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Seed production capability of monocotyledonous and dicotyledonous weeds in segetal and ruderal habitats

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The main cause of wide presence of weeds in segetal and ruderal habitats is their high seed production capacity. It defined in expressly establishing field experiments, in industrial sowings, in segetal and ruderal habitats of steppe zones of Ukraine. It is determined that average fruitfulness of weeds in ruderal habitats was larger, than in segetal habitats by 3.8 times, and indexes of the maximum fruitfulness – by 4.0 times and reached accordingly 7028 and 9345 pieces, and 20112 and 98337 pieces. In segetal habitats monocotyledonous species of weeds on seed production on conceded dicotyledonous species by 2.9–3.7 times, and on ruderal habitats – by 9.8–10.5 times. Average seed production of monocotyledonous plants made up accordingly 3594 and 5660, and dicotyledonous – 12417 and 55629 pieces of seeds from one plant. Most species of monocotyledonous weeds (56,1 %) formed on one plant from 1 to 10 thousand pieces of seeds, and dicotyledonous weeds (37,9 %) – more than 10 thousand pieces of seeds. In segetal habitats the maximum seed production had families *Asteraceae*, *Brassicaceae*, *Chenopodiaceae*, *Lamiaceae*, and on ruderal habitats – *Asteraceae*, *Chenopodiaceae*, *Caryophyllaceae, Apiaceae, Brassicaceae.* The highest seed production the most widespread and abundant in sowings and on ruderal habitats had weeds: *Convolvulus arvensis* L., *Ambrosia artemisiifolia* L., *Cynodon dactylon* (L.) Pers., *Echinochloa crus-galli* (L.) P.Beauv., *Eragrostis minor* Host, *Descurainia sophia* (L.) Webb ex Prantl, *Cirsium arvense* (L.) Scop., *Chenopodium album* L., *Amaranthus retroflexus* L., etc. The greatest reserve weed seeds in soil in segetal habitats descended at the expense of species from genera *Amaranthus*, *Galium*, *Cirsium*, *Setaria*, and on ruderal habitats – *Amaranthus*, *Chenopodium*, *Plantago*, etc. In segetal habitats proof presence of weeds of genera with low seed production was sustained at the expense of their larger number of species, and genera with low number of species – at the expense of high seed production. In ruderal habitats – as at the expense of larger number of species, and their high seed production. The absolute maximum of seed production in segetal habitats have been reached at weeds of genera *Amaranthus, Cirsium, Galium* – from 3288 to 242266 pieces, and in ruderal habitats – *Amaranthus, Chenopodium, Plantago* – from 108903 to 1911683 pieces from one plant.

Keywords: seed production; weeds; segetal; ruderal; taxonomic groups

Introduction

In the Steppe zone of Ukraine over 62.2 % of its territory is occupied by sowings of agricultural crops (Zubets et al., 2004). Numerous researches testify that segetal habitats have strong feed infestation by monocotyledonous species which part in weed communities fluctuated from 3.5 to 63.2 % and dicotyledonous species – which specific mass varied from 5 to 99 %. The quantity of shoots in sowings reached 0.25–3.20 thousand pieces/m^2, and on ruderal habitats – 16–72 thousand piece/m^2 (Kempen, Graf, 1981; Ivashchenko, 2001; Mertens, Jansen, 2002; Tsykov et al., 2012; Kurdyukova, 2013). Century efforts of the man to get rid of them in sowings do not bring expected results. Weeds remain, as before, constant companions of crop plants and nontreated lands.

The main cause of their wide presence at segetal habitats and on ruderal habitats is high seed production (Hosamini et al., 1971; Ivashchenko, 2001; Kurdyukova, 2015). It defines adaptability of the species to environmental conditions, character and rate of widening and range of various species of weed plants, composition and structure of phytocoenosis (plant association), a direction of successions in plant communities etc. (Schwerzel, 1970; Perron, Légère, 2000; Ivashchenko, 2001; Kosolap, 2004). The success of seed revegetation and constant presence of weeds at phytocoenosis is provided with enough of their seeds in soil. Entering of seeds in soil under the different data on 70–92 % was defined by level of seed production of weeds in the given field (Kosolap, 2004; Konoplia, Kurdyukova, 2013).

