etc.). There were 4 weed species in arable plant communities of row crops: 2 native species (*Bidens radiata* Thuill., *Persicaria hydropiper* (L.) Delarbre) and 2 alien species (*Armoracia rusticana* P. Gaertn., B. Mey. & Scherb., *Hyoscyamus niger* L.). Two weed species were found only in arable plant communities of winter rye: the alien species *Bromus secalinus* L. and the native species *Rumex confertus* Willd.

All the weed species were divided into four groups.

Weeds most common in arable plant communities formed a group of highly active species with a high abundance. It was an extremely small group that included 17 species or 7% of the total weed species composition. Monocarpic grasses were most prevalent (71%) in this group, while the other species were polycarpic grasses with intensive vegetative propagation (rhizome and root sucker plants).

The highly active weeds group contained 59% alien species that were naturalized species in the natural flora: *Erodium cicutarium*, *Thlaspi arvense* L., *Fumaria officinalis*, *Galeopsis bifida*, *G. speciosa*, *Convolvulus arvensis*, *Avena fatua*, *Viola arvensis*, and *Chenopodium album* L. Native highly active weeds were mainly meadow species: *Artemisia vulgaris* L., *Cirsium arvense*, *Taraxacum campyloides* GE Haglund, *Elymus repens* (L.) Gould, *Tripleurospermum inodorum* (L.) Sch. Bip., *Capsella bursa-pastoris* (L.) Medikus, and *Stellaria media* (L.) Vill.

A group of moderately active weeds can also be considered as the most adapted to the arable plant communities and regarded as the active weeds of crops. This group comprised 9% of the total weed species composition. Monocarpic grasses dominated

this group (61%). Among the polycarpic grasses in this group were rhizome and rootsucker plants, tuber-forming species (*Stachys palustris* L.), and above-ground stolon-forming species (*Potentilla anserine* L.).

Native moderately active weeds accounted for 39% of the group. Meadow plants were most prevalent: *Arctium tomentosum* Mill., *Bromus inermis* Leyss., *Linaria vulgaris* Mill., *Potentilla anserina*, and *Vicia cracca* L. Alien moderately active weeds were represented by *Cyanus segetum* Hill, *Echinochloa crus-galli*, *Sonchus arvensis*, *S. oleraceus* (L.) L. etc.

Underactive and nonactive weeds comprised the majority of the weed species composition in the Central Urals (84%). Underactive weeds (82 species or 32%) were found in arable plant communities of many crops, but mainly in small numbers. The group of nonactive weeds was the most diverse and included about half of the weed species composition in the Central Urals (52%).

In these groups the proportion of polycarpic grasses increased among life forms that did not have intensive vegetative propagation, such as cespitose plants.

Native species dominated the underactive and nonactive weed groups (60% and 62% respectively). Moreover, their cenotic spectrum became more diverse. Forest species (*Angelica sylvestris* L., *Aegopodium podagraria* L. etc.), xerophytic community species (*Dracocephalum thymiflorum* L., *Nonea rossica* Steven), and petrophyte-steppe species (*Cerastium arvense* L.) appeared. In addition, there were species of waterlogged habitats such as meadow-bog (*Ranunculus repens* L., *Lysimachia vulgaris* L.), coastal water (*Mentha arvensis* L., *Persicaria amphibia* (L.) Delarbre, *Rorippa palustris* (L.) Besser), and erosiophilic species (*Leonurus quinquelobatus* Gilib., *Polygonum aviculare* L.).

The proportion of ruderal species was increased: *Conium maculatum* L., *Bunias orientalis* L., *Erigeron canadensis* L., *Malva pusilla* Sm., and *Veronica persica* Poir.

Table 2. Features of weed plants in the Central Urals (absolute number/proportion of the total, %).

Features	Highly active	Moderately active	Underactive	Nonactive
Total	17	23	82	136
Number of native species	7/41.2	9/39.1	49/59.8	84/61.8
Number of alien species	10/58.8	14/60.9	33/40.2	52/38.2
<i>Plant life-forms</i>				
Monocarpic grasses	12/70.6	14/60.9	36/43.9	58/42.7
Polycarpic grasses	5/29.4	8/34.8	45/54.9	75/55.2
Trees	0	0	0	1/0.7
Semiarborescent plants	0	0	0	1/0.7
Spore plants, rhizomatous have grasses	0	1/4.3	1/1.2	1/0.7

To mobilize collected data, we published the dataset for weed species composition and distribution in the Central Urals, through Global biodiversity information facility GBIF (Tretyakova et al. 2019). The occurrence dataset includes 2 730 records of the authors' collections from 2016 to 2019 of vascular plants from the phylum *Magnoliopsida*, *Liliopsida*, and *Equisetopsida*. The dataset includes metadata about the natural conditions of the Central Urals and the methods of data collection. The authors plan to supplement the data with the herbariums of the Institute of Plant and Animal Ecology (SVÉR) and Ural Federal University (UFU), which will extend the observations.

GBIF dataset contributes to open biodiversity data for Russian territory. It provides new information about geographical distribution of weeds in crops of the Central Urals. We hope that it promotes the data accessibility and reuse for Russian and foreign researchers.

Conclusion

Most weeds in arable plant communities in the Central Urals are underactive (82 species or 32%) and nonactive (136 species or 52%). The groups of the most active (aggressive) weeds include 40 species (16%). They are dominated by alien species which naturalized in the natural flora. The proportion of monocarpic grasses is higher than polycarpic grasses, mainly represented by rootsucker plants and rhizome species with intensive vegetative propagation.

The same patterns were noted in other region of Russia – Ryazan oblast (1 300 km towards west from Sverdlovsk oblast): only 27 weed species (10%) were highly and moderately active weeds. Most of them were annual plants. It should be noted that the composition of the most active weeds in arable land of Sverdlovsk and Ryazan oblasts was presented by almost the same set of species (Palkina 2015).

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