Research Article

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Alien species as a part of plant composition in the periphery of agricultural fields

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Abstract: An extensive survey of plant species in the field borders between the crop land and adjacent territories was conducted in representative agricultural areas in Bulgaria. All insect-pollinated plant species, irrespective of their phase of development were recorded. There were totally 4597 records of 374 plant species in 272 experimental plots. Totally 24 adventive species were recorded in 64% of all experimental plots. Four arboreal invasive plants belong to the category of most dangerous invasive alien species, threatening the European biodiversity. The results indicate that alien species in the agricultural land and its peripheral parts, including field borders, still represent relatively small percent of the species composition, but could be a threat in specific environmental conditions.

Key words: Agricultural field borders, hedgerow, exotic species.

Introduction

Biological invasions became an important issue in many fields ranging from biological systematics to conservation biology and management of natural, semi-natural and human-made ecosystems. Even though biological invasions have been documented for centuries, they were considered a serious threat to global biodiversity only in the second half of 20th century (Elton 1958, Drake et al. 1989, Richardson & Pyšek 2006, Richardson et al. 2000) and the interest to the topic exploded in the last three decades (Richardson & Pyšek 2006, Petrova et al. 2013). This interest is caused not only by the impact on biodiversity and natural ecosystems, but also by the socio-economic consequences (Baskin 1998, Pimentel 2002, Pimentel et al. 2005). Usually main concern in plant invasion ecology are the natural and semi-natural ecosystems, where the impact could be significant and sometimes irreversible. However, plant invasions could be as important also in managed ecosystems and plant communities, most important of them being agricultural crop fields and the adjacent territories (Paini et al. 2016), where easier and non-intentional introduction of alien species can happen together with crop plants (Radosevich et al. 2007) and with change of farming practices (Chen et al. 2013).

To date the invasive plants in Bulgaria were studied mainly in relation to the threats they pose to natural ecosystems and biodiversity (Petrova et al. 2013, Vladimirov & Petrova 2014), with numerous floristic notes (Petrova & Vladimirov 2012) and only occasionaly – with control and management (Milanova et al. 2010, Vladimirov & Milanova 2012).

The objective of the present study was to assess the flowering plant diversity and to evaluate the invasive potential of alien plant species and their significance as a threat to biodiversity and ecosystem integrity in representative agricultural fields and their periphery.

Material and methods

The study was performed in September-October 2016 and was a part of a large-scale study aimed at evaluation of pollinator availability. The field survey

was done in 28 large circle plots (landscape units) with diameter 4 km, situated in different regions of Bulgaria (more details about the scoring plots are availabe from authors upon request). Ten scoring experimental plots, 100 m^2 each, were set in each circle, with some insignificant exceptions, where number of plots was lower by one or two, leading to a total number of 272. The scoring experimental plots were along the field borders and hedges at the periphery of the agricultural fields. The position of scoring plots was determined by expert evaluation of the existing crop diversity, with the aim to cover different crops. Scoring plot selection was done together with the experts entomologists.

All plant species were recorded with the exception of wind-pollinating ones. Arboreal species were recorded irrespective of their mode of pollination. Besides the plant species composition, the following information was collected in each plot: number of species recorded, number of flowering species, and number of adventive species.

Origin of the adventive species was taken from Assyov & Petrova (2012), with some *ad hoc* corrections done in the course of the work. Several species with cosmopolitan distribution were considered invasive, following Petrova et al. (2013).

A database in Excel was established and used for the statistical analyses. Standard descriptive statistics and linear regression analysis were applied to test the relationships among the variables studied.

Results

Total 374 plant species were identified during the field survey, and 24 of them were classified as adventive and/or invasive (Table 1), which is 6.42 % of all species. Of these species 14 are considered invasive, and four of them are included in the List of the most dangerous invasive species, threatening the European biodiversity – *Acer negundo, Ailanthus altissima, Amorpha fruticosa* and *Robinia pseudoacacia*. It can be seen that these are all arboreal species, which are considered serious threat, but usually for other types of landscape, rather than for agricultural one (see Discussion).

Six species are considered potentially invasive and four – not invasive. These are *Morus alba*, *Symphoricarpos albus*, *Ricinus communis* and *Cannabis sativa*. *M. alba* is cultivated in relation to silk production since the medieval time and to date did not show invasive behavior in Bulgaria. *C. sativa* is heat demanding and with limited competition abilities and occurs, therefore, only on ruderal places without substantial competition by other species. The occurrence of *S. albus* is incidental and close to a road, where it had been planted for ornamental purposes at the time of road construction. *Ricinus communis,* a long-lived perennial in its native range, behaves in Bulgaria as annual, since it cannot survive the severe winter conditions. Therefore, these four species are classified as non-invasive.

There were 4597 records of plant species in the different experimental plots and 1363 records (29.6 %) of the species identified were flowering. The 24 adventive species were recorded 521 times (11.3 % of all records) and 14.2 % of these records were flowering. Adventive and/or invasive species were present in 227 of 292 experimental plots (77.7 %). Most frequently recorded species was *Xanthium strumarium* – in 148 scoring plots, followed by *Erigeron canadensis* – in 121, and *Amaranthus retroflexus* – in 55 scoring plots. In the opposite tail were species like *Fraxinus americana*, *Kochia scoparia*, and *Phytolacca americana*, which were recorded in only one or two scoring plots.