Therefore, last years the problem of seed production of weeds attracts attention and presented in various research (Mertens, Jansen, 2002; Konoplia, Litvinova, 2007; Lutman et al., 2008; Borona et al., 2009; Kosolap, 2011; Hill et al., 2014; Kurdyukova,

2014; 2015). However, there are not enough data available in literature on fruitfulness of monocotyledonous and dicotyledonous species of weeds in sowings and on ruderal habitats.

Materials and methods

Seed production of different weed species were recorded within 2007–2017 in segetal and ruderal habitats of Steppe zones of Ukraine. Samples of weeds in coenopopulations were covered all their morphological diversity. The area of record plots of seed production of small species or insignificant quantity of all weeds which were a part of community or synusia, made up from 16 to 100 m^2, and at high density of generative individuals, and also neotenic and dwarf species (forms) – 0.25–1.0 m^2, standing alone weeds with small frequency – 1.0–10 thousands m^2. Record plots on the large areas were evaluated by their diagonal, by criss-cross pattern or by «envelope» method, placing them through equal spacing from each other, using for their separation special metal frameworks (at the area 0.25–1.0 m^2) or special cords with pegs (at the area 10–100 m^2).

We use actual quantity of seeds or fruits which were produced by one specimen of the plant for one generation as seed production size. Average seed production was defined as quotient from division of the sum of quantity of seeds from each record plant on number of registration plants among samples. Average minimum (maximum) seed production was determined as quotient from division of the sum of the least (greatest) quantity of seeds from one registration plant in each sampling series on total number of samplings. Absolute (minimum) maximum seed production – as the least (greatest) quantity of seeds from one registration plant, fixed ever during all long-term period of researches. Weeds and seeds classification was made in accordance with the standard field guides (Maisurian, Atabekova, 1978; Kosolap, 2011; Flora SSSR, 1934–1960).

Results

It has been determined that average fruitfulness of monocotyledonous and dicotyledonous weed species in ruderal habitats was larger, than in segetal habitats by 3.8 times; indexes of the maximum fruitfulness – by 4.0 times and it was accordingly 7028 and 9345 pieces in segetal vs 20112 and 98337 pieces in ruderal habitats.

In sowings of agricultural crops, the monocotyledonous species of weeds on fruitfulness of one plant conceded to dicotyledonous in 2.9–3.7 times, and on ruderal habitats – in 9.8–10.5 times. However, the seed production difference of monocotyledonous weeds which occurred in sowings, in comparison with ruderal habitats was smaller, made up on average indexes of fruitfulness of 43.2 thousand pieces and reached in ruderal habitats 55629 pieces, and in segetal habitats it was only 12417 pieces. The same dependences were determined in relation to the minimum and maximum seed production (table 1).

Table 1. Seed production of monocotyledonous and dicotyledonous weeds in segetal and ruderal habitats, thousand seeds per plant

Classes of weeds	Segetal habitats				Ruderal habitats			
	species	Seed production			species	Seed production		
		minimum	average	maximum		minimum	average	maximum
Monocotyledonous	20	2058	3594±464	7028	25	3005	5660±1385	9345
Dicotyledonous	138	7772	12417±943	20112	238	30586	55629±2831	98337

Most species of monocotyledonous weeds (56.1 %) formed from 1 to 10 thousand seeds per plant. This were *Apera spica-venti* (L.) P. Beauv., *Setaria viridis* (L.) P. Beauv. and *S. verticillata* (L.) P. Beauv., *Digitaria sanguinalis* (L.) Scop., *Avena sterilis subsp. ludoviciana* (Durieu) Gillet & Magne etc.

A little smaller part (29.3 %) of monocotyledonous weeds formed on average up to 1 thousand pieces of grains per plant. This were *Bromus tectorum* L., *B. secalinus* L. and *B. arvensis* L., *Avena fatua* L., *Hordeum murinum* L., and *Aegilops cylindrica* Host. High seed production was typical only for species of monocotyledonous plants which had high stems – *Phragmites australis* (Cav.) Trin. ex Steud., *Leymus racemosus* (Lam.) Tzvelev, or they were well tillered and formed the considerable quantity of productive stems, in particular *Cynodon dactylon* (L.) Pers., *Echinochloa crus-galli* (L.) P.Beauv., and *Eragrostis minor* Host.