Number of adventive species (incl. invasive ones) recorded per landscape unit varied from 3 to 14, and number of records varied from 7 to 41 (full results not shown). There was strong positive relationship between the number of adventive species and number of their records per landscape unit (R^2 = 0.75; $p<0.001$). Mean number of adventive species recorded per scoring plot varied between 0.7 and 4.1.

Discussion

Taking into account that the study was done in September, it could be stated that the species composition established underestimates the real plant diversity. By this period some species, especially the short-lived spring ephemerals (annuals and perennials) cannot be seen and recorded. However, there were some exceptions when the species could be identified based on dry residues.

As pointed above, four arboreal species are considered dangerous invasive species. However, in agricultural landscape they could be a threat only in some species cases.

Acer negundo is considered invasive species with high phenotypic plasticity performing better mostly in non-limiting resource environment (Porté et al. 2011). In agricultural landscapes its growth and spreading could be limited by water deficiency and by soil tillage.

Today *Ailanthus altissima* is considered one of the worst invasive plant species in Europe (Sladonja et al. 2015), occurring mostly in urban areas, alongside the roads, and more rarely, in open

Table 1. List of the adventive and invasive plants recorded in the study

Species	Origin	Status	Occurence[1)]
Acer negundo L.[2)]	North America	Invasive	3
Ailanthus altissima (Mill.) Swingle[2)]	Eastern Asia	Invasive	3
Amaranthus albus L.	Tropical America	Potentially Invasive	8
Amaranthus retroflexus L.	Tropical America/Cosmopolitan	Invasive	55
Amorpha fruticosa L. [2)]	North America	Invasive	3
Cannabis sativa L.	Asia	Not Invasive	6
Cuscuta campestris Yunck.	North America	Invasive	15
Datura stramonium L.	Central America	Invasive	26
Erigeron anuus (L.) Pers.	North America	Invasive	17
Erigeron canadensis L.	North and Central America	Invasive	121
Erigeron sumatrensis Retz.	Asia	Invasive	17
Fraxinus americana L.	North America	Invasive	1
Galinsoga parviflora Cav.	Central America	Invasive	16
Gleditsia triacanthos L.	North America	Potentially Invasive	10
Kochia scoparia (L.) Schrad.	North America	Potentially Invasive	1
Lycium barbarum L.	Eastern Asia	Potentially Invasive	8
Morus alba L.	Eastern Asia	Not invasive	9
Phytolacca americana L.	North America	Potentially Invasive	2
Portulaca oleracea L.	North Africa and South Europe	Invasive	29
Ricinus communis L.	East Africa and Tropical Asia	Not Invasive	5
Robinia pseudoacacia L.[2)]	North America	Invasive	9
Symphoricarpos albus (L.) S. F. Blake	North America	Not invasive	2
Xanthium spinosum L.	Cosmopolitan	Potentially Invasive	7
Xanthium strumarium L.	North America/Europe	Invasive	148

[1)] Number of transect where the species was recorded.
[2)] A species included in the List of the most dangerous invasive species, threatening the European biodiversity.

dry forests. Control and eradication of *A. altissima* are difficult because of its sprouting ability. It is not typical in agricultural landscape (except in some pastures) and was recorded only three times during the field survey.

Amorpha fruticosa was introduced from North America mostly as melliferous plant, but also as ornamental. It is considered particularly dangerous in wetlands and along the rivers, where it could invade the natural riparian forests (Dumitraşcu et al. 2011). It can occur in the agricultural landscapes only on sites with enough water availability and along irrigation channels (Blagojević et al. 2015). Since such sites were not frequent in the region of study, the species was recorded only three times during the field survey.

Robinia pseudocacia is considered invasive, threatening especially dry and semi-dry grasslands, open dry forests, and agricultural landscape (Vítková et al. 2017). It is included in the list of invasive alien species of Member State concern (Article 12, Regulation (EU) 2016/1141). The species was recorded in 9 plots.

The percentage of the invasive and potentially invasive species recorded in the study is substantially higher than expected by "the tens rule" (Williamson & Brown 1986). However, it should be taken into account that not all introduced species were recorded, but only established ones. Also, the "tens rule" is a probabilistic assessment with many exceptions and differences among the groups of organisms. In plants, particularly, it is considered rather artifact, than rule (see Richardson & Pyšek 2006 for discussion).

The effect of alien invasive plants on agricultural ecosystems cannot be evaluated based only on the species composition. There are many factors affecting the invading of agricultural land (Meiners et al. 2001, Chen et al. 2013) and the dynamics of the process, like climatic conditions, use of chemical fertilizers and pesticides and other unpredictable factors (Chen et al. 2013). Most probably the threat and importance of invaders will differ among the regions, crops and

is expected to depend strongly on the temperature and water regime of the agricultural fields of interest (Theoharides & Dukes 2007) as well as on the soil and management history (Kulmatiski et al. 2006).

The present survey poses more questions than provides answers but it stresses the necessity of studies focused on the invasive plants and processes of plant invasions in the agricultural lands in different regions of Bulgaria.

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