Among dicotyledonous weeds the quantity of species which formed up to 1 thousand seeds, was lesser in comparison with monocotyledonous and made up 21.7%. It was mainly early-spring ephemers and ephemeroids, in particular *Veronica hederifolia* L. and *V. praecox* All., *Erodium cicutarium* (L.) L'Hér., *Ceratocephala testiculata* (Crantz) Roth, and *Myosurus minimus* L. The species ratio which formed from 1 to 10 thousand and over 10 thousand seeds per plant was almost equal – 37.9%. Among them there were such widely distributed and abundant in sowings and ruderal habitats species of weeds like *Convolvulus arvensis* L., *Ambrosia artemisiifolia* L., *Descurainia sophia* (L.) Webb ex Prantl, *Cirsium arvense* (L.) Scop., *Chenopodium album* L., and *Amaranthus retroflexus* L.

Consequently, the monocotyledonous and dicotyledonous weeds were characterized by the highest fruitfulness in ruderal ecotopes. Dicotyledonous species of weeds, irrespective of habitats exceeded the monocotyledonous species by 3.5–9.8 times concerning the seed production level. In segetal habitats specific mass of the most prolific dicotyledonous species from A*steraceae* and *Lamiaceae* with average seed production more than 10 thousand pieces per plant, reached 39.2 %, whereas on ruderal habitats these and others high fruitful weeds occupied just 45.6 %. Seed production of representatives of

Euphorbiaceae, *Fabaceae*, *Boraginaceae* with specific mass in segetal habitats of 17.1 %, and on ruderal habitats – 1.9 %, did not exceed 500 pieces.

The weeds of all dominant families of Dicotyledonous which occurred on ruderal habitats had more seed per plant than on segetal habitats – it were higher by 1.3–1.8 times (for families *Lamiaceae*, *Euphorbiaceae*), by 3.7–8.8 times (*Asteraceae*, *Chenopodiaceae*, *Fabaceae*, and *Caryophyllaceae*), and even by 11.4–20.3 times (*Boraginaceae*, *Apiaceae*), whereas species of family *Poaceae* had more seed just by 1.75 times. So, A*steraceae* weeds being the most species abundant formed on average 11.4 thousand seeds per plant in segetal more than 1000 thousand seed in ruderal habitats (this was 19.6 % and 19.4 % families respectively). The maximum fruitfulness was accordingly 20.7 and 176 thousand seeds per plant. Seed production of *Asteraceae* families, like *Brassicaceae and Chenopodiaceae* was similar (table 2)

Table 2. Seed production of weeds of dominant families on segetal and ruderal habitats, seeds per plant

Families	Segetal habitats				Ruderal habitats			
	Number of species	Seed production			Number of species	Seed production		
		min	average	max		min	average	max
Asteraceae	31	6668	11412±957	20701	51	55663	100292±7300	176349
Brassicaceae	15	6415	11025±1082	23068	20	19616	33601±2470	53617
Poaceae	20	2058	3594±548	7028	22	3381	6292±377	10370
Chenopodiaceae	11	9350	13018±869	18834	20	23241	47789±2842	82843
Lamiaceae	5	2852	11910±1170	34460	14	3267	15010±1334	34035
Fabaceae	12	209	496±42	875	13	751	2937±158	9126
Caryophyllaceae	7	3507	9086±169	22721	7	10782	41732±3016	138763
Boraginaceae	11	215	593±51	1303	14	2419	6781±455	9773
Apiaceae	3	1048	1768±123	2753	8	15918	35900±2021	54773
Euphorbiaceae	4	50	240±22	589	5	220	416±39	740

This variation was more larger in agricultural crops. So, the genera which included 4–5 species, formed on average from 111 (genus *Vicia* L.) to 1041 (genus *Atriplex*) seeds per plant that explains their rather low frequency and low abundance in sowings. At the same time, the plants of *Amaranthus* L., *Galium* L., and *Cirsium* Mill. (which have 2–3 species) formed on average from 14 to 95 thousand seeds per plant and were usual weeds with the high abundance in agriculture fields.

The maximum seed production of most weeds from dominant genera was from 5 to 25 thousand seeds, whereas the weeds from *Amaranthus* had over 100 thousand seeds and weeds of *Vicia* and *Euphorbia* – just about 1 thousand seeds (table 3).

Table 3. Seed production of weeds of the largest genera in segetal habitats, seeds per plant

Genus	Quantity of species	Minimum	Average	Maximum	Absolutely maximum
Atriplex	5	1015	1041±83	2389	3149
Vicia	4	31	111±10	225	288
Euphorbia	4	50	240±16	589	604
Amaranthus	3	66131	94792±5192	141399	242266
Digitaria	3	918	2616±145	5835	9524
Setaria	3	1401	3196±230	5717	6976
Anthemis	3	3193	6155±408	10404	13050
Sonchus	2	1740	3890±223	8984	11029
Senecio	2	1115	2643±197	5500	7083
Cirsium	2	7764	14057±903	23340	32388
Galium	2	11177	17124±916	22934	34608
Lactuca	2	916	2260±134	4327	5096

We suggest that low seed production of some weed genera in segetal habitats was compensated by their high species number, and poor species diversity of some genera - by high seed production. The seed production of weeds was considerably higher in ruderal habitats and this was true for *Euphorbia*, *Atriplex*, *Vicia* (5 species), they have seed production by 1.7–4.1 times higher. The Fruitfulness of *Chenopodium* weeds (9 species) exceeded 786 thousand seeds per plant, *Amaranthus* (3 species) – 717 thousand seeds. The other genera had also high seed production, for instance, *Plantago* L. – 21.5 thousand of seeds, *Carduus* L. – 9.5 thousand of seeds, *Lamium* L.– 5.4 thousand, and *Digitaria* Hall. – 5.0 thousand of seeds (Table 4).

Table 4. Estimated numbers of seeds produced by the largest genera of weeds in ruderal habitats

Genus	Quantity of species	Lowest count	Mean number of seeds per plant	Highest count	Absolutely maximum
Chenopodium	9	41283	78613±5400	115043	267444
Euphorbia	5	220	416±47	740	845
Atriplex	5	3015	4242±331	6645	9086
Vicia	5	119	282±29	1040	1916
Carduus	3	7039	9513±725	12125	14772
Veronica	3	340	553±52	1450	2155
Lamium	3	2443	5402±472	10703	17576
Xanthium	3	580	1259±79	2758	6053
Digitaria	3	3023	4994±506	8823	10000
Plantago	3	5538	21540±1890	81035	108903
Amaranthus	3	493855	17120±20136	1453846	1911683

The maximum fruitfulness of weeds of all genera, except for *Euphorbia*, exceeded 1 thousand seeds per plant; weeds of *Plantago* had 81.0 thousand seeds, *Chenopodium* – 115 thousand, and *Amaranthus* – 1454 thousand seed.
The absolute maximum of seed production of weeds in segetal habitats did not exceed 32.3–34.6 thousand seeds (*Cirsium*, *Galium*), for *Amaranthus* this was 242.3 thousand seeds, whereas on ruderal habitats the fruitfulness of most weeds of exceeded 10 thousand seeds (*Carduus*, *Lamium*, and *Digitaria*), *Chenopodium* – 267.4 thousand, *Plantago* – 108.9 thousand, and *Amaranthus* – 1911 thousand seeds due to absence of the competition with cultivated plants.

Conclusions

The maximum seed production in the all habitats was formed by dicotyledonous species of weeds. In segetal habitats the highest seed production was registered for the families *Chenopodiaceae*, *Lamiaceae*, and *Brassicaceae*; in ruderal habitats – for *Asteraceae*, *Chenopodiaceae*, *Caryophyllaceae*, and *Apiaceae*. The greatest reserve of weeds in soil of segetal habitats caused by *Amaranthus*, *Galium*, *Cirsium*, *Setaria*, and *Digitaria*, and in ruderal habitats – by *Amaranthus*, *Chenopodium*, and *Plantago* plants.

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